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SUMMARY

The dynamic nature of today's global marketplace places a premium on a firm's ability to anticipate and to respond to both customer needs and changing competitive pressures. It is then a matter of knowledge finding, transferring and cultivating, in order to stay competitive and active in an ever-changing environment. In an era when organizations are trying to catch up with global competition, benchmarking has been gaining attention among managers and academics as means of strengthening a company's ability to compete. Benchmarking has been defined as the search for industry best practices that will lead to superior performance. This definition has been coined by Robert Camp, who first wrote a book on the subject based on his experience at Xerox Corporation in the USA.

On the other hand, in most economies, technology policy has sought to bring the worlds of scientific and commercially oriented research closer together. New technologies that need to be tracked, developed, evaluated, transferred, or elsewhere managed by the company have become more numerous, as have their potential sources. Effective acquisition and utilization of new technology from an outside source can contribute greatly to the operational success of a firm, though acquiring and assimilating new product and process technologies is often quite difficult.

To have a successful startup and result when transferring technology or, in a more general sense knowledge, not only must its elements be properly selected, but also the implementation process must be carefully planned out. All the above, when following world class practices, consist steps of a benchmarking methodology, which if properly implied will contribute so, that the technology transfer will finally lead to competitive advantage for both the donor and the recipient, which is eventually the ultimate purpose of benchmarking.

Accordingly, this thesis aims to contribute to the technology transfer literature by developing a conceptual framework of effective benchmarking the technology transfer at the whole project level. The conceptual framework captures the nature of the technology to be transferred, the activities and interactions across organization boundaries, and contingent relationships between technology and organization, searching for the "best practice" in every step, action and best management approaches for transferring a technology from or into an organization. Technology transfer is an inherently multidimensional task characterized by complex and interrelated relationships among many variables. This multidimensionality and multivariate complexity is explicitly considered in the development of the model.

The study is based on literature review and the scope is the creation of a methodology for implementing benchmarking in technology transfer.

Sections I and II provide useful knowledge on Benchmarking and Technology Transfer theories, in order:

⇒ for both concepts to be well presented and understood
⇒ gaps, limitations and obstacles to be mentioned
⇒ possible contributions and interactions to be set in question.

Section III presents the proposed methodology on technology transfer benchmarking, expected benefits, prospective problems and limitations, as well as success factors, marking the fact that the methodology needs testing and implementation, in order for real problems and critical success factors to emerge. The need for further study on theoretical consolidation with new definitions, efficient techniques, methods and tools is stressed and theorists and practitioners are welcomed to structure this new branch of benchmarking with experimental work and case studies.

Section IV deals with benchmarking and technology transfer in EU. Short reports on the industry - science relations for representative countries of EU, USA and Japan, broaden the reader's view on aspects concerning technology transfer, mechanisms and channels, as they occur round the world. The reference to current EU programs prepares the climate for a new framework proposal, regarding the benchmarking in technology transfer, which will be part of Chapter VI.

A special reference to SMEs states the specific problems that they confront, because of their size and potential, when seeking to benchmark or transfer technology. Solutions and political interventions are proposed, especially when implementing technology transfer benchmarking. Finally, there is an acquaintance with moral, legal and financial aspects of benchmarking.

Section V presents case studies from the areas of benchmarking and technology transfer, since no case has been found in literature to deal with benchmarking in technology transfer. The cases are selected to show the unlimited possibilities and the potential of benchmarking, as well as the pitfalls, problems and unexpected difficulties that arise in technology transfer processes, even when transfer agents are used. The aim is to mark out the necessity of technology transfer benchmarking. The thesis ends with conclusions and recommendations.

The thesis addresses the question of involving benchmarking in technology transfer and how benchmarking can promote and ameliorate the transfer of technology. In the emerging economic and social environment, where knowledge, its use and exploitation will be the key to competitiveness, the interaction of knowledge generators and users will be critical for success and cannot be deserted to lack or even common thinking.

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INTRODUCTION

Over the last few years an extraordinarily important socioeconomic phenomenon has changed the world we live in. This phenomenon consists of an unstoppable globalization of the economy and markets. Advances in transportation, communications, electronics, data processing, telecommunications and new materials have converted the world into a global village whose inhabitants are getting to know each other much better, and in which consumption patterns and production methods and techniques are becoming increasingly uniform. The very same McDonald's, Burger King, Body Shop, Ermenegildo Zegna, and multinationals such as IBM, Samsung, Sanyo, Seiko and Nestle, are found in all the built-up areas of the industrialized and developed countries. As a result, similar appliances and utensils (washing machines, videos, refrigerators and PCs, for example) can be found in many homes, and the same occurs in offices and companies (fax, electronic mail, PCs and Windows). Multinational companies encourage this process and also promote strategic alliances, franchises and co-operative agreements.

Opening up of frontiers (USA, NAFTA, Mercosur, etc.) promoted the circulation of products, which have become international, the increase in the number of new companies and the acquisition of companies, while communications created worldwide telecommunications networks, the circulation of images, the rapid spreading of fashions and the internationalization of tastes.

The dynamic nature of today's global marketplace places a premium on a firm's ability to anticipate and to respond to both customer needs and changing competitive pressures. All companies are obliged to develop their activities in a highly competitive and increasingly international environment, regardless of their size and the country they are located in.

Laurence Prusak in an article published in 1996 stated "Researchers in the areas of sustainable competitive advantages have come to the conclusion that the only thing that gives an organization a competitive edge, the only thing that is sustainable, is what it knows, how it uses what it knows, and how fast it can know something new".

It is then a matter of knowledge finding, transferring and cultivating, in order to stay competitive and active in an ever-changing environment. In an era when organisations are trying to catch up with global competition, rapid technological advances and cool customer needs, benchmarking has been gaining attention among managers and academics as means of strengthening a company's ability to compete. Benchmarking has been defined as the search for industry best practices that will lead to superior performance (Camp, 1989). This definition has been coined by Robert Camp, who first wrote a book on the subject based on his experience at Xerox Corporation in the USA.

On the other hand, in most economies, technology policy has sought to bring the worlds of scientific and commercially oriented research closer together. Innovation and technological development depend increasingly on the ability to use new knowledge produced elsewhere and combining it with the stock of knowledge available in a particular enterprise. For this purpose, absorptive capacities, transfer capacities and the ability to learn by interaction are crucial success factors. New and commercially useful knowledge is the result of interaction and learning processes among various actors in innovation systems, i.e. producers, users, suppliers, public authorities, and scientific institutions. Universities and other public research institutes, as major producers of knowledge, are increasingly expected to contribute to this process.

The commercialization focus of new technologies has increased in importance for companies in order to stay competitive. New technologies that need to be tracked, developed, evaluated, transferred, or elsewhere managed by the company have become more numerous, as have their potential sources. Effective acquisition and utilization of new technology from an outside source can contribute greatly to the operational success of a firm, though acquiring and assimilating new product and process technologies is often quite difficult.

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Accordingly, this thesis aims to contribute to the technology transfer literature by developing a conceptual framework of effective benchmarking the technology transfer at the whole project level. The conceptual framework captures the nature of the technology to be transferred, the activities and interactions across organization boundaries, and contingent relationships between technology and organization, searching for the "best practice" in every step, action and best management approaches for transferring a technology from or into an organization. Technology transfer is an inherently multidimensional task characterized by complex and interrelated relationships among many variables. This multidimensionality and multivariate complexity is explicitly considered in the development of the model.

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"In God we trust; the rest bring data."
The slogan in FPL (Florida Power Utility)
In November 1989, FPL was the first non-Japanese company to receive the prestigious Deming Prize for quality.

CHAPTER I
BENCHMARKING

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BENCHMARKING

"If you know your enemy and know yourself, you need not fear the result of hundred battles."
General Sun Tzu

INTRODUCTION

The markets today are moving fast, competition is increasing by the day, customers are more aware and demand more, and change is occurring at an unprecedented rate. To survive into the next decade, organizations need to rethink their structures, products, processes, and markets. They must re-establish themselves to be quicker to market, customer focused, innovative, nimble, flexible, and be able to handle rapid change. A major weapon in the organizational arsenal to face these challenges is benchmarking (Zairi et al., 2000).

The essence of benchmarking is the process of identifying the highest standards of excellence for products, services, or processes, and then making the improvements necessary to reach those standards - commonly called ``best practices". The justification lies partly in the question, "Why re-invent the wheel?" Benchmarking is not just competitive analysis or number crunching, nor is it spying, espionage or stealing. It is a process to establish the ground for creative breakthroughs (Bhutta and Huq, 1999). Many organizations publicize what they have achieved, but it is unusual for them to be open on the more mundane facts of how this transformation was made to work. More than 70 percent of the Fortune 500 companies use benchmarking on a regular basis, including AT&T,Ford, Eastman Kodak, IBM, Ford Motor Company and Weyerhaeuser (Greengard, 1995).

Benchmarking is a way to move away from tradition. It carefully dissects the organization into segments, and then removes and inserts pieces to account for changing environments. Changes occur once the process has started, and will continue to change and mold the organization for as long as individuals are continuously striving to make it better. If these individuals lose the ability to analyze and make changes, they begin to lose ground.

Benchmarking was traditionally used as a problem solving technique (problem based benchmarking). During the past several years, through extensive efforts, leading organizations have come to realize that there is a better way to focus benchmarking activities for greater payback. The most effective vehicle to ensure continuous improvement is to focus on the basic processes that run the organization. It is this concentration that will deliver the outputs that will achieve the organization's objectives, priorities, and mission. This (process based benchmarking) is a new and revolutionary perspective in benchmarking.

Benchmarking is a recently established management tool, - almost unknown in Greece - that draws wide attentions from various disciplines, including engineering, education, business, hospitality, etc. A flurry of studies related benchmarking to improving work practices. Its charm comes from its commitment to performance improvement (Allio & Allio, 1994), which is a norm in the field of general management (Cheng, 1998).

Benchmarking has become an integral part of business for many successful companies. Organizations are encouraged to continuously benchmark their performance with the world's best, adapting the new best practice, and innovating to become world class. This type of copying, adapting, and learning from other's best practices is becoming virtually mandatory for future success.

Notwithstanding its growing popularity, particularly in conjunction with quality initiatives to drive business improvements, benchmarking remains a relatively underutilized tool in many fields (e.g. innovation, technology transfer etc). In fact, despite the vast existence of a literature base identifying success or failure factors in product development (de Bretani, 1996; Cooper, 1979; 1986; 1990; Cooper and Kliendschimdt, 1987; Madique and Zirger, 1984; Rothwell, 1972), few have tried to explicitly incorporate benchmarking best practice methodology.

Exceptions, having used benchmarking in one form or another, have been Pierz (1995) who uses a benchmarking methodology to examine best practices for new product development funding in the telecommunications industry.
Cooper and Klienschimdt (1995) also report on a benchmarking study to identify critical success factors that set successful companies apart from the not so successful ones.

BENCHMARKING BACKGROUND

Benchmarking has a variety of meanings attached to it. There remains a certain degree of confusion and even mysticism about what benchmarking really is about.

"Benchmark" is a simple word that refers to a "cut by surveyors to mark point in line of levels"(Oxford Dictionary). However, when it is used as a verb (i.e benchmarking), it is a technique or a tool for performance improvement and good quality practice by striving to be the best (Beadle & Searstone, 1995).

The narrower focused forms of traditional benchmarking have been used for centuries. One early use was by military leaders when they used reconnaissance to size up the enemy. Later, artisans from guilds observed prices and workmanship of fellow craftsman. This observation was refined to become the competitive analysis that became a basic tool in the industrial age. The practice then broadened to analysing entire industries and countries (e.g. the Japanese electronics industry).

Watson [1993] has described the evolution of benchmarking, starting with reverse engineering during the 1970s. Reverse engineering involved purchasing competitive products and taking them apart. The purpose was not only to delineate features in the competitive product offering but to gain as precise an understanding as possible into the embodiment of product features and their associated costs. Reverse engineering was a form of product-centred competitive intelligence gathering with little or no involvement required of the benchmarkee (Langowitz and Rao, 1995).

Expanded benchmarking evolved in the 1980s. It may be defined as “the ongoing activity of comparing one’s own process, practice, product, or service against the best known similar activity so that challenging but attainable goals can be set and a realistic course of action implemented to efficiently become and remain best of the best in a reasonable time”[Balm, 1996]. This definition has several implications about benchmarking, as described in Balm[1996]. The benchmarking tool is valuable for setting goals necessary to remain competitive and for learning new ideas.

Xerox Corporation expanded benchmarking to its current level. The former “little b” benchmarking is the traditional competitive analysis and industry analysis referred to earlier, coupled with performance and function comparison benchmarking. The new “Big B” benchmarking compares not only products and services, but also processes and practices. It looks at standard performance factors (speed, timeliness, etc.) and at key customer satisfaction metrics. In addition, it targets for comparison not only direct competitors or others in the same industry segment, but also any organization that does what you do and does it very well. Finally, the new Big B benchmarking helps set challenging goals to achieve competitiveness, and it offers some ideas as to how to make substantial improvements.

The first major published work on the subject of benchmarking was produced by Camp in 1989, based on his experiences as a logistics manager within Xerox. This has now been followed by a number of other works, including, for example: Spendolini (1992), Karlöf and Östblom (1993), Leibfried and McNair (1992), Bogan and English (1994), Zairi and Leonard (1994) and Cook (1995).

According to Camp (1989a), the concept was originally attached to a gigantic organization, Xerox Corporation, in the late 1970s. The company adopted the process, named competitive benchmarking, to examine its unit manufacturing costs and compare competing copiers in terms of their operating capabilities, features and mechanical parts in 1979. Xerox named these applications "product quality and feature comparisons". In fact, the formalized benchmarking practice began when Xerox compared its copiers with those of its Japanese affiliate -at first-, and other Japanese - manufactured machines, later.

Since then, the successful application of benchmarking gradually spread to other operations. Until 1981, it was running well in every part of the corporation (Camp 1989a). Xerox had benefited from reducing machine defects by more than 90 per cent, increasing its marketing productivity by one-third, improving the level of incoming parts acceptance to 99.55% and reducing its service labor costs by 30% (Mittelstaed, 1992).

Benchmarking became one of the core elements to achieve excellent quality in all products and processes involved. According to Ed Boyce, a vice president of Vienna, Virginia - based Kaiser Associates, 60 to 70 per cent of the largest US companies are undertaking some king of benchmarking program (Biesada, 1991). Its footmarks can be first found from the manufacturing sector and later the service sector including government departments. A recent study by the America Productivity and Quality Center (APQC, 1998) evaluated the experience of several organizations and found that the reported average payback for the first year was US$76 million from their most successful benchmarking project. Among the most experienced benchmarkers, the average payback scoared to US$189 million, and developing benchmarkers reported an average $1.4 million payback.

For companies such as Xerox, which was responsible for the early development of the concept and is a leader in the application of this methodology, benchmarking has provided significant improvements. However, for others the experience has been rather ephemeral and somewhat elusive. Many of the problems of failure can be related to the lack of clarity about the meaning of benchmarking and in its method of application (Zairi, 1999).

The Japanese are generally given credit for inventing the concept through their practice of sending managers to visit a wide range of companies as way to understand and learn from good business practices. Taichi Ohno, for instance, tells how Toyota adopted a new inventory system after a visit to a US supermarket in 1956. Ohno spent his time studying and learning about the supermarket's inventory replenishment system. From his observations of supermarket shelf-stocking, he subsequently developed the concept of JIT (Ohno, 1988). What the supermarket visit did was to provide Ohno with an example of an enabling process from which he derived the Kanban system.

Watson (1993) in scrutinising the historical development of concepts suggests that benchmarking is moving from an art to a science. In so doing, it has traversed distinct generations of development :

First generation: reverse engineering
Characteristics:
- Product orientated involving reverse engineering of competitive product offerings.
- Comparison of product characteristics, functionality, and performance of competitive offerings.
- Reverse-engineering initiatives involve tear-down and technical product analysis.
- Competitive analysis on market-orientated features.

Second generation: competitive benchmarking
Characteristics:
- Refined into "science" by Xerox, mainly during the period 1976-86.
- Involves comparisons of processes with those of competitors.

Third generation: process benchmarking
Characteristics:
- Mainly during the period 1982-88.
- Recognition that learning can be made from companies outside their industry (i.e. outside competitive boundary).
- Sharing of information becomes less restricted (non-competitive nature of intelligence gathering).
- But requires more in-depth knowledge and understanding to do properly (need to understand similarities in processes which on the surface appear widely different).

Fourth generation: strategic benchmarking
Characteristics:
- Involves a systematic process for evaluating alternatives, implementing strategies and improving performance by understanding and adopting successful strategies from external partners – who participate in an ongoing business alliance.
- Partnership perspectives;
- Continuous and long term;
- Use to make fundamental shifts in process (i.e. feeds re-engineering);

Fifth generation: global benchmarking
Characteristics:
- Involves applying and learning globally;
- must bridge international trade issues;
- cross cultural barriers;
- and do away with business process distinctions.

While Watson (1993) suggests the arrival of the strategic and even global era, it is suggested here that strategic benchmarking is still relatively uncommon. In fact only a handful of companies have managed to create systematic approaches to benchmarking, thus making Strategic and Global approaches, to a large extent, aspirations for the future.

Today, companies are beginning to benchmark strategic issues. When Helene-Curtis decided to revamp their global organization structure, they benchmarked organization structures at other global organizations. This next stage in benchmarking requires the participation of the designers and implementers of strategy. They have to spell out the critical success factors in their business and explain their strategy in this context (Langowitz and Rao, 1995).

Although benchmarking in business organizations is a relatively new concept and practice, it has rapidly gained acceptance worldwide as an instrument of continuous improvement in the context of total quality management (TQM). Besides the large number of organizations that make use of benchmarking, there are many organizations in the USA and Europe that promote the use of benchmarking, such as the International Benchmarking Clearing House or the The European Network for Advanced Performance System (ENAPS), which provide benchmarking databases and assistance in identifying partners.

THE CONCEPT OF BENCHMARKING - EXAMPLES

Why would a leading medical center want to study Marriott's hotels guest registration process? Avis Rental Car's steffing system? Why would an airline spend time comparing notes with - of all things - an Indianapolis 500 pit crew?

Forms of benchmarking have been employed for many years. Walter Chrysler used to tear apart a new model of Oldsmobile to determine what went into the car, how much it cost, and how it was made, an early example of 'reverse engineering'.

This information helped Chrysler understand his competitors. He benchmarked the Japanese industries' development of new products techniques before developing its Viper sports car. The company cut three billion in developmental costs and reduced development time by one year through establishing cross-functional lines of communication and involving suppliers in the project's earliest stages(Khade, Metlen, 1996).

Many companies employ this benchmarking in marketing, production, and research and development, either formally or informally. Successful firms use benchmarking to be creative, not reactive.

Benchmarking legitimizes a company's goals by linking them with external markets. It is a proactive way to effect change. It establishes standards for customer requirements and encourages employees to think competitively. It often increases employees' awareness of company costs and performance in products and services. The process encourages an organization to look outside the firm for solutions to a problem and to compare performance against other firms, thus fostering competitive self-renewal (Shetty, 1993).

Boxwell (1994) writes that benchmarking is becoming widely practiced for some primary reasons:

1. it is a more efficient way to make improvements;
2. it helps organizations make improvements faster; and
3. it has the potential to bring corporate while Lucertini et al. (1995) add the:
4. Increases profitability
5. Maintains and increases competitive advantage
6. Learn other processes

Wheelwright and Clark (1992) found that there were three critical changes driving product and process development in all manufacturing environments:

1. intense international competition;
2. fragmented demanding markets; and
3. diverse and rapidly changing technologies.

The messages that business organizations are receiving now from their customers are ``better, cheaper, and faster'' (Bogan and English, 1994; Griffin *et al.*, 1995; Stundza, 1993). This new customer trend in the marketplace will not allow an organization to waste any time in reinventing the skills that other organizations have developed and proved to be the best at the time. It is under these pressures of both foreign and domestic competitions in meeting the new market expectations from customers that benchmarking emerged as one of the favorable quality improvement techniques (Sameer, Charu, 2001).

In the 1980s, Chrysler, Caterpillar, Chemical Bank and other computer network customers of General Electric Information Services (GEIS) would not be bothered by a two-hour maintenance delay when a system went down. After the early 1990s, a ten minute delay would turn away a customer to competitors such as IBM, British Telecom or the myriad local telephone companies. Customers have no tolerance for problems. About 10 per cent of GEIS's annual revenue is spent on keeping customers satisfied (Gold, 1993).

The transformation of British Airways' into a customer- driven business after its privatization in the late 1980's probably provides the most well-documented example of benchmarking within the airline industry (Francis et al., 1999) The "putting people first" customer satisfaction program used cross functional teams to benchmark internally to promote service improvement across the different divisions of the airline (Zairi, 1998). One of the few examples of airports engaging in Best Practice Benchmarking with organizations outside the airport field was BAA plc who benchmarked car parking processes and passenger throughput control by examining the behavior of Wembley stadium and also Ascot race course. In the wider air transport context Best Practice Benchmarking activities by airlines have been reported such as Southwest (Murdoch, 1997) and Britannia (Francis et al., 1999).

Benchmarking was used to improve different aspects of business process management, for example the arrivals procedure was improved through a close examination of business processes at seven benchmark competitors (Zairi, 1998). One recent, well publicized example of benchmarking was the case of Southwest Airlines, based in Dallas, who were trying to improve their 40 minute refueling time for their aircraft. Benchmarking within the industry showed that they were already an industry leader, so the airline looked across industry and by adopting practices from the fastest refuellers in the world, Formula 1 motor racing, the airline can now refuel its aircraft in just 12 min (Murdoch, 1997).

The initiation in 1988 of the Malcolm Baldrige National Quality Award has also positively influenced the proliferation of benchmarking in the USA (Spendolini, 1992a). The Baldrige Award's influence is twofold: first, companies that receive the award are required to share information regarding quality and business process improvements with other organizations, thus creating a readily available source of benchmarking data; second, the award criteria require that organizations implement and maintain trend data and conduct competitive comparisons (Czuchry *et al.*, 1995). Benchmarking is reflected in the Malcom Baldrige National Quality Award criteria more extensively than any other management concept.

Today, benchmarking has become a widely practiced and generally accepted business practice. Benchmarking is the process of identifying, sharing, and using knowledge and best practices. Three themes course through successful benchmarking and transfer efforts in business, government, healthcare, and education. First, transfer is a people-to-people process; relationships precede meaningful sharing and transfer. Second, learning and transfer is an interactive, ongoing, and dynamic process that cannot rest on a static body of knowledge. Employees are inventing, improvising, and learning something new every day. Finally, benchmarking stems from a personal and organizational willingness to learn. A vibrant sense of curiosity and a deep respect and desire for learning may be the real keys (Yasin, 2002).

As this management tool continues to evolve, innovative adaptations and extensions of the original intent, scope, and methodology continue to appear in the literature. This is not surprising, as managers in competitive, dynamic operating environments tend to seek new ways in which to enhance operational efficiency and strategic effectiveness. As such, benchmarking strategies, activities and tactics continued to be relevant and timely concerns. This is especially true in light of the growth of e-commerce and supply chain management practices. Thus, benchmarking today not only focuses on internal operations, rather it encompasses the entire supply chain and how it should bemanaged electronically.

Benchmarking, especially when used in association with total quality management and continuous quality improvement, is thought to have its place in today's business organization. Benchmarking is a multi-faceted technique that can be utilized to identify operational and strategic gaps, and to search for best practices that would eliminate such gaps. In this context, benchmarking has an internal dimension whereby the organization critically examines itself in search of best practices. Also, benchmarking has an external dimension whereby the organization searches its industry and other domains in an attempt to identify external and competitive benchmarks and practices, which may then be implemented in its operating environment. Therefore, organizations utilizing the differing facets of benchmarking stand to gain both operationally and strategically, which has positive implications for customer service and satisfaction. This notion is based on the experiences of ICI Fibres (Clayton and Luchs, 1994), Texas Instruments (Baker, 1994), Weyerhaeuser (Karch, 1992) and many other organizations.
Benchmarking is a tool directed to implement change, more than a tool for merely evaluating company performances.

In the European Business Review (2002), the core elements of benchmarking are given as:

- regularly comparing aspects of performance (functions or processes) with best practitioners;
- identifying gaps in performance;
- seeking fresh approaches to bring about improvements in performance;
- following through with implementing improvements; and
- following up by monitoring progress and reviewing the benefits.

Although benchmarking involves making comparisons of performance, the review suggests that benchmarking is **not**:

- *Merely competitor analysis.* Benchmarking is best undertaken in a collaborative way.
- *A comparison of league tables.* The aim is to learn about the circumstances and processes that underpin superior performance.
- *A quick fix, done once for all time.* Benchmarking projects may extend over a number of months and it is vital to repeat them periodically so as not to fall behind as the background environment changes.
- *Copying or catching up.* In rapidly changing circumstances, good practices become dated very quickly. Also, the fact that others are doing things differently does not necessarily mean they are better.

Benchmarking can further be seen as a strategy for knowledge acquisition, a relationship that has been previously suggested by Garvin (1993), who cites "learning from others through benchmarking" as a building block in his vision of the learning organization.

"Predisposition for organizational learning" indicates the capabilities that can be identified and leveraged within the organization to bolster learning. It is described as organizational awareness that a portfolio of learning opportunities exists (Roth and Marucheck, 1994). Without at least some prior related knowledge, firms are not likely to benefit from benchmarking. This concurs with the finding reported by Port (1992): benchmarking will not improve performance unless a company already has a comprehensive quality programme.

Benchmarking innovation is particularly important because of the relationship between overall company innovativeness and company performance. Brainstorming meetings are the highest rated factor in soliciting new ideas. These results indicate that high-performance companies tend to take advantage of internal expertise to a higher degree than lower performance companies.

Still, benchmarking has its own disadvantages according to Rodwell J., Lam J, and Fastenau M., (2000), the changes needed to implement benchmarking require a great deal of teamwork, commitment, an objective focus on the issues concerned, and the willingness and ability on the part of the organization and individuals to change. It can also be expensive and difficult to implement. Further, the use of the wrong approach to benchmarking can be counterproductive for the organization or organizations involved and can ultimately undermine an organization's benchmarking efforts.

By observing production methods in a Chicago slaughterhouse, Henry Ford got the inspiration for assembly line manufacturing. On the other hand, the Ritz-Carlton hotel chain revamped its housekeeping process after benchmarking innovative best practices at a competitor's hotel (Hewitt et al., 1996). To gain success according to McNair and Leibfreid, "The value of the benchmarking exercise lies in its ability to ask the right questions". The corollary to this statement is that benchmarking questions must be updated as functions evolve. The primary objective of benchmarking is to increase the probability of attaining competitive advantage. Benchmarking has become a necessary tool for growth and survival in today's competitive environment.

Areas of Benchmarking	Benchmark Companies
Manufacturing Operations Quality Management	Fuji-Xerox Toyota Komatsu
Billing and Collection	American Express
Research and Product Development	American Telephone and Telegraph Hewlett - Packard
Automated Inventory Control	American Hospital Supply
Distribution	L.L. Bean Inc. Hershey Foods Mary Kay Cosmetics
Employee Suggestions	Milliken Carpat
Factory Floor Layout	Ford Motor Company Cummins and Gamble
Marketing Participate Management Employee Involvement	Proctor & Gamble
Quality Improvement	Florida Power & Light
Strategy Implementation	Texas Instruments
Computer Operations	Deere & Company

Fig. 1. Companies benchmarked by Xerox – products, processes and practices.

DEFINITIONS OF BENCHMARKING

The essence of benchmarking is the process of identifying the highest standards of excellence for products, services, or processes, and then making the improvements necessary to reach those standards, commonly called "best practices". The justification lies partly in the question: "Why re-invent the wheel if I can learn from someone who has already done it?" Jackson Grayson chairman of the Houston-based American Productivity and Quality Center, which offers training in benchmarking and consulting services, reports an incredible amount of interest in benchmarking (Ross, 1995).

Robert C. Camp headed up the now-famous study at Xerox in which the buzzword "benchmarking" was coined in late 1980. When asked whether the best work practices necessarily improve the bottom line, he replied: "the full definition of benchmarking is finding and implementing best practices in our business, practices that meet customer requirements. So the flywheel on finding the very best, is 'Does this meet customer requirements?' There is a cost of quality that exceeds customer requirements. The basic objective is satisfying the customer, so that is the limiter" (Linsenmeyer, 1991).

Defining benchmarking and its various forms can be a confusing task as both managers and academics tend to create their own definitions according to their perceptions and applications of the technique and philosophy.

In 1951, Feigenbaum, in his book Total Quality Control, defines benchmarking as the process of continuously measuring and comparing one's business processes against comparable processes in leading organizations to obtain information that will help the organization identify and implement improvements.

Allan (1993), among others, defines benchmarking as a technique that helps in measuring and comparing the performance of an existing process, product or service, against that of the recognised best in class, both outside and inside the company. Allan goes further by stating that benchmarking can be seen as one of the quality activities that can be applied to process improvement.

Similarly, Shetty (1993) explained that benchmarking is a continuous process of measuring products, services and practices against the best competitors, or those recognised as industry leaders.

O'Dell, states in The Benchmarking Workbook: Adopting Best Practices for Performance Improvement (Watson, 1992), that benchmarking is a sequential process of learning the recipe for organisational success.

The term benchmarking has been reported and defined in widely different ways.

Hardjono et al. (1997) and Venetucci (1992) defined benchmarking as a process to gather standards for improvement and insights which may lead the organization to better performance.

McNair and Leibfried (1992) described it as an external focus on internal activities in order to obtain continuous improvement.

Camp(1989a) refers to benchmarking as "the search for industry best practices that will lead to superior performance". This definition, which was adopted by the International Benchmarking Centre (Lema and Price 1995), is broad enough to accommodate all levels or types of practices to benchmark. For example, Motorola's general systems division learned from the delivery systems of Domino's Pizza and Federal Express, aiming at shortening the cycle time between order receipt and delivery of its cellular telephones (Biesada 1991).

Furthermore, the definition emphasizes superior performance. This would let staff embed in their minds to search for the best practices, which are the only ones to result in superior performance. A best practice is a method selected by an organization to excel in individual activities (Biesada, 1991). Organizations should search for the best by any possible means, otherwise they will suffer from parity but not gain in superiority. Camp refers to it as the pursuing of " dantotsu"(i.e. the best of the best). Later, Camp (1995) adds that benchmarking is a continuous process of evaluation of production process, products, and services with reference to those of the strongest competitors, known as best practice.

The definition was further developed by the Design Committee of the International Benchmarking Clearinghouse in the USA, which was adopted by more than 100 companies (Watson, 1993). This definition sets benchmarking as "a systematic and continuous measurement process; a process of continuously measuring and comparing an organization's business process against business leaders anywhere in the world to gain information which will help the organization to take action to improve its performance" (Lema & Price, 1995).

The above definition offers more details in four essential themes:

1. the value of learning from contexts outside an organization's usual frame of reference (Cox et al.,1997),
2. the importance of undertaking this learning using a structured, formal approach (Cox et al., 1997),
3. the comparisons of practices between oneself and the best-in-class on a continuous basis and
4. the usefulness of information to drive actions for performance improvement (Fong et al., 1998).

According to Fong et al., this definition neglects the possibility of comparison with internal processes. Furthermore, it does not include the concept of searching and the concept of the superior performance.

Vaziri (1992) suggested that "benchmarking is the process of continually comparing a company's performance on critical customer requirements against that of the best in the industry (direct competitors) or class (companies recognized for their superiority in performing certain functions) to determine what should be improved".

Spendolini (1992) defines benchmarking as ``a continuous, systematic process for evaluating the products, services, and work processes of organizations that are recognized as representing best practices for the purpose of organizational improvement''.

Watson (1994), defines benchmarking as "a business practice which stimulates process improvement by determining best practices across organizations through performance measurement and understanding those factors which enabled the higher performance of the leading organizations".

The characteristics to emerge from these definitions are:

- Measurement via comparison
- Continuous improvement
- Systematic procedure in carrying out benchmarking activity

Benchmarking is essentially, an improvement methodology, which functions by getting organizations to compare themselves to how other companies are carrying out business and use this as a source of stimulus to improve themselves. Benchmarking in this sense is a learning and developmental process. It works on the principle of identifying best practices, improving them, adapting them to the needs of the company and then implementing them.

Benchmarking is not exclusively about quantitative measurements , although unfortunately in the majority of practice it has tended to be so. In its true sense benchmarking is much more about general improvements above those of hard metric based comparisons. In fact some of the most useful information for organizations tends to be qualitative learning about organizational practices and procedures. While benchmarking can be used to set targets yet it is more than just a target setting device by management because it is based on what is being achieved by other organizations.

It therefore allows an objective assessment of what can be achieved, how it can be achieved and where the organization is in relation to these criteria.

The understanding of the others' practices often serves to provide inspiration and impetus to move the company forward.

In essence benchmarking is about continuously striving for improvement by learning from others better than oneself.

Definitionally, "Benchmarking is the ongoing structured and objective process of measuring and improving products/services, practices and processes against the best that can be identified world-wide in order to achieve and sustain competitive advantage" (Grinyer and Goldsmith, 1995).

Freytag and Hollensen (1999) have gone further, defining benchlearning and benchaction:

Benchlearning. The process of learning from the ''best in class'' with the purpose of integrating these best practices in all organizational levels of the company.

Benchaction. The actual implementation of the planned changes in the organization, e.g. in the form of upgrading personal skills through training and development activities.

Actually, Benchmarking is a total quality management (TQM)/reengineering/continuous improvement technique brought to the forefront in the last few years mainly due to the efforts of the Malcolm Baldrige National Quality Award in the USA (Sarkis, 2001). Benchmarking is still not well defined, since over 42 definitions were found by one source (Heib and Daneva, 1995).

CLASSIFICATION OF BENCHMARKING

Benchmarking practices can be generically classified according to the nature of the object of study of benchmarking and the partners against whom comparisons are made. In terms of object of study, benchmarking can be classified as: product, function, process, management and strategy.

Product benchmarking : used to compare products and/or services; sometimes is done through reverse engineering, primarily because of the antitrust problems related to visiting competitors' sites(Geber, 1990). If reverse engineering is not possible, or in the case of process benchmarking, consultants can be used to prepare normative benchmarking studies among competitors. Summary information is provided to the companies without identifying from which company the information came. Most consultants agree that their role in benchmarking is somewhat limited, but many provide useful training on how to select, measure and apply best practices. Consortiums of companies in the same industry are also used. This is particularly useful for expensive projects because it allows the companies to divide the cost. All of the companies participate in the study and then receive disguised summary information. The clearing houses can offer extensive databases that contain benchmarking data across industries (Enslow, 1992). Again, these methods of collecting summary data are useful because they allow a company to compare itself with direct competitors without violating antitrust laws.

Product benchmarking used to be the most widespread form of benchmarking in Japan during the previous decade. It reflected the "me too" mentality of Japanese firms In response to any product based on an original concept or any merchandise that combines an existing product with a new idea, Japanese firms can generally market similar products within a few months.

In 1980, Ford Motor Company acquired 50 midsize autos from competitors around the world and dismantled them part by part. Ford found 400 best-in-class features in those cars, and designed 80 per cent of them into the well received Taurus and Sable models introduced in 1985 (Connelly, 1995).
A summary of some typologies was exhibited in Table I.

Such a classification was established based on the nature of the referent other, the content of what was to be benchmarked (Lema and Price, 1995), and the purpose of the formation of the inter-organizational relationships associated with benchmarking (Cox et al., 1997).

Table I
Classification of benchmarking

Classification	**Type**	**Meaning**
Nature of referent other	Internal	Comparing within one organization about the performance of similar business units or processes
	Competitor	Comparing with direct competitors, catch up or even surpass their overall performance
	Industry	Comparing with company in the same industry, including noncompetitors
	Generic	Comparing with an organization which extends beyond industry boundaries
	Global	Comparing with an organization where its geographical location extends beyond country boundaries
Content of benchmarking	Process	Pertaining to discrete work processes and operating systems; used to compare operations, work practices and business processes;
	Product	used to compare products and/or services.
	Functional	Application of the process benchmarking that compares particular business functions at two or more organizations
	Performance	Concerning outcome characteristics, quantifiable in terms of price, speed, reliability, etc.
	Strategic	Involving assessment of strategic rather than operational matters: used to compare organisational structures, management practices and business strategies. In a

		sense, it posses some similarities to process benchmarking.
Purpose for the relationship	Competitive	Comparison for gaining superiority over others
	Collaborative	Comparison for developing a learning atmosphere and sharing of knowledge

With reference to the nature of the referent other, there are internal, competitor, industry, generic, and global benchmarking.

Camp (1989d) defines ***competitor benchmarking*** as a direct product competitor benchmarking regarding processes and products, whereas Lema and Price (1995) refer it as the objective comparison of specific models or functions with competitors. Nevertheless, their deviation in definition can be converged again by classifying competitor benchmarking based on the nature of the referent other. In other words, competitor benchmarking is the comparison of one company with its direct competitor who is the best performer in the practice that is chosen to be benchmarked. Such a comparison may be of general practices or services, specific product design, business processes, and administrative methods (Lema and Price, 1995). An example would be McDonald's versus Burger King. Comparing against competitors is quite difficult to achieve, as the competitors may not divulge private knowledge or other key productivity data and they can, sometimes, purposely mislead each other. Therefore, competitor benchmarking is better to be performed in **partnership**. In other words, both parties would learn about one another's practices. To improve such a comparison, a third-party benchmarking agent can be hired to organize the benchmarking process (Enslow, 1992). More competitors are sometimes invited to join the benchmarking team to enhance brainstorming and collect more useful data. The sharing of information may be facilitated by frequent team discussions. Despite the above difficulties and drawbacks, large organizations do exchange information in select areas of joint venture. Competitive benchmarking, if successful, can lead to step changes and productive results.

Internal benchmarking is a measure of a single business unit or process compared with other similar units or processes inside the organization (Camp, 1989d). This approach eliminates the need to overcome barriers between strangers, especially when it may appear that competitive advantage will not be compromised. Internal benchmarking data provide in-depth information of the company that can be used for external comparisons later (Cecil and Ferraro, 1992). Further advantages of internal benchmarking are: the information is readily available, attention can be focused on specific areas for improvement, constructive competition is possible, and performance measures can be linked to internal appraisal and reward systems.

Internal benchmarking also has several disadvantages: it ignores competition, encourages a narrow or internal perspective, may emphasize company trends, and may create a tendency to postpone major change(Fitzpatrick and Huczynski, 1990).

However, benchmarking parties sometimes neglect the possibility of benchmarking other practices within one's own organization. In fact, internal benchmarking would be more convenient, receive a higher level of cooperation, and be less expensive than searching for a partner from the outside world, provided that such internal practices are actually the best ones.

External benchmarking relates to performance comparison with partners from differing business units of the same organization, or with different companies, (Zairi, Youssef, 1996). The authors note that the emphasis on external focus intrinsic to this approach offers greater potential for identifying superior performance and for rectifying cultural opposition to the adoption of ideas from outside the organization. It is recognized at this stage that attempts to benchmark with direct competitors is likely to prove difficult owing to the issues associated with sharing sensitive information.

Best practice benchmarking involves identifying and comparing performance against the owners of processes regarded as “best-in-class”. The authors indicate that an initial problem will be to determine a definition of “best”. It is suggested that only through correct and thorough planning and data collection can this be achieved.

An example of best practice benchmarking is the Westinghouse Electric Corporation’s Naval Systems Division (NSD) in Cleveland which began in the mid-1980s and became a world class operation. These activities, according to Stevens (1993), include ``. . . learning about kit carts for better material handling from Texas Instruments, training from Ford, a new approach to subcontracting from Boeing, empowered work teams from Rockwell, and involving union personnel in process improvement from General Motors.'' NSD was considered the most improved division of Westinghouse. Another well known example relates to 3M Corporation. When this company decided to commercialize medical laser imagers, it benchmarked Analogic Corporation, a hightechnology engineering company with expertise in medical products, in Peabody, Massachusetts. Lessons learned from Analogic Corporation’s expertise in manufacturing and designing imagers enabled 3M to shorten research time by 40 to 50 per cent (David, 1993).

Industry benchmarking is similar to *competitor benchmarking*, so is the *generic* or *global benchmarking* (Cox et al., 1997). It many times detects market trends and creates a sense of urgency that provides a legitimate basis for instituting essential change (Fitzpatrick and Huczynski, 1990).

It can also ensure that a company’s goals are proactive and industry-leading instead of just being an improvement on last year’s performance (Camp, 1989). Industry benchmarking redefines broader possibilities for the company. Instead of just small improvements, managers can more clearly see what is possible and strive for higher goals (Fitzpatrick and Huczynski, 1990).

Similarly, best-in-class benchmarking is important because it allows companies to identify desirable objectives. Camp stresses that great improvements are possible only when comparisons are made with the industry leaders and the best practices are well understood.

Industry benchmarking is different from competitor benchmarking because the former involves more benchmarking or comparison parties, which include non-competitors.

Generic benchmarking focuses on excellent work processes across industry boundaries. It is the most complex form of benchmarking in that often it cuts across narrow functional boundaries, leading to comparisons of business processes across a wide variety of industries.

This form offers the potential for making radical improvements and truly searches for best practices. The problem of this type of benchmarking is the level of complexity involved. Companies undertaking this form would need to have a deep experience of benchmarking coupled with an understanding of their own vision and competence, and a sensitivity to be able to recognize broad processes from different sectors that maybe of relevance and potential. Additionally the integration of radical and novel concepts into the company is likely to present a great adaptation and implementation challenge (Pervaiz, Zairi, 1999).

APQC gives some reasons about why and when an organization should benchmark outside the industry:

1. To avoid reinventing the wheel (or existing solutions). No one has the luxury of time or money anymore to reinvent what others have already discovered and tested.
2. To achieve breakthrough improvement and accelerate change.
3. To drive and direct reengineering by looking outside to see how others have approached the same objective.
4. To set stretch goals. Without some external stimulus and example, the goals for improvement are likely to be "the same as last year... plus 5 percent", which will not cut in this world.
5. To overcome the "Not Invented Here". Benchmarking takes thinking outside normal channels (also known as ruts), to look at brand new approaches that would never have occurred to them had they not stepped out of their well - worn thinking.

In the past, one could identify easily who competitors were and monitor them. Today, industry lines are growing fuzzy. Competitors come from other industries, from other technologies and certainly from other nations. For example the Swiss watchmakers were overwhelmed by competitors that were not even in the same business.

Global benchmarking involves the comparison with an organization from a global perspective (Watson, 1993) where its geographical location extends beyond country boundaries. An individual third-party convener is sometimes used when many comparison parties join together in learning one another's work practices.

Process benchmarking, on the other hand, pertains to discrete work processes and operating systems (Bogan and English, 1994) while *performance benchmarking* is concerned about outcome characteristics, such as elements of price, speed, and reliability (Cox et al., 1997). Process benchmarking is also called *operational benchmarking* by Watson who sets examples such as studies of specific manufacturing practices (printed circuit board loading, computer-aided machining, or bar-code applications) or business support processes (contract approval process, accounts receivable process, or recruiting process for new employees). Toyota's Just-in-Time(JIT) system and Seven Eleven Japan's POS (Point Of Sale) system have offered models for many companies.

Functional benchmarking applies the process benchmarking on the comparison of particular business functions among two or more non competitor organizations (Camp, 1989d). This type of benchmarking has several advantages:

- information is accessible because the competitive angle is absent, and often leads to the development of partnerships;
- learning on function by function basis facilitates adaptation and ease of implementation;
- functional leaders are easy to identify.

The drawback or limitation of the approach is often the learning that can take place is narrow, and a large proportion of holistic aspects, which cut across functional areas is likely to be missed (Pervaiz, Zairi, 1999).

Some authors have suggested the use of strategic benchmarking which involves the assessment of organizational strategies, such as the longterm development of organizational infrastructure, rather than key operational practices (Bogan and English, 1994).

Watson (1993) defines strategic benchmarking as "the continuous search for and application of significantly better practices that lead to superior competitive performance".

Strategic benchmarking studies influence broad-based change and have the ability to shift the entire focus of an organization – restructure it, realign its goals, re-engineer its core business processes, redesign its product line, or renew its competitive commitment. Such studies can fundamentally change the business. Representative examples are NEC's business redefinition based on its C&C (Computer & Communication) scheme and General Electric's business strategy which focuses resource on becoming the No1 or 2 in the world. The main disadvantage, as stated by Fernandez et al. (2001) is that strategy cannot - or at least is very difficult - be imitated.

Cox et al. (1997) introduced a bipolar concept of benchmarking (i.e. one pole is competitive benchmarking while the other pole is collaborative benchmarking), and perceive it as a mixed metaphor. They developed a model to identify some key factors that determine the competitive and/or collaborative natures of benchmarking programmes. These factors include context, activities, partnership, and outcomes. *Competitive benchmarking* here refers to the comparison undertaken in a unilateral, voluntary activity for the purpose of gaining superior performance (Fitzpatrick and Huczynski, 1990; Mann et al., 1998). It is an imitation by one party of the other even if there is a partnership formed by both parties.

Collaborative benchmarking, on the other hand, emphasizes the sharing of knowledge and conveys a learning atmosphere (Cox et al., 1997). In practice, collaborative partners like to arrange site visiting.

Benchmarking is likely to be either extremely competitive or extremely collaborative when benchmarking partners are highly interdependent. Benchmarking is likely to be competitive when it is initiated by an individual "benchmarker"; it is likely to be collaborative when it is initiated by a respected third-party agent. A simple criterion is that when an organization is trying to gain superiority over others, it should choose competitive benchmarking. In contrast, it should use collaborative benchmarking if it looks for sharing of knowledge and developing a learning atmosphere.

Finally, it is worth noting ***"Futures benchmarking"*** (von Stackelberg, 1993), a process benchmarking approach that may have applicability in aiding the analysis of breakthrough advancements. It is a technique that looks at technologies associated with business processes and uses forecasting techniques to determine what breakthroughs exist among these technologies, which could eventually serve as benchmarks. The futures benchmarking technique is primarily focused on technology benchmarking, but analysis and forecasting of advanced processes may be added to this technique. These upstream measures and forecasting techniques will prove useful for agility measurements.

HARD AND SOFT MEASUREMENT IN BENCHMARKING

As a framework, benchmarking involves focusing on quantitative and qualitative measures of performance throughout various levels of the firm. While measurement is hardly new in the area of benchmarking it is nevertheless fraught with problems.

Measurements can be either *quantitative (hard)* or *qualitative (soft).* "Quantitative benchmarking" has exactly measurable indicators and aims at effective measurements of the process in different implementation environments. "Qualitative benchmarking" examines the way in which work is performed. McNair and Leibfried (1992) suggest that hard measures make the user feel as if they are dealing with fact. However, quantitative precision is often unable to capture vital insights provided by qualitative indices. In addition to traditional financial measures such as those encapsulated by the Dont Return on Investment model McNair and Liebfried suggest the following quantitative benchmarks:

Productivity measures

- Total product output divided by total headcount.
- Cost per good unit produced.
- Total output of product divided by total resource inputs.
- Product complexity
- Orders processed/shipped per employee hour.
- Overtime and absenteeism
- Capacity utilization
- Level of automation
- Value added per employee.
- Inventory turnover ratios.
- Non-value-added costs/total costs.
- Value-added/total costs.

Quality measures

- Yield rates.
- Scrap rates.
- Percent of products reworked.
- Percent of total labor performing rework.
- Incoming vendor defects in parts per million (ppm).
- Outgoing product defects in ppm.
- Number of customer complaints.
- Warranty claims.
- Returns and allowances percentages.
- Good units produced/planned output.
- Parts availability/on-time deliveries.
- Forecast accuracy.
- Number of engineering change notices.

Delivery/timeliness measures

- On-time delivery percentage.
- Lead time to engineer (design) a finished product.
- Start-up time from design to production.
- Component lead times – purchased and manufactured.
- Transportation lead time.
- Number/percentage of late deliveries.
- Number of back orders.
- Number of late orders.
- Manufacturing lead time (queue, move, cycle).
- Set-up number and time.
- Inspection number and time.
- Value-added/total time.
- Waste time.
- Average level of order fulfillment.
- Order processing cycle time.
- Average engineering change notice execution time.
- Preorder cycle time.

Source: McNair and Liebfried, (1992)

Delbridge et al. (1995) summarize measures in three areas: productivity, quality and time

<u>*SUMMARY OF MEASURES*</u>

Plant performance

Productivity Annual units of output divided by annual labour hours, adjusted for vertical integration, product complexity, overtime and absenteeism

Quality Failure rate at first final inspection and test

Time Throughput time

Plant characteristics A series of features likely to impact on performance was measured, including annual volumes, value of sales and headcount

Product characteristics Measures were taken of product variety (number of live part numbers), product age and product complexity, the last of these being assessed via a "part count"

Contextual measures Age and automation of equipment, capacity utilization, absenteeism

Internal management practices

Factory practice Hours of inventory of specified parts; relative amount of rework and repair versus first time production

Work systems Relative distribution of responsibility for 12 tasks within the factory; activity rates of problem-solving structures

Human resource management Amount of training effort; remuneration policy; presence or absence of "high commitment" employment practices

Customer and supplier relations

Geographical closeness Travelling time between sites

Operational closeness Inventory levels of incoming parts and finished goods; delivery frequency; defect rates of incoming parts

Communication Frequency of information exchange; existence of structures to permit information sharing between the parties

The typical quantitative measures, if used to benchmark, provide insights but these remain primarily market based. Interpretations resulting by benchmarking against such hard metrics yields only superficial insights as to how well the companies are doing. Such metrics say little in the way of how they have got there, how they could improve the product, what new product opportunities exist and what is the most appropriate process of building new positions (Pervaiz, Zairi, 1999).

What's more, the danger with quantitative measures is that they are often the parameters that are accorded the greatest level of attention. This focus serves to distract attention away from qualitative indices which are often more difficult to collate.

In order to understand such issues, organizations need to involve themselves in qualitative terms of assessment. McNair and Leibfried (1992), suggest that despite being more difficult to codify it is possible to create proxy measures for qualitative issues. These qualitative proxy benchmarks are reproduced below:

(1) The complexity of the product:

• Number of material moves.
• Number of total parts.
• Average number of options.
• Number of products produced per line, machine, or plant.

(2) Existing capacity:
• Number and location of bottlenecks.
• Part/component bottlenecks.
• Number of process changes.
• Preventive maintenance and repair levels.
• Statistical quality control capabilities.
• Material velocity.
• Average lot size.
• Number of material-handling control points.
• Demand fluctuation.
• Number of quality control/inspection points.

(3) Customer satisfaction:
• Intention to repurchase.
• Satisfaction index (summary of product characteristics).
• Actual performance against expectations.
• Recommendation to others to buy.
• Perceived quality.
• Perceived functionality.
• Ease of use.

(4) Marketing/distribution channel:
• Number and location of warehouses.
• Number of stockouts.
• Total lead-time.
• Market areas covered/penetration.
• Channels used versus available.
• Support provided/responsiveness.
• Scope of coverage.
• Flexibility.
• Number of new products.
• Product success rates.

(5) Paperwork:
• Number of days to process an order.
• Number of steps/hurdles faced by customer.
• Average number of contacts per order filled.
• Number of errors/rework.
• Number of exceptions generated.
• Days to close general ledger/accounts.
• Days lag in producting/distributing reports.

Mohamed Zairi (1995) introduces the McKinsey model for benchmarking Innovation, which can be seen from a more general point of view. The premiss behind

the McKinsey model is that for organizations to function effectively they have to rely on the interdependence of seven variables:
(1) *Strategy.* The plan leading to the allocation resources.
(2) *Shared values.* The goals shared by all employees.
(3) *Style.* The management style of the organization
(4) *Structure.* The organizational map/chart.
(5) *Skills.* The strengths and capabilities of all employees
(6) *Staff.* The people employed.
(7) *Systems.* Procedures, guidelines and control mechanisms.

The seven variables are classified as:
• *Hardware variables*; strategy, structure.
• *Software variables*: style, systems, staff, skills and shared values.
The major contribution of the framework is perhaps the attention it draws to the less tangible and visible aspects of organizational systems. As explained by Peters and Waterman in their book *In Search of Excellence*: "In retrospect what our framework has really done is to remind the world of professional managers that "soft" is hard. It has enabled us to say, in effect, "all that stuff you have been dismissing for so long as intractable, irrational, intuitive, informal organization can be managed. Clearly, it has as much or more to do with the way things work "(or don't) around your companies as the formal structures and strategies do".

This was further explained by Waterman *et al.*: "Our ascertion is that productive organization change is not simply a matter of structure, although structure is important. It is not so simple as the interaction between strategy and structure, although strategy is critical too. Our claim is that effective organizational change is really the relationship between structure, strategy, systems, style, skills, staff, and something we call superordinate goals".
The model, which is also referred to as "happy atom", reflects the following haracteristics:
- *Multiplicity of factors*: all influence how organizations behave.
- *Interconnectedness of variables*: progress can only be achieved by giving attention to all areas.
- *All seven variables act as a driving force*: at particular points in time, one or more of the 7Ss will emerge as the most critical variable(s).

Furthermore, since benchmarking refers to best practices, it is worth defining them, although, there can be no universally agreed operational definition of best practice; every organisation will operationalise best practice to suit its own circumstances and preconceptions. Defining best practice simply as a list of components is unsatisfying, but the elements can be classified in various ways: e.g. as primarily internal and external (relations with customers and suppliers); as direct and indirect (training) or as pertaining to people or processes. Seen et al. (2001) opine that best practice is best treated as a mechanism for expressing and implementing a strategy. Motivated by the strategic context, we identify three aspects of best practice:
(1) *Operational Best Practice*: optimises production of goods and services.
(2) *Internal Best Practice*: optimises structure, staffing, systems and culture so that strategy is optimally expressed. If, for example, rapid fulfilment is emphasised, customers will be able to order goods and services through web pages, these orders

will be made available to factory schedulers instantly, and there will be sophisticated scheduling and order tracking systems and flexible production systems.
(3) *External Best Practice*: optimises relations with and from external parties, especially customers and suppliers but also with legislators, regulators, communities and labour; obtains required resources (e.g. raw materials and labour) on the best possible terms and conditions; and sells finished goods on the best possible terms and conditions.

BENCHMARKING: UNILATERAL OR SHARING?

The original concept of benchmarking is to induce a sharing of best practices among the involved organizations. Booth (1995) suggests that benchmarking involves a methodology for developing a framework, including an understanding of current position and targeted direction and a selection of the right criteria and partners with whom to benchmark.

Choosing an appropriate partner for benchmarking is important because improved competitiveness will be attained most probably through collaboration (Cox et al., 1997). According to Watson (1994), deciding what organizations to solicit as partners is one of the two most difficult things about benchmarking (the other one being the decision on what project to focus the benchmarking resources on). Therefore, research is necessary to make sure that the company being benchmarked is really the best; in many cases, benchmarking an average company is beside the point (Enslow, 1992). For example, Thompson advises companies that performance across large populations follows a statistical pattern and at least 2 per cent of the population will be three or more times better than average; he believes that these are the companies that should be benchmarked. Richard Buetow of Motorola says that error rates at best-in-class companies are 500 to 1,000 times below average. Depending on company aspirations, resources and the industry's competitive structure, benchmarking against the best is essential.

In the criteria for the Malcolm Baldrige National Quality Award there is an examination item which asks the applicant to describe the criteria for selecting benchmarking partners. This is an interesting point; it assumes that organizations recognize that they should be seeking to learn from "analogous" organizations and that the organization initiating the study understands the criteria that form the basis of the analogy. The criteria used to form the analogy may include such factors as organization size and type (centralized or decentralized), industry, decision-making culture, use of teams, sophistication of quality system, reputation or recognition for business excellence, and degree of admiration by the management team of the benchmarking team.

One of the best known examples of "analogous" organization is the analogy that Bob Camp drew between Xerox and L.L. Bean for his study of warehouse operations. On first examination there does not appear to be a great degree of similarity between outdoor clothing and copiers. Similarity arises when the process characteristics are considered – the need for rapid turnaround and high reliability of accuracy in the shipment integrity as well as the empowered culture of the organizations at the team level – ; then it becomes clear that one work process may be potentially transferable to the other organization. It is not necessary to identify all processes to be studied from a single organization. Bob Camp also studied Sears and The Limited in his logistics study. The final lessons learned used “creative imitation” * to blend together the lessons and adapt them to the Xerox business model and quality culture using the known differences between the organizations as the basis for adaptation.

Sometimes, the best practice may be possessed by one’s direct competitor. Apparently, the direct competitor will reject the sharing of its competitive practice. As such, an organization can only find other sources to attain the benchmarking purpose. For example, one can request a third-party agent that has no conflict of interest with the target organization to learn its practice. It then benchmarks what the third-party learned. In this case, the organization is involved in a unilateral benchmarking process.

Aly (1995) emphasized that a benchmarking approach is better if it is bilateral. He suggested that organizations could undergo benchmarking with their joint venture partners, to join a project sponsored by joint venture partners or their associates, or to find corporation sponsorship of a benchmarking project. Credibility can be gained by being part of a team. The more the parties that join the team, the bigger the vast network of partners that can be developed with a regional or even an international outlook.

In any way, a basic convention of benchmarking is the principle of exchange, as it is described in the Benchmarking Code of Conduct. Fundamentally, it means that when an organization benchmarks another organization, they should be prepared to share their own business processes or work processes in exchange for the information that they receive. It is this *quid pro quo* (Latin meaning “this for that”) of benchmarking studies that makes the exchange of information equally valuable to all parties.

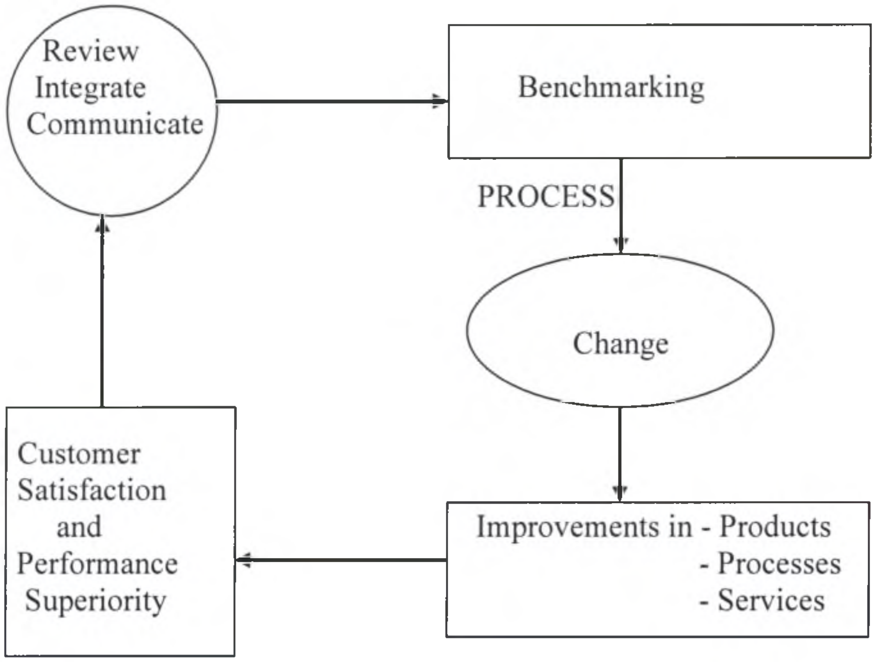
* "creative imitation": Creative imitation means that the final solution is suggested by the results of the entire study – supplemented by the research team’s own contributed insights – with the initiative for change being the input to a re-engineering effort that may be a “clean sheet” redesign using various elements from a full spectrum of inputs. Contributions to such an improvement effort are eclectic and do not represent a direct transfer from any one organization (Watson 1994).

BENCHMARKING: WORTH IT OR NOT?

As mentioned previously, the fundamental objective of benchmarking is to gain and sustain performance superiority. This would involve change and improvement in products, processes, and services. Figure 2, which is adapted from Booth’s (1995) benchmarking objective diagram, illustrates that the process of benchmarking induces changes occurring in the benchmarked practices, leading to anticipated improvements which match customers’ needs and help an organization gain in superior performance. Such improvements can be in the form of simplified processes, shorter cycle times and reduced costs (Whiting, 1991). So, benchmarking provides a stimulus for making breakthrough change initiatives a reality by enhancing the creativity and innovation of teams who are working on process improvement (Watson 1994).

In order to measure and sustain such improvements, the organization should create an appropriate quality system. It should also review and integrate the quality system into the company-wide system as well as develop effective communication channels for the benchmarking project. This forms the platform for the next benchmarking process in the upward spiral of continuous improvement and performance excellency.

Figure 2
Fundamental objective of benchmarking



Source: Booth (1995)

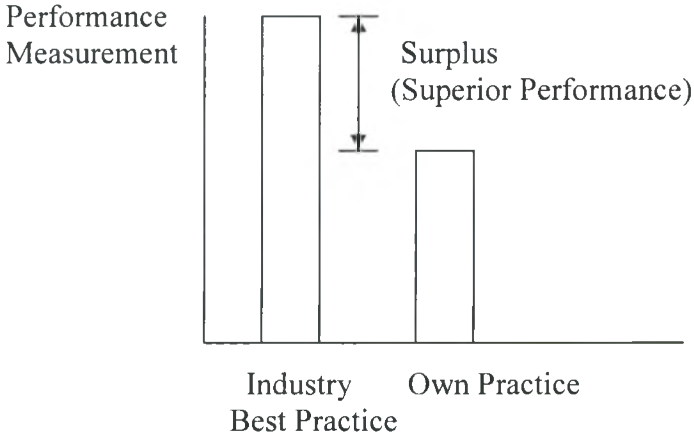
Moreover, benchmarking involves a goalsetting process. To achieve these goals, benchmarking encourages the organization to empower employees and to effectively assign and integrate the responsibilities, work processes, and reward system (Camp, 1989c). Employees generally gain a sense of professional growth from benchmarking with the realization that they are taking on the best in their field (Weimer, 1992).

What benefits will organizations get through benchmarking? Benchmarking provides a means to sustain a continuous superior performance, by providing an independent assessment of how well a process is operating through evaluation of similar processes across different organizations (Watson 1994). It is a continuous process, which can be better done by short steps than great leaps forward (Ohinata, 1994).

Figure 3 illustrates such a concept of superior performance. The graph reveals that the reach of the surplus of performance involves the filling of the benchmarking gap by learning the best practices. In essence, such a process needs to be run for a certain period of time, possibly several years continuous improvement, until the surplus could be achieved (Camp, 1989d).

Figure 2

An illustration of superior performance



Benchmarking facilitates cross-organizational learning. It is an efficient vehicle for transferring "learning" across organizational boundaries. It is really a learning process for taking lessons from one organization and translating them into the unique culture and mission orientation of a different organization. Benchmarking can support a variety of operational practices. It can be used to develop or clarify options in problem solving, create ideas for design of new processes or products, identify the product and process advantage competitors, or it can provide a baseline input to assure a realistic strategic planning process (Watson 1994).

Benchmarking is a formal method. The more systematic the method, the more the benefits that the eventual outcomes will secure (Mittelstaedt, 1992). Some authors (e.g. Camp, 1989c; Mittelstaedt, 1992) have suggested that the systematic method would lead to outstanding performance while other informal methods would not. The potential benefits of benchmarking are listed in Table II.

Table II
Benefits of benchmarking

Defining customer requirements	Market reality; objective evaluation; high conformance
Establishing effective goals and objectives	Credible, unarguable proactive; industry leader
Developing true measures of productivity	Solving real problems; understanding outputs; based on industry best practices;
Being competitive	Concrete understanding of competition; new ideas of proven practices and technology; high commitment
Industry best practices	Proactive search for change, new technology; many options; business practice breakthrough; superior performance

Source: Camp (1989c) and Mittelstaedt (1992)

Spendolini (1992) adds the "seeing out of the box" - benefit , since benchmarking helps to change internal paradigms and according to Sedgwick (1995), it provides significant leaps in performance not always attained by other management techniques.

Reviewing the literature, it is possible to find many examples of applications of benchmarking, ranging from manufacturing to non-manufacturing organizations including education (Moreland et al., 2000), public sector administration (Kouzmin et al., 1999), health care (Bullivant, 1996) and many others. In the manufacturing industry, benchmarking focuses on subjects such as product innovation (Dacko, 2000), logistics (Bagchi, 1997), maintenance (Muthu et al., 2000), human resource management (Rodwell et al., 2000) and quality assurance among others.

In a survey conducted by Voss et al. (1997) involving a sample of over 600 European manufacturing companies, it is shown that increased levels of benchmarking use were associated with higher levels of both adoption of best practices and operational performance. Based on the study, the authors proposed a relationship model between learning, benchmarking, understanding and performance, in which benchmarking, as part of a learning process of an organization, at the same time promotes a company's understanding of its strengths and weaknesses and higher levels of performance.

Elmuti and Kathawala (1997) give some more benefits and reasons for benchmarking:

Increasing productivity and individual design: By simply looking outside itself, a company can identify breakthroughs in thinking. A similar process used in a different way can shed light on new opportunities to use the original process (Muschter, 1997).

Strategic tool :Leapfrogging competition is another reason to use benchmarking as a strategic tool. A company's competitors may be stuck in the same rut as the company deciding to benchmark. It would be possible to get a jump on competitors by using new-found strategies.

Enhance learning : Another reason to benchmark is overcoming disbelief and enhancing learning. (Brookhart, 1997).

Growth potential : Benchmarking may cause a necessary change in the culture of an organization. The company would be better off looking outside its walls for potential areas of growth. An outward looking company tends also to be a future oriented company. This often leads to a more enhanced organization and increased profits (http://www.utsi.com/wbp/ reengineering/benchmark.html, 2/19/97).

Assessment of performance tool : Benchmarking is defined as "the process of identifying and learning from best practices anywhere in the world" (Allan, 1997). By identifying the "best" practices, organizations know where they stand in relation to other companies. The other companies can be used as evidence of problem areas, and provide possible solutions for each area. When companies benchmark, they use partners to share information with and learn from each other. Benchmarking allows organizations to understand their own administrative operations better, and marks target areas for improvement. It is an ideal way to learn from other companies who are more successful in certain areas. Additionally, benchmarking can eliminate waste and help to improve a company's market share (Allan, 1997; http://www.spinet.org/legeth.html, 2/19/97).

Continuous improvement tool : Benchmarking is increasing in popularity as a tool for continuous improvement. Organizations that faithfully use benchmarking strategies achieve a cost savings of 30 to 40 per cent or more. Benchmarking establishes methods of measuring each area in terms of units of output as well as cost. In addition, benchmarking can support the process of budgeting, strategic planning, and capital planning (Lyonnais, 1997).

In the early 1980s, Ford Motor Company needed to change many aspects of its operations to cut costs due to the suffering automotive market. Management believed it could improve processes in the accounts payable department. After gathering data on Mazda's accounts payable operations, Ford analyzed and compared its own accounts payable operations. As a result, Ford reduced costs by 5 per cent (http://138.87.10.1/web/nacubo/ch2e.html, 2/19/97).

Vehicle to improve performance : Benchmarking also allows companies to learn new and innovative approaches to issues facing management which, in turn, provides the basis for training. Benchmarking acts as vehicle to improve performance by assisting in setting achievable goals that have already been proven successful. It overcomes disbelief that there are, by example, other ways of achieving and creating overall enhancement of an organization (Fuller, 1997).

The practice of benchmarking has also been characterized by Longbottom (2000) in a survey involving over 200 British organizations. In his study he reported, among other things, that very little evidence was found to show that organizations are identifying and prioritising projects based on their corporate and strategic planning process. According to his study, selection of projects is largely ad hoc, mostly arising from project/benchmarking champions, based on the need to update equipment or technology, or reacting to rising costs/falling profits.

Benchmarking is now one of the most popular tools for faster organizational learning and change, the success of business process redesign and new product development.

In the USA the International Benchmarking Clearing House of the American Productivity and Quality Center help in identifying partners and commission studies. Business associations such as the Society of Competitive Intelligence Professionals (SCIP), the Strrategic Planning Society and the Stategic Leadership Forum offer educational programmes and networking opportunities. Numerus databases are available, notably the PIMS (Profit Impact of Marketing Studies) database for strategic studies.

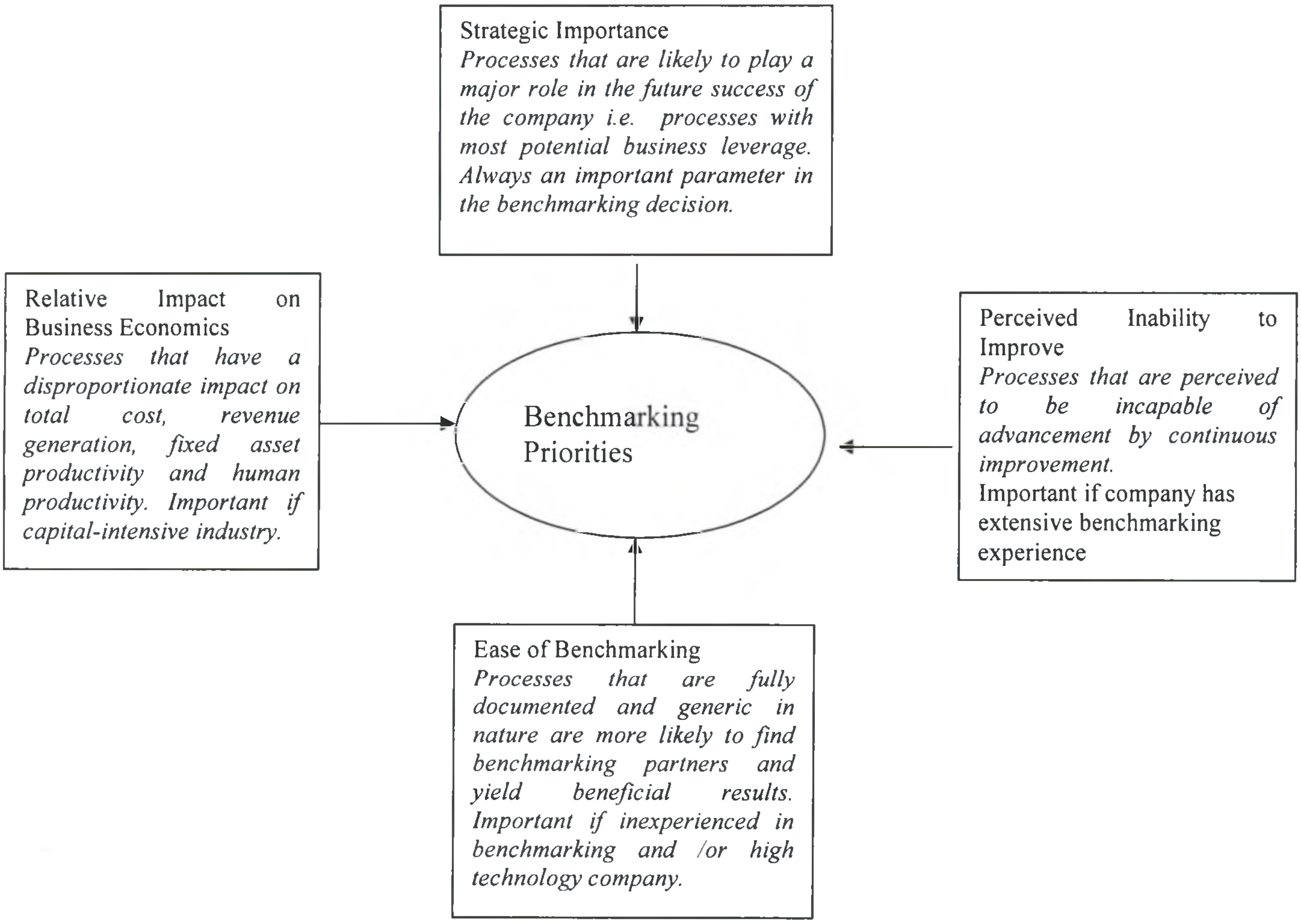


Fig. 4 Benchmarking Priorities Decision

PREPARATION FOR BENCHMARKING

In order for a benchmarking project to be successful there are plenty of factors that have to be satisfied. Ohinata (1994) names as key factors the following:

- Formal approach
- Top management involvement
- No competition in the areas of information shared
- Information exchange (by both sides)

To better prepare for benchmarking projects, one may adopt the process suggested by Mitchell (1995) which is a structural approach to problem solving and general management (Cheng et al., 1998).

The process consists of four phases, which contain the essential features of the Deming cycle, namely focus, plan, do, and review. This cascade is used to assist in convincing the organization of the importance of commitment to change by developing and reinforcing a common norm of all line managers.

The process is related to the preparation of benchmarking because it focuses on the importance of satisfying customer needs and requirements. Team effort and company visits for benchmarking incur a very high cost that, without a complete understanding of customers, can be a risk to the whole organization.

After knowing the customers, top management should provide dedicated support to benchmarking, including instructing middle and lower levels of management to use this technique and providing adequate training to induce a planned transfer of knowledge. Sometimes, a benchmarking consultant will be employed since the consultant might help effectively with a much faster pace at a similar cost (Mitchell, 1995).

Building the benchmarking team is one of the preparatory steps. It will typically consist of a project leader and two to five people in charge of collecting and analyzing the data. It will also include staff from the legal or other specialized areas. Each member of the team should possess sufficient technical knowledge and a certain level of skills and abilities.

BENCHMARKING PROCESS MODEL

Choosing the right benchmarking methodology is an essential key in making benchmarking a success.

Benchmarking is related to target setting and treated as a component of the formal planning process (Camp, 1989b). Some authors have modeled the benchmarking process on the basis of the Deming cycle (e.g. Watson, 1993). The Deming cycle is a continuous looping model which is composed of four functional elements: plan, do, check, and act.

Various models may have a different number of phases from four steps to even more than 30 (Fitzenz, 1993).

Some representative examples are:

- ⇒ Camp (1989b) suggested a ten-step generic process for benchmarking;
- ⇒ McNair and Liebfried (1992)

⇒ Kaiser's seven-step benchmarking process is created for the public sector (Bruder and Gray, 1994);

⇒ Drew (1997) gives a five - step process: object identification, selection of the superior performer (benchmarking partner), collection and analysis of data, setting performance goals for improvement and implementation of plans and monitoring of the results.

⇒ Allio and Allio (1994) proposed a six-step process for the field of water and wastewater utilities;

⇒ the Aluminum Co. of America adopted another sixstep to benchmark giant organizations, such as Hewlett-Packard, TriNova, Xerox, and Motorola (Biesada, 1991);

⇒ Fitz-enz (1993) has worked out a four-phase model for adding value to human resource practices.

⇒ Among other companies, AT&T involves 12 steps, IBM 16, Weyehaeuser 33.

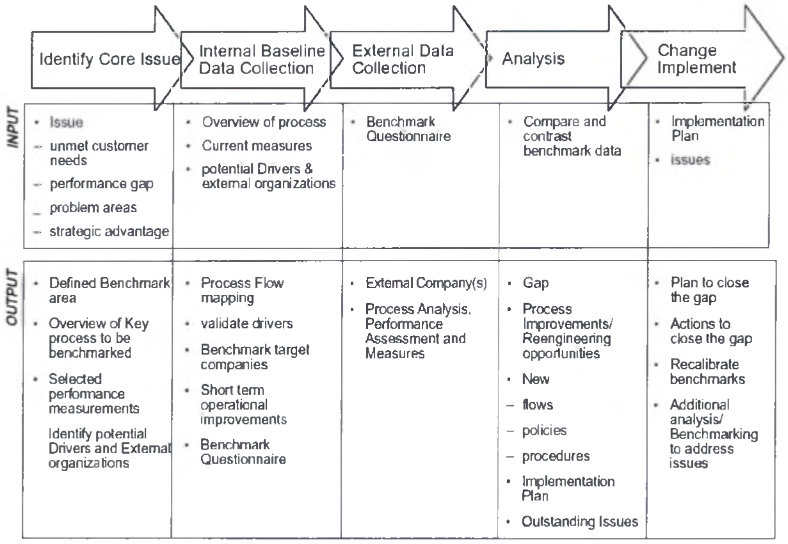


Fig. 5 A generic framework for benchmarking

Six different models are presented in table III, in the end of the section, adapted by P. Fernandez et al. (2001), which verify that all models follow the same generic stages.

There is nothing magical about the number of steps; the fundamentals are almost identical (O' Dell and Grayson, 1997). After analyzing most of these approaches, Zairi (1996) concluded that

". . . most, if not all, of the methodological approaches are preaching the same basic rules of benchmarking, but using different languages" and ". . . most methodological approaches are based on the Rank Xerox approach, which is considered to be an effective and generic way of conducting benchmarking projects". After conducting a benchmarking study of 14 documented methodologies to benchmarking at the European Center for TQM, Zairi (1996) noted that The

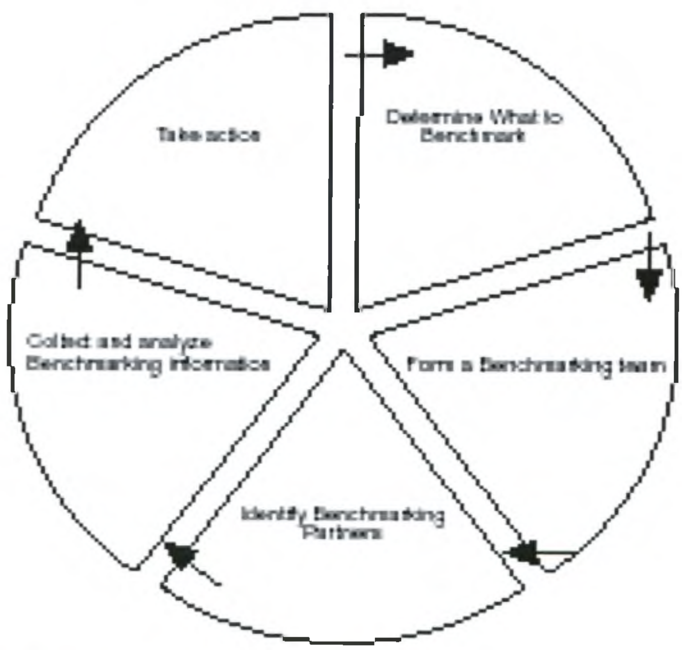
International Benchmarking Clearinghouse (IBC) benchmarking methodology came in at number one as it demonstrated better clarity, clearer focus, more logical progression, and completeness.

In essence, it involves a judgement process (Shetty, 1993) of which functions or firms are to be benchmarked, and the continuous search for best practice information for setting new performance goals in achieving performance superiority (Lema and Price, 1995).

A year before, (1995), Zairi with Youssef presented the following comprehensive methodology for benchmarking:

1) What to benchmark
2) Choose type (internal, competitive, functional, generic)
3) Choose partners and understand them
4) Criteria for information gathering
5) Questionnaires
6) Gap achieved through comparison of data (qualitative, quantitative)
7) Project future trends tool "Z" charts
8) Communicate the results to all levels
9) Set goals.

Among all these models, many corporations, including Xerox, Du Pont, and National Cash Register adopted the one that was described by Camp (1989b).



Source: Adapted from Camp (1989)

With the above benchmarking wheel in mind the basic content of the benchmarking process is described as under.

Step 1: plan the study.

Step 2: form the benchmarking team.

Step 3: identifying partners.

Step 4: collect and analyze information.
Step 5: adapt and improve. Some improvements will be immediate or short-term, requiring few or no additional resources. Others will be long-term and will require considerable resources.

A method of evaluating improvements over time is critical to effective adaptation of best practices. The measures developed in the planning phase can now be used to track performance improvements on an ongoing basis. Measurable improvement usually takes at least three months after the completion of the study. The time taken on the benchmarking process depends what is being benchmarked and how smoothly the process progresses. There is usually a degree of overlap in the processes of the benchmarking exercise and feed-back loops are ever present to enable evaluation.

However, this model did not comprise a path concerning customer satisfaction. Thus, Vaziri's (1992) model is highly recommended as it includes a needs assessment team which produces inputs to culminate in feeding information to the original benchmarking team.

A modified model is shown in Figure 7, which is largely adapted from the model of Vaziri (1992) and Camp (1989d). This model has several implications.

First, it indicates that benchmarking is a systematic approach to performance improvement in order to satisfy customers' needs and requirements. Such a systematic approach involves stages of planning, analysis, integration, action, and maturity.

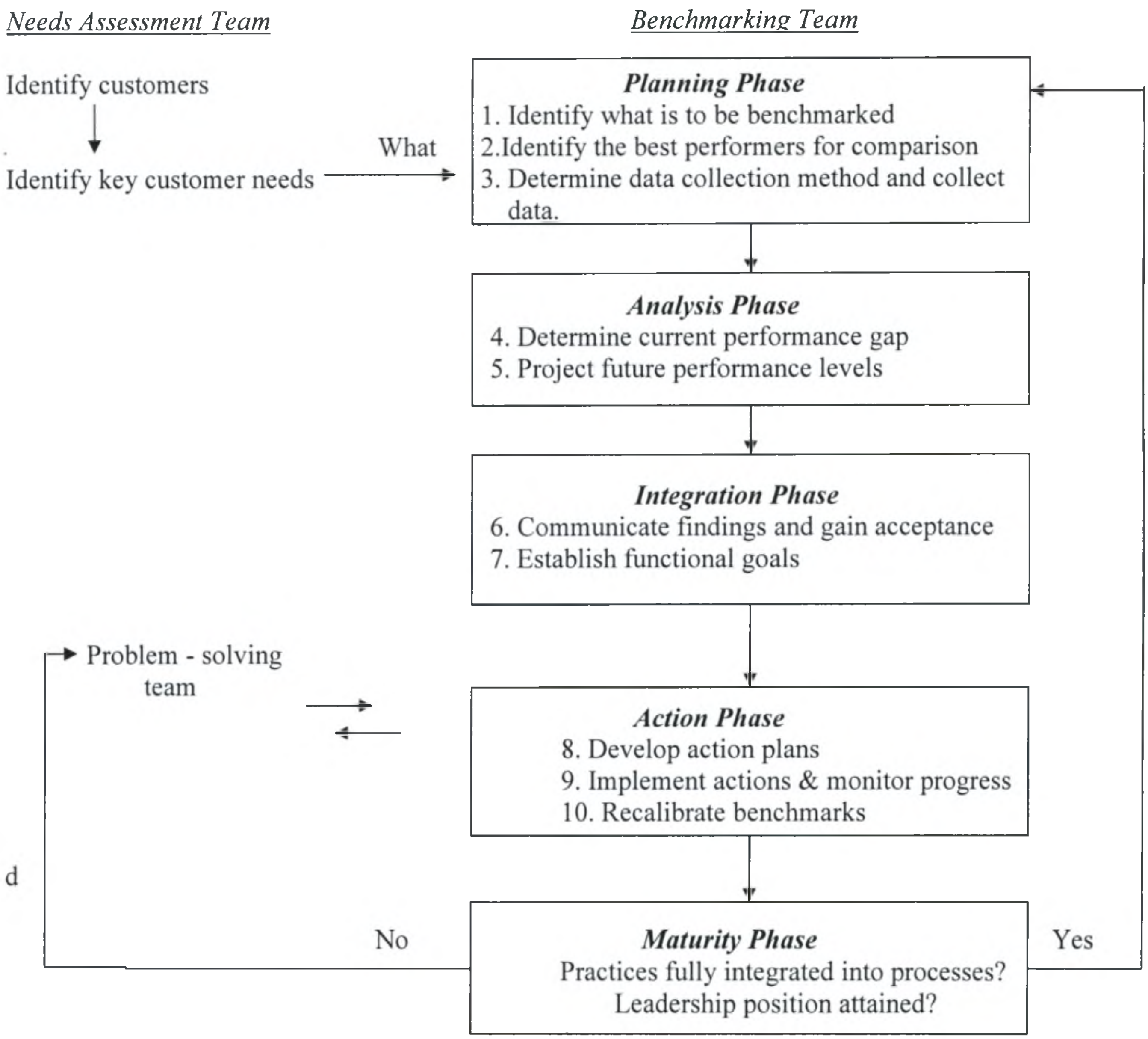
Second, it has a cyclical or repetitive nature. Camp (1989b) refers to it as an ongoing management process that initiates periodical collection of the information regarding the best practices in order to update the current management practices and business functions.

Third, it involves a goal-setting process. It not only projects new operational performance attainment levels, but also provides the organization with a general direction to be pursued. It navigates the organization by transforming the long-term targets into operational actions.

Finally, it raises the importance of communication and commitment. Benchmarking findings must be communicated to all staff to gain support, commitment, and ownership.

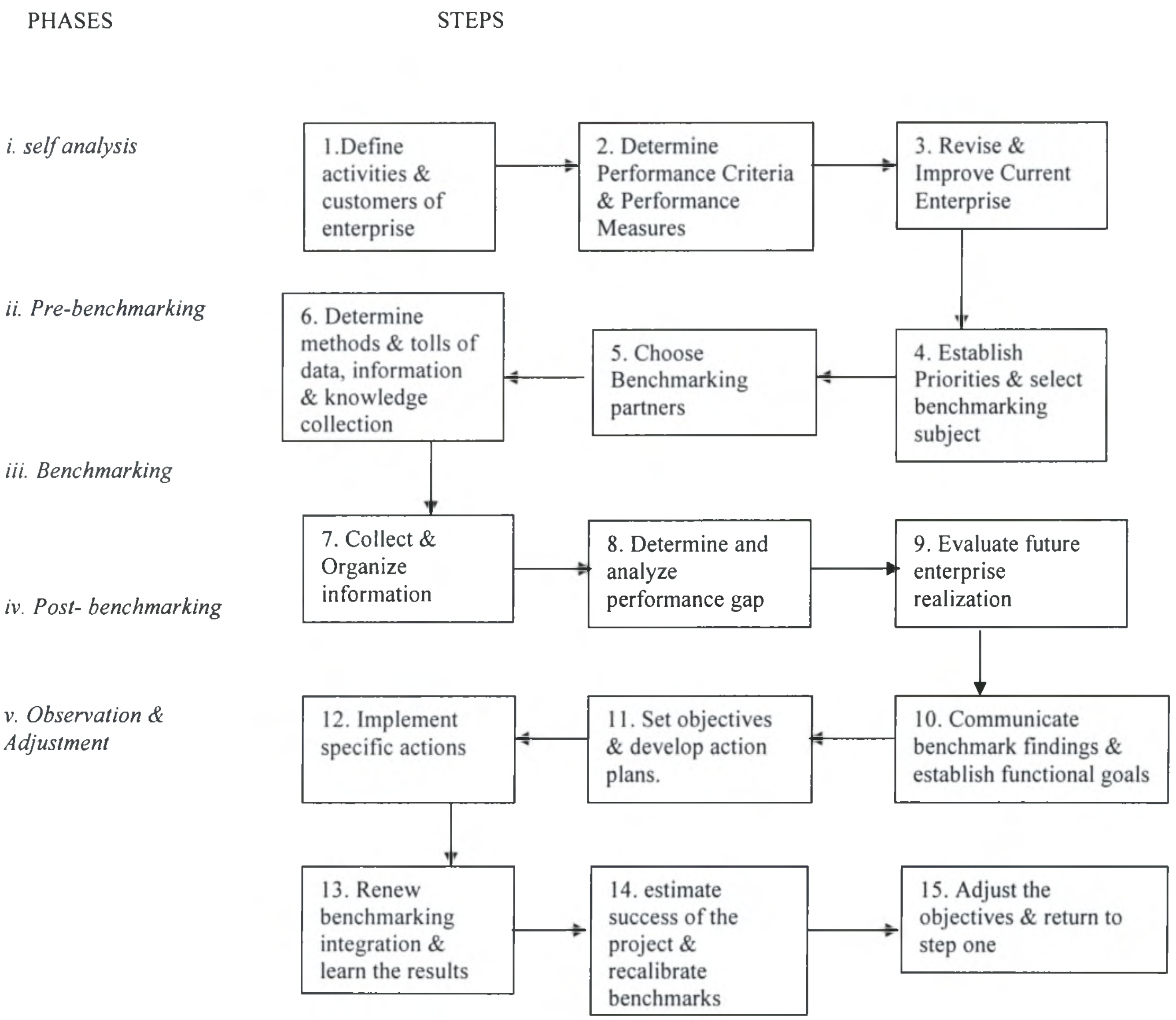
One of the key communications is to translate benchmarking findings into a statement of operational principles which act as the rules to indicate actions for change in order to meet customer needs and eventually to obtain superior performance. Findings must be accepted by both operational and management personnel. Management committed to benchmarking would provide adequate resources and supports for implementing benchmarking programmes. Employee commitment from an operational level will facilitate benchmarking since they are the ones who carry out the benchmarking practices. To gain support, the findings must be able to convince others. The benchmarking team should put efforts in to collecting data from different reliable sources and analyzing them correctly, and subsequent findings must be clear and presentable.

Figure 7
Benchmarking process model



In the appendix, there are two case studies of leading international firms who have adopted the benchmarking approach to their activities.

The four types of benchmarking can be conducted individually by organizations, through a voluntary consortium of participating institutions, or through a third-party association that is paid by participants. Individually conducted benchmarking projects have the advantage of being specifically tailored for the institution, but can be costly, time-consuming, and nonproductive unless properly implemented. Voluntary consortia programs can share costs and program development time, but may lack expertise and direction for effective benchmarking implementation. Association benchmarking offers organizations a practical alternative to the first two methodologies. Professional associations have the required expertise in the industry, and can share the costs of benchmarking program development with participating member organizations.



The steps of the benchmarking process Adapted by Büyüközkan and Maire

PROCEDURES FOR BENCHMARKING

PLANNING PHASE

As with most management and development initiatives, planning is crucial. Therefore, in order to achieve the maximum benefit and minimum effort and work disruption (data collection, analysis, checking and implementation effort, etc.), the planning step must be accomplished in a systematic manner.

The planning phase of a benchmarking effort (Camp, 1989 and Weimer 1992) involves three steps:

The first step is to determine **what is going to be benchmarked**. Defining the object of study of a benchmarking initiative is fundamental, if improvements on product or operational performance intend to boost competitiveness and business results. Therefore, the selection of a product or process for benchmarking must be preceded by a diagnostic of the current situation and an analysis of factors of success or top priority dimensions of product and process performance (which in turn depend upon strategic decisions about what market segments and dimensions it wishes to compete on) to deliver expected value to customers. A needs assessment team or so-called quality function deployment (QFD) team is formed to identify the critical issues (Vaziri, 1992). The team will identify which process outputs are most important to the customers of that process (i.e. the key quality characteristics).

Mitchell (1995) refers to this stage as the business process improvement (BPI) which flowcharts the procedures, processes, and activities of an organization. A few questions should be asked to develop a comprehensive list of key quality characteristics:

1 What is your mission statement?
2 Who are your customers and what do they want from you?
3 What are the important features of the outputs required by your customers?

Finally, key quality characteristics can then be determined by:

- ⇒ listing out your major customers;
- ⇒ determining these major customers' needs or complaints;
- ⇒ identifying the major value-added vs costs added areas;
- ⇒ identifying areas prone to direct competition.
- ⇒ listing those areas closely related to your mission or goal statement (Cheng et al., 1998)

In fact, the major customers, outputs, or features typically account for the main impacts. Most often, major customers, outputs, or features represent a small part (say 25 per cent of total customers) but they have a larger effect (say 75 per cent of sales turnover). After selecting the key quality characteristics, the next step is to identify the critical success factors (CSF).
Talking to customers, knowing the company's internal process and the environment and determining if the topic is significant and could be influenced or changed in the near future, are the major factors that lead to the decision of what is to be benchmarked.
The CSFs cover a wide range of very different factors (production factors, organizational factors, managerial factors, marketing factors, etc.), but some of them are more critical to the firm's performance than others. A few key functions demand that ''things must go right'' for the management goals to be attained. Therefore, these functions must be given greater importance in the overall quantitative measurement of business performance. Another reason for a different weighting is that CSFs are not the same for all firms. They are market- and firm-specific. Hence, the weights of the different factors (CSFs) must reflect these different conditions (Freytag and Hollensen, 1999).

The APQC defines the *Critical Success Factors (CSFs)* as those characteristics, conditions or variables that have a direct influence on customer's satisfaction and therefore the very company's success, while *enablers* as those processes, practices or methods that make possible the "best - in - class" performance. Enablers tell the reasons behind the successful implementation (system, method, document, training etc).

To ensure that the results are manageable, each benchmarking activity should be limited to five key quality characteristics and their respective critical success factors (Vaziri, 1992). These characteristics and factors will then be measured with appropriate indicators (i.e. performance measures or metrics), either using existing measures or establishing new ones.
Specifically, each indicator should have a clear operationalized meaning of how to measure and interpret the characteristic or factor. These standardized measures ensure the effectiveness of comparison.

Carpinetti and Melo (2002) present a five - step methodology for defining the object of benchmarking:
Step 1: product and market analysis: Gather information on product characteristics, target customer and markets, competitive priorities, manufacturing and financial strategies and general
areas for improvements. This will help to understand what dimensions and activities are most crucial to competitiveness.
Step 2: critical dimensions: Gather information on customer expectations and perceived quality for different categories of customers/products and rank relative importance of requisites for most important customers; also, gather information on performance against competitors in attending customer expectations. This helps identify dimensions most in need of improvement.
Step 3: critical processes: Map all the processes and activities belonging to or supporting the value adding chain and understand their relationship with the dimensions most in need of improvement. This may be helped by constructing a matrix relating processes to dimensions. This will help to focus on the attention on the
Step 4: performance assessment: Conduct a qualitative or quantitative assessment of performance of the critical processes and activities. A diagnosis of current situation is of fundamental importance to realizing what areas or activities are the weak points and need to be addressed. Quantitative information, if available, can reveal areas and dimensions in need of improvement.
Step 5: improvement priorities: After performing the analysis proposed in steps 1 to 5, the dimensions and activities most in need of improvements become evident. From this point onwards, the benchmarking project itself can start for those subjects for which a benchmarking application is considered to be adequate.

There are a whole lot of articles in the practitioner and management literature that provide models of how to benchmark a variety of company activities, for example HR activities (Holt,1994); accountancy practices (Weiss, 1993); innovation (Zairi, 1995), and product development (Brady and Coughlan, 1995).

Partovi (1994) suggests that this key decision about what to actually benchmark is a key facet of all the various prescriptive models that are designed to enlighten practitioners about the benchmarking process. Given that benchmarking requires considerable time, effort, resources and management attention, he argues that if this first stage is not done correctly, and the appropriate activities of a firm are not prioritized, then subsequent stages of collecting and analyzing benchmarking information may prove futile.

Focused on the question of determining what to benchmark are also the studies presented by Partovi (1994) and Byk¬zkan and Maire (1998). Partovi (1994) proposes the use of the analytic hierarchy process (AHP) as a means to prioritise benchmarking projects. Byk¬zkan and Maire (1998) propose the use of principal component analysis (PCA) and common factor analysis (CFA) also as prioritization tools.

The second step is to identify **the best performers for comparison**. Benchmarking initiates a learning process triggered by looking at the best practices which may be present within the benchmarking organization or in others. Hence, searching for the best company's practices is of primary concern. Nevertheless, a common mistake in selecting the benchmarking organization will be the halo effect. This is the assumption that a famous organization should be exceptional in all aspects, has an overall excellence, and is the best in every success (Fitz-enz, 1993). Actually, this is not necessary. The best practice may be present in every kind of organization, regardless of what industry or nation they are in. The team can overcome this problem by the following procedures.

First, the benchmarking team should identify the prime benchmarking candidates. For such a purpose, organizations should identify a list of all potential candidates, including direct competitors and companies regarded as the best-in-class, based on the key quality characteristics and critical success factors.

Through a brainstorming session, team members should collect information from all possible sources, starting from internal departments and extending to external contacts, such as professional associations, trade journals and business newspapers, business contacts, industry experts, consultants, quality award winners, books on well-run companies and customers.

Company employees are an excellent source of competitor intelligence through their professional and personal associations. Customers can provide information about competitors' products, service, pricing, and other attributes. According to several studies, customers are the primary source for market and competitor intelligence. Suppliers and distributors are also useful sources (Shetty, 1993).

One should bear in mind that the emphasis is on selecting those organizations exhibiting outstanding performance in the specific key quality characteristics and critical success factors so that causal relationships can be constructed to identify specific action items (Vaziri, 1992). In such, it is worthwhile taking into account those that have enjoyed success in certain general performance indicators, say market share or sales volume. These organizations may not be limited to the same industry but be extended to unrelated industries. This method is especially useful for those organizations without apparent competitors, as in the case of public service organizations.

After compiling a list of potential candidates, the team should select three to five to shortlist. Some candidates who look promising early in the process may need to be eliminated later due to the fact that they are not the best performer, not interested

or having the time, unwilling to share information and practices, and suspected in giving true and updated information, or because of other factors such as costs, location and already established relationships. Moreover, refinement of the key quality characteristics and critical success factors should be continuous since the organization had improved in the understanding of its own strengths and weaknesses through the planning process.
Competitors rank at the top of possible benchmarking targets. This avoids unpleasant surprises. Among the various methods of approach are direct application through a senior manager, application through a correspondent bank and an approach to the benchmarking initiator's own suppliers through its material department.

Anderson-Miles (1994) suggested that benchmarking organizations could either determine the benchmarking topics and target organizations before the collection and sharing of data and information, or collect and share data and information first in order to determine benchmarking topics and targets. No matter which approach one uses, the collection of data aims at quantifying the key quality characteristics and critical success factors to be measured. Such performance measurement is a standard or criterion and will differ among different variables.

Measuring internal performance forms the baseline for comparison. The knowledge gained during internal data gathering also provides a reference point to add or delete the key quality characteristics and critical success factors or to refine the measurable indicators.

For instance internal operations is the most important factor for ***Rover Group*** (Zairi, 1998).
Rover considers similar functions within different operating units performing the same tasks, and recognizes that sharing internal information is prior to going outside. The second priority for sharing information is amongst direct product competitors. Although the access is difficult and complicated, Rover believes that it is vital to approach this category. However, Rover benchmarking teams do consider non-competitors, but mainly for general processes such as logistics, recruitment, accounting, etc. It is believed that genuine innovative solutions can be obtained via this route. Before officially contacting a potential partner, Rover makes an initial contact in order to assess aspects of communication and practices according to the following factors (Zairi, 1998):

- geographical and physical layout;
- methods involved;
- policies and procedures affecting the method;
- management responsibilities;
- skills and training levels;
- investment and operating costs; and
- the relationship between the specific benchmarked process and the rest of the business how it fits into the big picture.

Unlike Rover that focuses on internal operations in the first step for sharing information, ***IBM*** (Zairi, 1998) encourages benchmarking teams to employ a wide variety of information resources prior to considering potential partners.
The following sources are considered:

- organisations that have won quality/business awards;

- top-rated firms in industry surveys;
- admirable stories published in learned journals;
- organisations with excellent financial results; and
- feedback received from internal and external experts, customers, suppliers, and business partners.

IBM has developed a methodology based on a matrix that compares potential partners to world-class standards. The required information is obtained through questionnaires. The results are plotted on a matrix and then potential partners are recognised based on the set of predetermined criteria such as profits, revenue, market share, level of customer satisfaction, quality level, contribution of the company to the state of the art in its industry, and the evidence of the company's leadership. When the potential partners have been recognised, the second phase of the internal process is initiated for developing a list of benchmarking partners. The steps to achieve this are as follows:

- compiling the characteristics of the process/business area;
- listing best-of-breed or world-class criteria for business area or process of interest;
- listing of currently restraining factors with regard to the process or business; and
- preparing the open-ended questions for assessing best-of-breed or world-class factors.

Like Rover and IBM, ***Xerox*** has developed a methodology to select the most appropriate partners. Xerox designed a flowchart that reflects Xerox's straightforward process for benchmarking partner selection. This methodology has been designed to assess six attributes of potential partner organisations, namely: process, product similarity, organisation type, culture, and similar criteria.

The above examples illustrate some attributes which organizations have considered in selecting their benchmarking partners. Indeed, each organization is interested in different factors. Therefore, the universal application of existing approaches may not be practical for all types of organizations. Generally speaking, large organizations like Rover, Xerox, IBM, etc. always have enough resources to develop a designated methodology for benchmarking partner selection, which is not always the case for small to medium-sized enterprises (SMEs). One might assume that because of the size of the SMEs, making such decisions is easier for them. However, the situation is more complicated. First, the number of competitors in the SME sector is much more than that among the large enterprises. In addition, an SME is still likely to be interested in comparing itself with world-class standards, which adds more complications due to possible differences. For example, the nature of the problems in logistics for SMEs and WCMs may be different and the present gaps may not provide useful interpretation. These issues direct SMEs to select their partners in a very determined manner, otherwise the process of observation and analysis will be very hard and arduous (Zairi et al. 2000).

Ramabadron et al. (1993) have collected the following partner characteristics from literature:

Partner appropriateness. A potential partner organization is considered appropriate for a benchmarking project if it has had prior benchmarking experience, has non-competitive product lines, team members readily agree on its choice as a partner, the nature of information being sought is not too sensitive, the findings from that organization would not be too difficult to implement and implementation would enable the benchmarking organization to achieve substantial improvements in the benchmarking topic area. This variable is defined by the extent that a partner organization satisfies these requirements.

Partner interest. Benchmarking authors point out that, in order to get potential partner organizations interested in a project, a team's initial approach should be very professional with regard to questionnaire preparation and the legal/ethical aspects of data collection. Potential partners may also show interest in a benchmarking proposal because of successful prior benchmarking experience. They are apt to be less reluctant if they have non-competitive product lines. Partner interest can be defined by the extent that the above factors are true, by the extent to which they show readiness to share information and actual sharing of quality information with a team.

Constraints. Constraints for partner selection and data collection arise because of lack of preliminary information about potential partners, lack of time on the part of proposed partners to participate in a project because of prior commitments, problems faced by a team in establishing a relationship upfront with key personnel in those organizations, legal or ethical aspects of gathering information and the confidential or sensitive nature of required information. Because of these constraints, teams may have to accept the most appropriate partner organization(s) from among those that are willing to share information with them even though such organizations may not be ideal for a benchmarking project. Partner constraints are defined by the extent that these constraints for partner selection and data collection are present.

The establishment of measurable indicators or criteria guides which external data collection method is supposed to be used. There are two sources of data. First, the primary source involves original research where data are collected from surveys, interviews, direct site visits, trade shows, and reverse engineering. A major advantage of original research is that the data collected matches more to individual needs. Another is the secondary source which is completed research provided from periodicals, books, brokerage reports, and on-line databases.

This source is particularly useful if the required database is very large or the data are difficult to collect. Today, organizations advanced in benchmarking end to develop such databases of potential benchmarking partners, their areas of strength and best practices. Several organisations offer benchmarking services that facilitate the development of benchmarking projects. For instance, The Benchmarking Exchange enables members, among other things, electronically to locate and communicate with potential benchmarking partners, to research best in class companies, find out how they achieved best in class performance or to seek assistance and advice from others who have already benchmarked what a company is about to benchmark. Benchmarking services are also provided by the Benchmarking Clearinghouse of the American Productivity and Quality Centre (AQPC).

Well-publicized examples of benchmarking are the cases of Xerox Corporation, LL Bean (Camp, 1989), Alcoa, Motorola, AT&T, Florida Power and Light and General Electric (Longbottom, 2000).

However, organizations should evaluate each source based on its accessibility, accuracy reliability, validity, timeliness, scope of coverage, cost, target audience, and readability.

The next step is to determine the data - collection method and transform the raw data into information that can be used to compare the current state of the organization with external practices (Biesada, 1991, Camp, 1989). The step consists of locating the areas where the target organization excels and identifying the requirements to be satisfied, in order to achieve the excellence. A formal meeting is needed to define both parties' objectives, assess the types of information that the initiator and the target company need, determine the range of information to be shared, its characteristics (qualitative and quantitative) and the ways to use it. Mutual trust is very important for both parts (Ohinata, 1994).

After the organization has identified performance variables and measures (metrics) based on current operations and customers requirements, chosen the data collection methods, and collected the internal and external data, it can then summarize and document the findings. A benchmarking grid (see Vaziri, 1992) is useful to capture the findings for further analysis.

TABLE IV : Selecting target organizations

Target organizations	Advantages	Disadvantages
Other in - house organizations	Information readily available	Not convincing enough, biased.
Domestic competitors	Information already available	Difficulty in collecting new information.
Foreign competitors	Highly convincing	Internal resistance to disclosure, concern about the risk of leaks.
"National class"	Innovative	Operat5ional environment of a firm in another industry difficult
"World class"	Highly informative	Different corporate culture costly and time - consuming

There are several methodologies for the planning stage, as well. For example, according to Zairi et al. 2000, the objectives of the planning step can be listed in the following four steps:

(1) identifying customer needs;
(2) identifying the critical processes related to fulfilling these needs;
(3) linkage between the purpose of benchmarking and organisational objectives; and
(4) identifying the benchmarking candidates and partners.

ANALYSIS PHASE

As soon as the data are gathered, the benchmarking team will smooth the data by detecting any abnormal responses. For example, if the team discovers that an individual response is abnormally high and a further check reveals that the abnormal response is due to different industry standards, the scale will be modified to fit for the comparison.

The fixed data can yield useful information which helps the team select the best performer for each key quality characteristics.

Then, the team will calculate the difference between the company's current (internal) and desired (benchmarking) performance, based on the following two formulas suggested by Vaziri (1992):

1. *When a smaller number is desirable, the difference is calculated as:*

$$1 - \frac{\text{Internal performance}}{\text{Benchmarking performance}}$$

2. *When a larger number is desirable, the difference is calculated as:*

$$\frac{\text{Internal performance}}{\text{Benchmarking performance}} - 1$$

Using his example, let safety be a key quality characteristic for an operating unit (measured by recorded accidents as a proportion of all accidents), and the internal performance is 21.35 per cent while the benchmarking performance is 12.74 per cent. Thus, the current performance gap is – 0.676 or – 67.6 per cent [1– (21.35%/12.74%) as a smaller number is desirable].

A negative number indicates a lag in performance, while a positive number indicates a lead in performance. After the determination of the difference in key quality characteristics, the team can identify what practices should be benchmarked according to the critical success factors. Using the previous example, let safety training be one of the critical success factors in lowering the recorded accident rate (measured by the ratio of safety training hours/total maintenance hours). The benchmarking performance compared to the internal performance relative to this critical success factor is:

Internal safety training	0.002%
Benchmarking safety training	0.014%
Gap	–85.7%

This indicates that the 67.6 per cent gap in the safety record was likely to be related to the lack of sufficient internal safety training.

The benchmarking analysis assesses an organization's current state relative to those of the best organizations and results in highlighting major opportunities, threats, strengths, and weaknesses. It helps to discover improvement activities and project future performance levels to be achieved through such efforts. Only through a complete diagnosis of the organization will the benchmarking parties truly know what changes are appropriate. Since the desirable process or function used by the best performer may not be transferable, this is the organization's effort to make sure that the transfer is feasible. After the appropriate goals and changes are determined, the process of change can begin.

INTEGRATION PHASE

Once benchmarking parameters of change are identified, the benchmarking team should integrate the findings into the organization, including sharing the idea of change with those who would support and provide input into the process and those who will be affected by the changes.

The team will do this by first communicating their benchmarking findings with and gaining acceptance from those who are involved in the change process. The purpose is to enhance commitment to the benchmarking plan. As Biesada (1991) stresses, the toughest part of benchmarking is to get people out of their routine way of working and get them to think about the underlying process. Benchmarking will shake people if they think that benchmarking is a device to get rid of them. To overcome their worry becomes a primary goal. The team also encourages feedback in an ongoing communication process. This will improve quality and minimize misinterpretations respectively.

Additionally, the team should pay attention in order to coordinate various activities effectively.

Any new or updated information on methodology, key findings, and recommendations should be explained to management and employees. Coordinating with them closely not only lets them know the progress but also ensures their continuous support. The earlier the detection of resistance, the greater the chance that the team can find way to break the wall.

The output of the previous step is the establishment of functional goals, which target the benchmarking practices that offer the highest potential benefits by describing the desired performance levels of such practices and the action plans to reach them. This includes rewriting the mission statement that describes the general direction. This is a pivotal part as it stimulates creative thinking of how to get to the future direction. Then, the team should create the clear, quantifiable, and attainable objectives that support the restated mission by means of key quality characteristics, critical success factors, and the respective measures.

The last task in this phase the team should do is to have a formal presentation to conclude the findings and improvement activities. The entire team, or at least a portion of it, will remain intact to work with additionally elected members from management to develop action plans to attain the objectives and goals.

ACTION PHASE

The action phase inducing the desired changes consists of three steps: developing action plans to reach the functional goals; implementing specific action plans and monitoring their progress; and recalibrating benchmarking measures (Cheng et al., 1998).

Organizations should establish specific action plans (e.g. improve product design, quality control, or packaging) to achieve the objectives. This includes stating such issues as required resources, legitimate accountability, and a time frame for the change process. The action plans also address who are the improvement teams, which areas are to be focused on, what activities are set, and what support functions (such as training and external consultants) are expected.
If the links between the mission, objectives, and action plans are clear and have less or even no resistance, the implementation of the action plans will be more efficient. Further monitoring will resolve any conflicts appearing during the change process.

In fact, the dynamic marketplace may change the projected gap or even reposition the benchmarking leader. Recalibration of the benchmarking measures is needed if the selected benchmarking organizations are no longer a barometer of excellence (Nelson, 1994).

MATURITY PHASE

There are two questions which the organization should ask itself after it implements new benchmarking practices. First, are the practices fully integrated into the processes? If the answer is no, there should be some problems that have not been solved. The organization can establish a problem-solving team to ensure the action plans can work. They should provide solutions for those issues identified during implementation and monitoring.

Second, after the organization has started the new practices, one may doubt whether it has attained a leadership position. As we know that the mind-set that the new established practices are the best is always challenged in this dynamic and globalized market, new leaders will create competition that surpasses the existing standards. The leadership position attained is only the entry ticket for another round of the benchmarking game. Therefore, the organization should induce a new benchmarking process after the old one has been completed.

True leadership results from a continuous concern for understanding customers' needs, identifying processes through which the products and services are offered, and developing improvement activities that include both incremental performance improvement and radical work restructuring. It emphasizes superior customer satisfaction by considering customer value, trying to exceed the cost of creating the value, and continually striving to reduce the cost or differentiate the benefits to offset a higher price. Benchmarking is an effective management tool to attain this ultimate competitive advantage (Vaziri, 1992).

A benchmarking team should acquire adequate benchmarking knowledge before it starts to work on it.

- Organizations should first establish a benchmarking team, which consists of experts from within the organization and should have different backgrounds. The top management must fully support the team and let team members' imaginations run free. The purpose is to facilitate brainstorming by generating more ideas from team members.
- The team would identify specific areas for their benchmarking activities. It may not be necessary for every practice. The team should pay particular attention to some practices that are crucial to organizational performance, such as practices where large financial savings might be made, practices that are critical to sales turnover, etc. This is the identification of the key characteristics and related critical success factors.
- The benchmarking team should then search for the benchmarking partners and determine the performance measures for the critical success factors. This involves extensive research. Business periodicals, trade journals, consultant reports, magazines, and newspapers all serve as useful sources. The team cannot expect one or two companies to have all the best practices matching their needs. It should

focus on an organization's core competencies. Conducting research is time-consuming and requires a lot of effort and resources. Therefore, some organizations would hire a consulting firm to undertake such research.

- The team should consider the feasibility of a benchmarking practice in terms of technology, resources, organization structure, etc. This would guide them to choose the benchmarking partner who not only possesses a superior performance, but also fits their own organization.
- After determining the performance measures, the team should compare its own performance with that of the benchmarking partner. If the benchmarking partner has a better performance, its practice is worth benchmarking. Then, the next step is to prepare the implementation of such a practice, which has been clearly described in the previous section.

At the initial stage of benchmarking it is very possible to let excitement about the ability to visit other organizations create a high level of enthusiasm and involvement in benchmarking. It is important to make sure that initial studies not only bring back information that is significant to the business, but also that the initial studies teach the teams how to do benchmarking so that the organization develops its own competency in this field. Another caution that is equally important is that a company must be prepared to benchmark when they contact external organizations. This means they have documented and measured their own process, they have developed a set of questions which focus their study, and a set of criteria which describe the target benchmarking partners, and they have conducted secondary research of business literature to understand what is already in the public domain. Benchmarking is a rigorous process and it is absolutely necessary to do your homework before contacting external parties.

BENCHMARKING TOOLS

An effective benchmarking process needs to be supported by appropriate tools (identification, collection, analysis and implementation tools) and metrics. In a relatively comprehensive review of the techniques and tools available for benchmarking, Camp (1995) summarizes the tools available for each of the major steps in the benchmarking process. Most current tools focus on presenting the data in some graphical form. The presentation graphics are simply understood and capable of showing the multiple dimensions simultaneously, but it is still up to the analyst to integrate these elements into a complete picture. Some of the more popular techniques include the ``spider'' or ``radar'' diagram and the ``Z'' chart for gap analysis. Another approach is the use of the analytic hierarchy process maturity matrix (Eyrich, 1991) which utilizes a weighted scoring technique in the analysis of various benchmarks and provides a single score using perceptual values as set forth by decision makers. Some analysis on tools is given to the relevant chapter.

Statistical methods to analyze the data include regression and various descriptive statistics (Blumberg, 1994; Schefcyzk, 1993). Yet, even with the strong theoretical foundation of statistical tools such as multiple regression, a limitation occurs in the number of simultaneous inputs and outputs to consider (from a dependent/independent variable perspective) and that regression measures a correlation or central tendency, but not best practice. Advances and application of benchmarking tools for agility are described below.

BENCHMARKING MEASUREMENTS AND METRICS

Performance measurement and metrics are critical elements within benchmarking, which is meant to be a fact-based process for improvement.

The tools for benchmarking can be categorized by the purpose of their function within the benchmarking processes. The tools that are identified here focus on data acquisition, manipulation and analysis and are found in Camp, (1989; 1995), Boxwell (1994), Christopher and Thor (1993) and Watson (1992).

The data acquisition tools incorporate data resources for aiding in the benchmarking process. The resources for data acquisition are varied including secondary archival sources, individual organizations, industry groups, government agencies, academic groups, and private benchmarking organizations.

Databases can be created for: integrated product process development (IPPD); people; legal; virtual enterprises; process and equipment; and information/control architecture. Future directions include satellite centers, acquisition reforms support, and environmental benchmarking practices. The process for gathering this information involves third-party experts validating the data through observation. Only those processes that have *proven* successful are added to the database. What is interesting about this database is its availability through minimal expense, easy access, and a diverse body of experts confirming best practices.

In 1995, research by Anderson and Camp (1995) indicated that the role of computers and the Internet in benchmarking was expected to grow. Judging by the number of benchmarking Web sites in operation today, this indeed has been the case. In a recent review of Web sites, the Centre for Organisational Excellence Research (COER) identified nearly 200 Web sites serving an interest in benchmarking or a related improvement approach (Welsh, Mann,1998).

The use of the Internet, World Wide Web, electronic data interchange networks, and other electronic information sources will prove useful in benchmarking.The difficulty lies in managing and controlling benchmarking data over these sources. The ``Data Mining'' family of tools linked to these information sources could prove to be an invaluable strategic weapon. In data mining the basic concepts include: ``data is often buried deep within very large databases; sophisticated new tools help to remove the information ore buried in corporate files or archival public records; striking it rich often involves finding an unexpected result and requires end-users to think creatively'' (Mace, 1994; Masi, 2000). Multimedia data, such as graphics, video and sound, are types of data that have not been typically mined for information and may aid in agility benchmarking.

State-of-the-art research in the area of benchmarking tools includes the development and use of data envelopment analysis (DEA) (Barr, 1995; Post and Spronk, 1999). This technique is an analytical approach that is based on fractional mathematical programming and productivity ratios. DEA may be transformed into a linear programming input/output model that helps to define the efficiencies of various entities called decision making units (DMUs). It supports the identification of best practice units and can help identify those processes that either need improvement or could be used for benchmarking.

DEA could be useful for application in internal, process, competitive and strategic benchmarking (Sarkis and Talluri, 1996). It provides more insight than the traditional "gap analysis" that is being used for benchmarking. Rigorous multidimensional analysis tools seem to be one of the weaker elements of the benchmarking process, and DEA can aid in bridging this gap. It helps by discriminating the relative efficiency of various organizations.

A number of other multicriteria models and tools for a systemic analysis of benchmarking data are available (Islei and Cuthbertson, 2000; Olson, 1996; Talluri and Sarkis, 2001; Stewart and van der Honert, 1998). The use of these systemic tools for an analytical presentation of benchmarking data is efficacious since they are capable of analyzing the full enterprise while synergistic effects of individual elements may be considered. Further developments of new and available multicriteria techniques (which include multi-attribute utility theory, multi-objective mathematical programming, analytical hierarchy process, conjoint analysis, and game theoretic models) should be encouraged.

Computer simulation for purposes of benchmarking is an analysis tool that has yet to be fully utilized. By using historical and assumed distributions of benchmarking data, eventual outcomes for processes can be benchmarked. Simulation is a tool that can effectively be used for upstream benchmarking evaluation.

Assessment tools will also be necessary for benchmarking purposes. These tools include the Malcolm Baldrige application guide (see Voss *et al.* (1994)) for development and use of the Baldrige award criteria for internal benchmarking) for assessing organizations.

Metrics for benchmarking, should be rigorous, reproducible, quantifiable, analyzable and provable (Preiss, 1995). Metrics choices will be dependent on definitions of agility. Again, this requires a rigorous and acceptable definition that will help discriminate agile practices from other business practices.

KEY SUCCESS FACTORS IN BENCHMARKING

Profitability and increased competitive advantage prove the effectiveness of any benchmarking effort. In case that a benchmarking process is successful, several factors must be taken into consideration:

- Formal approach
- Top management commitment/involvement
- No competition in the areas of information shared
- Information exchanges must be both ways
- A relationship should be formed e.g. a stakeholder relationship or an alliance
- It should be a relationship between equals - not a teacher - student relationship
- The organizations' sizes must be similar
- Not too much work involved for the target organization.
- Well defined scope

- A well documented set of goals.
- Organizational culture
- Clarity of benchmarking goal(s). Elmuti (1998) finds that "unclear and inadequately understood objectives and goals of benchmarking projects is ranked first among all the critical factors for benchmarking projects failure."
- Effective communication of benchmarking findings
- Innovative adaptation of findings
- Management commitment

Sheridan (1993) adds:

- being tied to the corporation's overall strategic objectives;
- being able to operate efficiently;
- being composed of interested motivated people;
- focus on relevant work-group-level issues;
- set realistic timetables;
- pick the correct business partners;
- follow proper protocol;
- collect manageable bodies of data;
- understand the processes behind the data; and
- identify targets in advance.

LIMITATIONS (PITFALLS) AND MISCONCEPTIONS OF BENCHMARKING

Although benchmarking is very effective, it does have limitations:

- *Focusing on numbers*. Sometimes companies focus on data and not on the processes used to produce the data.
- *Losing focus on customers*. Because of limited resources for the benchmarking it often involves a high degree of selfevaluation. This may cause some organizations to lose focus on customers.
- *Losing focus on employees*. Companies that try to produce better benchmarking results can quickly cause employee burnout and errors.
- *Over-reliance on quantitative data (data benchmarking)*. Consequently, misunderstanding of the underlying reasons for the performance measures (strategic competencies and key processes).
- *Difficult to obtain useful information about competitors*. Competitors may be uncooperative. Gathering competitive intelligence requires considerable time, effort, and money. Further, there can be ethical and legal questions about some intelligence activities, such as paying a competitor's employees for information, recording conversations, etc. (Brownlie, 2000).
- *Emulating competitors*. May result in only short-lived competitive advantage.
- *Difficult to benchmark services*. Even though service operations can be broken down into their components it is more difficult to benchmark service operations than to benchmark products. Services often involve skills and other ''tacit'' factors that are difficult to quantify.
- *Lacking proper implementation*. For example, if employees are not involved in the process, this could cause some employees to resist necessary changes. The employees need information in order to improve the process.

- *Ongoing process, not a one-time project*. Some organizations may have difficulties in treating benchmarking as an ongoing process. It should not be viewed as a onetime project.
- *NIH (not invented here)*. In addition, some companies may believe tactics not invented by themselves to be inferior.
- *Exposure of weaknesses*. Some companies do not benchmark because their weaknesses are exposed.
- *Narrow scope of companies studied*. A common problem in benchmarking is the failure to expand the scope of companies studied. It may be relevant to benchmark against companies outside the user company's industry (process benchmarking).
- *Cultural difficulties in transferring ''best practices'' in multinational firms*. The biggest problems associated with transferring ''best practices'' across cultures are due to differences in behavioural and cultural background of the organizational members in the foreign subsidiaries of the firm (Zairi and Ahmed, 1999).

If employed simply to meet the competitor's performance, it will not lead to superiority and it may discourage action by innovative employees.

Bhutta and Huq, (1999) also note the following misconceptions and limitations encountered in the process:

- Benchmarking alone does not tell one what customers actually want. If the product or service is obsolete, no amount of improvements in production processes will make it competitive. Benchmarking is only of benefit if the improvement actions are implemented. An effort should always be made to seek out how a company has improved itsperformance, and this normally comes from the people, not the management (who will tell you how much performance has improved but not necessarily how).
- Not involving employees during the process. Ultimately, these employees will need the nformation to improve the process. Some organizations have difficulty treating benchmarking as an ongoing process: it should not be viewed as a onetime project. In addition, some companies think a tactic not invented by them may be inferior. Furthermore, some companies do not benchmark because it exposes their weaknesses.
- Benchmarking is too expensive. Benchmarking does come at a price, but costs vary considerably. Usually there are travel expenses and indirect costs (including employee time devoted to team meetings and travel) but with careful planning, benchmarking costs can be kept to a minimum. In a 1995 survey of benchmarking exchange members, benchmarking was one of the top five most popular current business processes. Resources and information are now more affordable and accessible. In 1992, the average cost of conducting one benchmark study was $50,000. By 1996, the average cost had dropped to $5,000. With the cost of benchmarking falling rapidly, its use is increasing. The knowledge gained is well worth the small investment.
- A way to control costs is to tackle benchmarking one step at a time. It is not an extremely difficult or complex process: companies can reduce financial stress by examining one process at a time. Actually, costs can be controlled if the company benchmarks in degrees and defines very narrow areas to explore.
- To minimize costly meeting and travel time, a company must work efficiently and communicate effectively. The company should do its homework and know specific problems before employees visit other companies. The trip should be

clearly defined: what to look for and what to accomplish. Make this information known to the other company and, since benchmarking is a two-way street, it is important to understand the other company's needs and decide what you are willing to share with them.

- Benchmarking gives too much information to one's competitors. Employees providing information should be smart about it and not give away the heart and soul of the company. As a whole, distributing information and processes helps our country become more competitive in the global marketplace.

Elnathan et al. (1996) suggest that benchmarking suffers from hidden costs that should be understood, such as (i) the costs of the time and effort needed to coordinate the process and the inputs of participants in order to obtain a comparable set of data and (ii) the quantification of costs which, while significant, may be hard to trace or measure, including costs relating to the cultural change required and costs arising from resistance to change by those involved and affected.

The major limitations primarily concern the difficulties of conceiving and implementing a viable programme. Companies should have reasonable expectations. For example, coupling benchmark studies with customers' expectations will lead to superior products and services. It may be more feasible to study non-competitors, who may be more willing to share information on a quid pro quo basis, particularly when both firms perceive that the study is open and beneficial. Professionals in non-competing firms are often eager to share more information. Xerox also found that many competing firms are willing to share information on a quid pro quo basis.

It is important to determine how much resources will be devoted to the process. Xerox and Ford spent millions of dollars while other companies have benefited from more limited efforts.
Firms can derive substantial benefits from analysing their own operations and the 'best-in-class' firms, so failing to collect all desired data will not nullify the value of such a study.
Further, the costs of benchmark studies will be less of an issue as companies become more knowledgeable about the process. Companies are developing guidelines to discourage unethical and questionable practices associated with intelligence gathering. Reasonable attempts to gather information are portrayed positively in the business press.

DeToro (1995) lists the commonly reported pitfalls as lack of management commitment, focusing on metrics rather than processes, and lack of follow-up to the benchmarking process, lack of adequate planning, establishing inappropriate performance measures, appointing inappropriate personnel to the benchmarking team, lack of depth in the benchmarking studies, inappropriate or inaccurate data gathering methods, failure to plan for implementation, failure to adapt the benchmarking partner's process to ones' organisational culture, and failing to involve the employees in decision making about benchmarking and its implementation.

Shaukat et al. (2000) in their article "Understanding the benchmarking process in Singapore", try to examine the strength of the relationship between pitfalls and the outcome of the benchmarking in their case study. Their results are rather interesting and are concentrated in the table below.

Factors
Pre-analysis factors
Wrong data gathering methods
Focusing on processes not in the plan
Poor documentation of processes
Failure to analyse the data collected
Not understanding the data source
Findings not communicated to the entire organisation
Copying best practices without adapting to the company's environment
Deriving unrealistic targets from benchmarking
Inadequate training for the employees in benchmarking
Implementation factors
Selecting too many processes to benchmark
Choosing the wrong processes to benchmark
Inappropriate performance measures
Conducting a superficial/limited search
Selecting the wrong benchmarking partners
Focusing on metics rather than processes during data-collection
Employees resistance to change
Management factors
Lack of leadership support
Failure to consider long-term strategic goals
Failure to review the benchmarking process
Failure to benchmark on an ongoing basis
Preconditions for benchmarking
Top level management support
Top level managers were dedicated to quality improvement
Top level managers fully understood the project's objectives and benefits
Top level managers were willing to commit time and resources to the product
Benchmarking was integrated into strategic planning
Internal assessment
We were open to changes and other new ideasa
We had a comprehensive quality programme (e.g. total quality management)
We had conducted internal benchmarking
We truly knew and understood our own operations
We were aware that a portfolio of learning opportunities existed
Employee participation
We had a dedicated project steering committee
Employees fully understood the project's objectives and benefits
Employees were educated and trained in benchmarking
Employees were willing to participate in the project
Benchmarking process
We were willing to share results with our benchmarking partnersa
There was a great understanding of benchmarking process in the company
Benchmarking was formally implemented
The benchmarking process was well planned
The benchmarking process was completely carried out
Pitfalls of benchmarking
Pre-analysis facators
Implementation factors
Management factors
Benefits of benchmarking

Improved customer satisfaction
Improved reliability of operations
Greater cost savings
Improved response time
Greater product innovations
Greater number of repeat customers
Improved decision-making
Setting realistic and achievable goals
Success of benchmarking
The objectives of benchmarking have been achieved
Costs have been justified in terms of benefits brought about by benchmarking
Overall benchmarking has been a success

Although the maxim "adopt, adapt and improve" is often advocated, benchmarking is not , *per se* a technique of organizational creativity. It is primarily an instrument for developing and implementing strategies which are either imitative or incremental innovations (Drew, 1997).

CONCLUSION

Intense international competition and declining profitability are encouraging firms to improve their competitive performance. One of the longterm initiatives that they employ to improve performance is benchmarking. Benchmarking is the continuous measuring of a firm's products, services, processes, and practices against those of the best competitors or those companies recognized as industry leaders. It helps managers compare performance function by function, and to determine why performance differs, and to establish performance goals to become the best in the industry.

Maximum and sustainable benefits require that the integration of benchmarking with the setting of the objectives, operating plans and overall management. Increasing evidence suggests that the best measure of performance involves a consideration of customers and competitive forces. Benchmarking can help companies accurately measure market requirements. By forcing companies to measure their performance against that of the best companies to identify strategies to improve performance, benchmarking shows considerable potential for improving competitive performance.

Camp (1989) calls benchmarking an applied discipline. It cannot be learned by taking a class or reading a book. It is a hands-on learning experience, and the drawback to this type of a process is that mistakes are inevitable. However, senseless mistakes are avoided by setting goals and following the rules to achieve them. Companies that benchmark identify specific areas of weakness, and find solutions to turn them into strengths.

Benchmarking is a process that can be and has been adapted to fit the managerial inclinations of an organization. It can be carried out in 33 steps or just five, however, the essence remains the same. It is also very important to remember improvements are continuous and benchmarks go out of date quickly, the competitor's performance will probably continue to improve in advance of one's own. The study should always remain honest and thoroughly professional.

TABLE III Benchmarking generic strategies.

	AP&QC model	Baxter's model	Shetty's model	Watson's model	Spendolini's model	Camp's model
Phase 1 Planning	1. Select a process to benchmark	1. Identify the process to Benchmark	1. Identification of the function to be benchmarked	1. Plan: understand and measure critical success factors		1. Identify what to benchmark
		2. Establish management commitment				
	2. Determine the project's scope	3. Identify the benchmarking team	2. Selection of the superior performers	2. Search: research appropriate companies for process comparison		2. Identify comparative companies
		4. Define and understand the process to be benchmarked				
Phase 2 Analysis and Data collection	3. Choose the relevant measures	5. Identify metrics and implement the change	3. Collection and analysis of data	3. Observe: monitor process performance and analyse performance gap	3. Identify benchmarking partners	3. Determine data collection method and collect data
		6. Identify the rank and implement internal process improvement				
	4. Study performance boosting best practices	7. Identify benchmarking partners	4. Establish performance goals	4. Analyse: determine the root causes of the performance gap	4. Collect and analyse benchmarking information	4. Determine current performance gap
Phase 3 Comparison and Results	5. Judge appropriateness and adapt practices					

(continued)

TABLE III Benchmarking generic strategies.

	AP&QC model	Baxter's model	Shetty's model	Watson's model	Spendolini's model	Camp's model
	6. Identify culture issues and factors	8. Collect process data from benchmarking partners				
Phase 4 Change		9. Analyse benchmarking partners' process data and compare				5. Project future performance levels 6. Communicate benchmarking findings and gain acceptance
	7. Plan and implement change		5. Implementing plans and monitoring results	5. Adapt: select best practices and modify the company environment	5. Take action	7. Establish functional goals
		10. Site visits, interviews and reanalyse data				8. Develop action plans
Phase 5 Verification and Maturity		11. Implement improvements and monitor results				9. Implement specific actions and monitor progress 10. Recalibrate benchmarks
	8. Measure results, do payback analysis			8. Improve: enhance and integrate business process improvements		Leadership position attained
		12. Continue to conduct benchmarking of process				Practices fully integrated into process

CHAPTER II
TECHNOLOGY TRANSFER

CHAPTER II

TECHNOLOGY TRANSFER

"Why re-invent the wheel?"

INTRODUCTION

When IBM grants a license to the government of Taiwan, the computer corporation undertakes a transfer of technology. When a French cheesemaker passes on recipes to Japanese firms, a transfer of know - how is performed. When Boston University organizes continuing - education programs in Belgium or Russia, the school undertakes a form of cooperation of technical and educational assistance. The flows of technology and know - how are various and wide - ranging. Technology transfer is a focal point in the management of technology and innovation in companies (Cooke - Mayes, 1996).

Technology transfer has long been discussed in a variety of disciplines including economics (Baranson, 1970; Mansfield & Romeo, 1980; Montalvo& Yafeh, 1994) and management (Contractor, 1980; Davidson & McFetridge, 1985; Kim, 1980; Rosenberg & Frischtak, 1985). Technology can be transferred through a number of different mode including FDI, licensing, and joint ventures (Contractor, 1980; Osborn & Baughn, 1990; Williamson, 1983). The selection of a particular mode depends on a number of factors including the licensor's strategy, licensee's absorptive capacity, recipient government regulations, among others (Tsurumi, 1984; Kogut & Zander, 1995).

The technological world is characterized by rapid changes in resource utilization, increasing levels of decision complexity and intense competition (Sharif, 1997). Reduced development cycles and the pace of technological change place greater urgency on the need to adopt new technology. To most manufacturing companies technology is a key part of their organizational knowledge, which gives them their distinctive capabilities and competitive advantage. In order to best make use of this resource such companies are increasingly extending the application of their knowledge through technology transfer. When transferred internationally this extension of technology application is seen increasingly as a means whereby companies can globalize their production operations in order to take advantage of cost or market factors (Bruun, Bennett, 2002).

The management of knowledge and technical information, equipment and software comprising the physical technology itself (Wang, 1997) are areas of interest in technology transfer (TT) in general. Other issues assume even greater importance, typically including human resources, skills and training, unique organisational issues, and "lore" (Hipkin - Benetti, 1997)

International technology transfer studies cover the economic relationship between a transferor and a transferee as well as a whole series of related issues, such as the national policies and legal framework of the nations in the world. The uneven nature of technological progress throughout the world provides the vary basis for technology transfer. In the past few decades technology transfer has multiplied by leaps and bounds. (Min Chen, 1996).

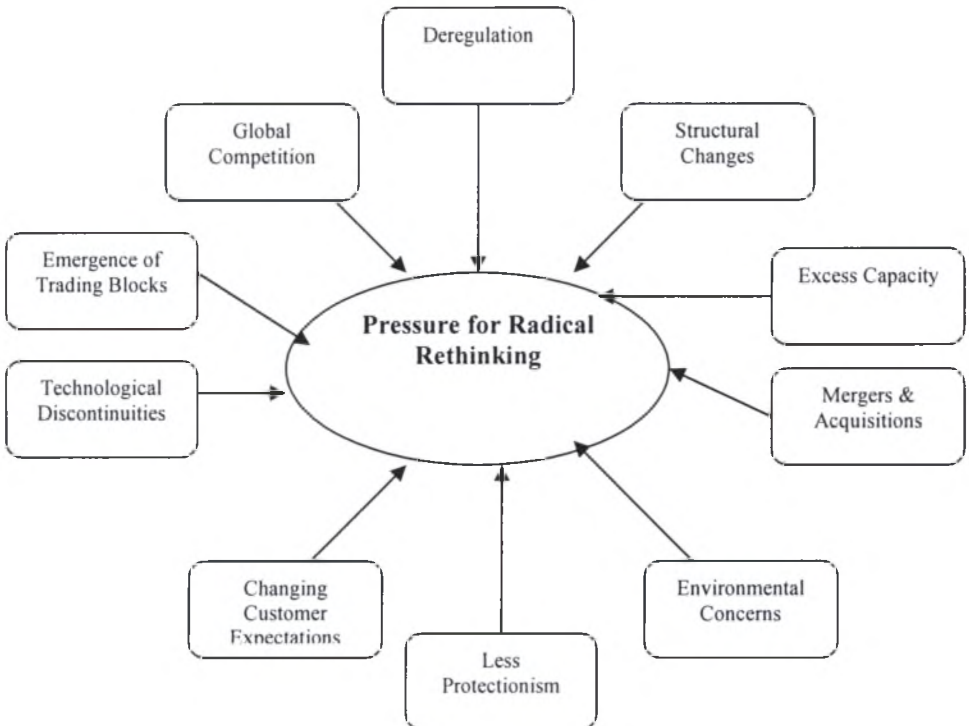


Fig. 1. The forces for industry transformation

ROOTS OF TECHNOLOGY TRANSFER

It is rather interesting to note that technology transfer occurred at every stage of human history. The method of glass production, brought into Britain by the Romans and Gauls, in 674 A.D. can be a typical example (Cooke - Mayes, 1996).

Technology transfer itself has been generally investigated since the 1960s (Quinn and Mueller, 1963). Most of the studies have focused on relatively aggregated transfer levels, such as firm-to-firm (often using the microscope of joint ventures), government institutes to industry, region-to-region or country-to-country. However, there have also been reports—often written by practitioners or consultants—describing *internal approaches* used by firms such as IBM, Canon, Sony, Kodak, HP, NASA, and Toyota (Harryson, 1998; Iansiti and West, 1997; Rebentisch, 1997).

In Germany, the first time that organized technology transfer started, was at the end of the nineteenth century. The establishment of engineering schools in the United States induced German technical higher education schools (*Technische Hochschulen)* to begin introducing research laboratories. The main mechanism was the professors who had consultancy arrangements with industry and provided trained personnel. In other words, the first forms of technology transfer appeared.

Between 1955 and 1970, with the help of its industrial policy, Japan absorbed almost all the advanced technologies invented in the first half of the twentieth century and successfully modernized its economy, becoming the second largest economic power. Japan spent only US$6 billion. If the Japanese had had to invent this technology, they would have had to spend US$180 to 200 billion (Min Chen, 1996).

Often the technologies transferred previously were the older generation types, and the established units were representatives of the lower levels in the Ferdows model, e.g. offshore and server types through the use of Joint Ventures and licences for limited time periods. Over the years the context of operations has evolved, e.g the business units are now aiming for higher positions in the model implying a greater degree of independence and competence and based on a long-term strategy. This seems to be of mutual interest both to companies and society within the objective of growth in business and the creation of welfare benefits for employees. At the same time it has also increased the sensitivity towards the security issue.

Technology transfer has been analyzed with several different terminologies. For instance, Roberts and Frohman (1978) examines technology transfer strategies by using three different bridges (procedural, human, organizational) while Eldred and McGrath (1997a) use the dimensions of program synchronization, technology equalization, and technology transfer management. (Nobelius, 2002).

ABOUT TECHNOLOGY TRANSFER

The process through which technology moves from outside sources to the organization is "technology transfer".

It should be clear that what is transferred may take one of many forms. It could be in the tangible form of a new piece of process equipment or embodied in a prototype product. It could be in the form of knowledge, codified via a patent license or a set of design specifications. It may be transferred in physical form or it may carry over in the knowledge and experience of a particular individual recruited to the firm. Technological knowledge may be coded in explicit form or held in a tacit mode, part of the informal knowledge derived from experience with particular activities. This multi - dimensional character of technology transfer suggests that mechanisms to encourage and enable it will need to be wide - ranging.

A second point to make about technology transfer is that it is not an instantaneous event but a time - based process involving several stages. These range from initial recognition of opportunity or need, through search, comparison, selection, acquisition, implementation and long - term use (involving learning and development). Leonard-Barton views technology transfer as a continuous process (Leonard-Barton, 1995).

In examining the literature of transfer the following critical points do emerge which should be taken into consideration in the development of technology policy. These include:

(1) Transactions in technology transfer are not always on the basis of one - to - one but may often operate through various forms of intermediary.

(2) Technology does not remain static over time but is constantly modified. This argues for flexibility in the design and application.
(3) There is often a strong cultural dimension embedded within a particular technology; when it is transferred to a different location implementation may fail because of an underlying cultural mismatch. One often cited example of this phenomenon is the case of computer - based production management systems such as Materials Requirements Planning (MRP) which evolved in the context of the US engineering firms. Transferring this technology to European sites, with a very different organizational model and underlying culture of working has not been entirely successful and thee are still problems with this technology some 30 years after its original development.
(4) Another point, which is often inadequately addressed in models of technology transfer, is the means by which firms learn to handle the process better over time. Development of managerial capabilities in technology transfer is of particular relevance in the case of transfers between industrialized and developing countries where there is a danger that a continuing state of dependence on outside sources will evolve (Bessant, Rush, 1995).

WHY TECHNOLOGY TRANSFER?

The Japanese firms had significant cost and time advantages over the US firms in cases where the firms' innovations were based on external technology - i.e. technology developed outside the innovating firm. Manslield suggests that a major reason for this result is the thoroughness and skill with which Japanese firms monitor and take advantage of foreign technology (Baron, 1992).
Mansfield cites other evidence indicating that Japan's rapid rate of technological advance is largely the result of technology transfer from abroad. He cites a 1978 survey of Japanese business leaders conducted by the Japanese Ministry of International Trade and Industry, which found that purely indigenous technology accounted for only about 5% of the advances in product quality and about 17% of the advances in processes. Mansfield also cites a 1983 survey which he conducted of 100 major American firms in 13 industries. in which the Japanese were consistently ranked first among the world's major industrial countries in their effectiveness at monitoring foreign technological developments.

Product life cycle

According to Vernon (1966) the product life cycle can be divided into three stages: new product stage, mature product stage and standardized product stage. In the new product stage, the product is manufactured in the home country and introduced into foreign markets through exports. In the mature product stage, as technology becomes sufficiently routine to be transferred and a firm's export position becomes threatened, the firm is induced to produce abroad, generally in other advanced countries. Finally, as the product becomes completely standardized, production will be shifted to low-cost locations in developing countries. Vernon pointed out that due to globalization the environment has changed. This change has weakened the power of the life cycle theory, although the age of technology may be correlated with the form of transfer, especially for large-scale projects. Firms invest large amounts of resources in research and development (R & D) with the intention of creating a unique competitive advantage. Their first move will be to export goods having the echnology content of the latest generation. It appears that brand new technologies may be positively related to foreign direct investments and mature technology with licensing. From the theory of the product life cycle developing countries can mainly obtain standardized technology through licensing agreements. Dunning (1995) points out that the only way in which developing countries can obtain advanced technology is through foreign direct investment (Wang Xing Ming, Zhou Xing, 1999).

The globalization of competition

The globalization of competition emerged from two factors: a) a dramatic shortening of the product life cycle in dynamic, knowledge - intensive industries, with every succeeding generation of products demanding new production techniques and (b) a need to attain global markets to amortize the enormous research and development costs required to stay at the cutting edge of technology and to remain competitive. In 1986, the top 10 firms in the telecommunications industry spent an average of $750 million each in research and development, representing 7.5 per cent of turnover. Reaching global markets became imperative and new forms of organization has to be devised to attain such goals.
According to a database of Futuro Organizzazione Risorse (FOR) reported in P. Mariti and R.H. Smiley and a sample o 143 European and 157 United States companies, Technology Transfer is considered to be the most important reason for interfirm cooperative agreements. The second motivation is the technological complementarity, while the others being marketing agreements, economies of scale and risk sharing.

Reasons and benefits

Competition, science & technology, market(saturation -wish for increasing the market share), legislation, human nature and company policy are some of the reasons that impose technology transfer.

The benefits that are hoped to derive of any action of technology transfer can be survival, competitive advantage, increased market share, higher growth rates, increased profit, improvements e.g. in quality, more flexibility, better service, greater long-term growth (Cooke - Mayes, 1996), that is to say, improved efficiency of the recipient's activities. Later in this chapter reasons and benefits of particular transferors and transferees will be analyzed.

Reasons and benefits are usually included in an organizations strategy, which specifies its objectives, such as: access to a market, improvement of competitive capability, access to cheap labor, gain benefits from foreign partner links, falling profit in existing markets, overcome trade barriers, access to cheap raw materials, and take advantage of favorable policies. Usually, technology transfer is part of the organization's global policy.

In most cases of the recipients, the triggering factor is the need to innovate in their product mix. Very often the object of the technology transfer is a specific design that the recipients identify in the international market, whether that is a simple transplant in the local market or a first- time introduction shortly after its international appearance.

Specially, when talking about developing countries, local recipients are no technological innovators. They need the new technology to increase their competitive advantage and strengths but the domestic markets for the innovations are relatively small, uncertain and probably unstable.

On the other hand, there are firms with a systematic growth strategy, based on the gradual introduction and mastery of successive innovations of increasing complexity. Some of these firms are usual visitors to international fairs and exhibitions and are permanently updated with respect to new developments.

Of course, there are still firms that reveal a more opportunistic strategy vis a' vis the role of technology transfer. They simply react to an external impulse, either in terms of an unexpected opportunity, or by way of a change in the market conditions (e.g. protectionist barriers to previous imports).

UNDERSTANDING TECHNOLOGY TRANSFER

Definitions

Technology transfer: a complex and multidimensional project

Technology is understood to mean a range of knowledge, skills, ideas, equipment and facilities that organizations need to produce goods and services. Transfer has three distinguishable modes:

(1) materials, final products, components, equipment and turnkey and/or ''product-in-hand'' plants;
(2) designs, blueprints and the ''know-how'' which provides the basic information, data and guidelines needed to create a desired capability;
(3) the ''know-why'' and software needed to adapt existing technology and to innovate [12,13]. (Saad et al. 2002).

Manuela Pe´rez defines Technology Transfer as the application of information into use, and involves a source of technology that possesses specialized technical skills, and the transmission to receptors who do not possess them and who cannot or do not want to create the technology themselves. (Pe´rez, Sa´nchez, 2002).

Economics defines *Technology Transfer* as the diffusion of the complex bundle of knowledge which surrounds a level and type of technology (Charles and Howells, 1996). (Coccia M., Secondo R., 2002).

Trying to give their own concept of Technology Transfer, E. M. Rogers et al. (2001), define *Technology* as information that is put into use in order to accomplish some task (Eveland, 1986). *Transfer* is the movement of technology via some communication channel from one individual or organization to another.
Therefore, *technology transfer* is the application of information (a technological innovation) into use (Gibson and Rogers, 1994). The technology transfer process usually involves moving a technological innovation from an R&D organization to a

receptor organization (such as a private company). So technology transfer is a special type of communication process.

According to Stock and Tatikonda (2000), Technology is "any tool or technique, any product or process, any physical equipment or method of doing or making, by which human capability is extended" In the operations context, technology is technical knowledge or "know-how" applied to improve an organization's ability to provide products and services. Because technical knowledge varies widely in degree of physical embodiment, a specific technology could be a machine, an electrical or mechanical component or assembly, a chemical process, software code, a manual, blueprints, documentation, operating procedures, a patent, a technique, or even a person.

Starting about forty years ago, several other definitions have been studied in literature, such as:

1. BROOKS, 1966: A process by which science and technology are diffused by human activities.
2. RUBENSTEIN, 1976: The transfer of abilities that fits, modifies and often innovates with respect to the product.
3. Zaltman et al., 1973; Kidder, 1981: Technology transfer is a complex, difficult process even when it occurs across different functions within a single product division of a single company.
4. ISLAM & KAYA, 1985: A creative adaptation of new technology to different environments.
5. Segman, 1989: Transfer is the movement of technology via some type of channel: person-to-person, group-to-group, or organization-to-organization.
6. Doinakis, 2003:Technology transfer is fundamentally the application of knowledge. The transfer of know - how from a unit to another one, aiming to the improvement of the effectiveness of the recipient's activities.

Technology transfer, for example, can refer to a company's development of a new commercial product. such as a new vaccine or a better computer, based on an advance in research at a university or another company. It can refer to the adoption by one company of an existing technology already in use at another company. a process generally known as ***technology diffusion.*** The word diffusion originates from the latin verb "diffundere" , which means the spread of something in an environment or a space (Hameri A, 1996).
It can refer to a company's obtaining advice from an expert on how to resolve a technical problem. such as a product design flaw or a failure in the manufacturing process. Evidence also exists that technology transfer between universities and industry can have a significant effect on the rate of innovation and productivity growth. (Baron, 1992).

To begin to appreciate the challenges of technology transfer, one needs to get beneath the view that technology transfer is simply handing off a piece of hardware from point "A" to point "B". In the present thesis, technology is defined to include knowledge or ideas as well as physical products (Weick, 1990; Pinkston, 1989).
Technology transfer can be ranked in terms of three levels of involvement. Technology development (Level I) is the most fundamental level. Here the transfer process can be largely passive through such means as research reports, journal articles, and computer tapes. A second, more involved level of technology transfer, technology acceptance (Level II), includes the responsibility of making certain that the technology is made available to a receptor(s) that can understand and potentially use the technology. The third and most involved level of technology transfer,

technology application (Level III), includes the profitable use of the technology in the marketplace as well as other applications such as intra-firm processes. Analysis of technology transfer must consider the rights and responsibilities of technology researchers and users given these three levels of involvement (Gimpson, Smilor,1991)

The common thread among the many extant definitions of technology transfer is movement of the technology from one organization to another; that is, across the organizational boundary of the source and recipient (Bozeman and Coker, 1992) However, characterizations of the initiation and conclusion of the technology transfer process vary widely. The starting point of the technology transfer process can be defined to be the point in time immediately after the recipient's decision to acquire a given technology has been made. People disagree on the factors that determine whether a transfer has really occurred. Some argue that technology is not transferred unless it is absorbed and actually used by the transferee. Others contend that how the transferee deals with the transferred technology should not be a determining factor as to whether the technology is in fact transferred.

Technology transfer is a person - to - person activity, or a body - contact sport. Inventions and new technologies spring from and reside in the human mind. Written descriptions, samples or even working prototypes rarely convey all that is to be known about a new technology. The developer's knowledge and intuition about further potential must be transferred via personal contact between individuals.
While the transfer of intellectual property is often thought of as the essence of technology transfer, such a view is misleading. Signing of license agreements, payments of royalties and transfers of intellectual property are among the few elements of technology transfer that lend themselves to quantification and thus they form the majority of available metrics of technology transfer. But unpatented know - how, ideas, and suggestions often constitute information of considerable value, however difficult to measure and evaluate. Among companies, mergers and acquisitions often have important technology components, but the value of technology is rarely visible in the public data on such events. Furthermore, other less formal mechanisms such as conferences, meetings and even personal relationships among technologists make an important but largely unmeasured contribution.
In addition, a semantic problem has arisen in recent years. The very term "technology transfer" has fallen out of favour among many who view the term as outmoded, too narrow in scope and too closely linked with the "linear" model of innovation. Others prefer "technology collaboration", "technology development", "technology utilization", or other terms. (Norman et al., 1997).

There are three types of information: a)Knowledge - based information (ideas, thoughts, plans, patents, theories). It can be conveyed in print through technical and learned journals, scientific magazines and patents and by word of mouth at conferences, at learned societies and in discussion with colleagues and acquaintances.

Knowledge is an abstract concept consciously or unconsciously built up through the interpretation of information acquired through the experience and meditation on the same giving its possessor mental and physical ability in an art (Nonaka, 1994; Rullani, 1994).

The creation of organizational knowledge is the result of social interaction between individuals. The former, also known as formal knowledge, includes the knowledge contained in books, manuals and documents and is produced by individuals through organization in the form of reports, documents, plans, databases, data sheets, projects, formulas, etc.

This knowledge is linked to the ease of acquisition, comprehension and application of the same by the users. Organizations generally meet no difficulties when they attempt to capture knowledge which is presented in this form. Azzone and Maccarone (1997) point out that formalized knowledge can be spread indirectly (or tacitly) through training courses with a theoretical approach.

However, another form of knowledge exists, informal knowledge, composed of facts, ideas, opinions, judgments, assumptions, meanings, questions, decisions, suppositions, stories, etc. This knowledge, also called tacit, has the same importance as formal knowledge, but it is almost invisible (Polanyi, 1962). It generally emerges when a process of social interaction occurs within a certain context (meetings, lessons, face-to-face conversations, in-the-field demonstrations). Consequently organizations often either underestimate its value or ignore because they find difficult to measure it. During the process of creation of knowledge, this changes continually passing from the informal state to the formal state and back again. Knowledge is the basis for effective interpretation of a situation, but tells us nothing about the ways in which it can be used.

Competencies, the other variable of the technological transfer function, can be defined as the capacity to apply one's know-how, the capacity to use knowledge efficiently. While knowledge is similar to a product, competency is more similar to a process. Competence, therefore has a strong procedural or behavioral component. It is the result of an interaction between the structures of knowledge and given abilities in applying it as a process. Organizational competencies emerge as the behavior of individuals within the organizations. They are, in a certain sense, trapped in the links between the different individual skills or competencies (Nelson and Winter, 1982).

Badaracco distinguishes two kinds of knowledge: the migratory and the embedded one. The migratory knowledge is the one that moves very quickly and easily, because it is encaptulated in know - how, patents, designs, manuals of machinery (frozen knowledge). It travels through the medium of professionals who relocate and through consultants and teachers, or it becomes available through licensing, joint ventures and other channels of technology transfer. Capable transfer can start with reverse - engineering, improve the technology (e.g. extend machine efficiencies or upgrade quality) and finally the improvers can become owners of know - how, while also becoming competitors. Japan employed migratory knowledge to improve foreign technology for its economic advantage and then moved the improved technology across Asia.

On the other hand, *embedded knowledge* moves slowly, for it resides in complex social relationships that cannot be easily articulated and shipped. Embedded knowledge is the collective competence (i.e. core competence) of the people forming a team, a department or a company. It is a holistic competence, strategic and valuable.

The enabling mechanism for transferring this competence is the knowledge link. Learning from the partner is a central objective of the alliance.
Badaracco illustrates this knowledge system by considering the capability within Toyota Motor Company, an interactive composite of the entire constellation of operating policies, traditions, morms, specialized knowledge and routine practices that Toyota has evolved over the past 50 years, through its managers and suppliers, networked in special relationships. It includes the just - in - time (JIT) inventory system, participative labour management relations and intense commitment to the success of the Toyota family of affiliated companies. By perfecting the "Toyota way", the company has become one of the most profitable and powerful companies in the world. Toyota Motor Company is only the pivot of a vast network of primary, secondary and tertiary subcontractors with special relationships with each other.

Tangible ⟷ **Intangible**

Patent, Coded Documents
Licensing
R&D, production process
Specialized knowledge
Capability

Fig. 2 Technology continuum by Tihanyi Laszlo, Roath S.

b) Skill - based information (hands - on experience).

c) Equipment - based information via products, trade magazines and conventions. It is also conveyed by sales representatives, direct mail and advertising. Another information channel is through contacts in other companies or acquaintances that move in other spheres (Cooke - Mayes, 1996).

Looking at the content of transferred intangible technology, there are three main elements to be mentioned: plant design technology (layout, building, infrastructure, etc), process know - how (organization or production line, planning of material flow, quality control etc) and product technology (choice of materials, product design, new product know - how etc). These know - how can be transferred in a package or separately.

In essence, technology transfer is the process by which manufacturing industry keeps up with the march of technology. It is the process that ensures that production once started is maintained or - ideally- expanded. The technology transfer helps the company more effectively use its human, physical and capital resources by providing information or assistance, which leads to improvements in its facility, equipment, manufacturing methods or marketing methods (Cooke - Mayes, 1996).

By Norman et al. (1997), Technology Transfer is defined as the movement of technological and technology - related organizational know - how among partners (individuals, institutions and enterprises) in order to enhance at least one partner's knowledge and expertise and strengthen each partner's competitive position. It is usually iterative, involving multiple transfer steps. It can take place via informal interactions between individuals, formal consultancies, publications, workshops, personnel exchanges and joint projects, involving groups of experts from different organizations and the more readily measured activities such as patenting, copyright licensing and contract research. Technology Transfer may be confined to specific regions, or may span regions or nations within one continent or across several continents.

In its most general meaning, “technology transfer” is seen as every process that aims at transferring technological know-how from (Kim, 1990):

- √ *donor* — e.g., a university, a research center or R& D departments of firms; with the technological capability to one or more:
- √ *recipients* — firms which may either directly use or co-develop the technology and own to have developed capabilities for new production.

Following the terminology of Bennett et al. (1999), a technology supplier is referred to as the “owner” of the technology, and the recipient is the “acquirer”.

There are a number of unique features in technology transfer. First, commercial technology transfer is highly monopolistic, since technology, as the product of an invention is unique. In order to maintain the advantage of its technology and products, the owner of a technology does not normally transfer the technology, except in some specific situations - for example, when a transfer is necessary for occupying the market, when the transfer can bring huge profits, or when the transfer does not threaten its monopoly.

Secondly, technology transfer can be of multiple exchange. The number of transfers will have a direct impact on the value of the technology (Min Chen, 1996).

The basic model of technology transfer is described by Samli (1985) and keeps five key components in balance: the sender, the technology, the receiver, the aftermath and the assessment. It also includes six dimensions of technology: geography, culture, economy, people, business and government.

Finally, it is worth referring von Hippel, who describes the innovation and technology transfer process as a distribution of activities between developers and users. There are three possible patterns in such an activity allocation process. These are:

1. *Manufacturer-Based Design*: Marketing research provides information to the manufacturer with regard to user needs. The manufacturer combines this information with available in-house knowledge to create a product or service that is responsive to user needs.
2. *Iterative User and Manufacturer-Based Design*: Problem-solving resources, both at the manufacturer’s and users’ sites, are utilized. An iterative shifting of problem-solving activities (very much a trial-and-error process) occurs between the two sets of sites.
3. *User-Based Design*: Solution information is transferred to users. Users then develop a new product or service that satisfies their own needs. Much information held by users is tacit in nature. Many skills and expertises are tacit in nature, as noted by Polanyi, who points out that often “the aim of a skillful performance is

achieved by the observance of a set of rules which are not known as such to the person following them" (p. 49) .Continuing, he notes that "even in the modern industries the indefinable knowledge is still an essential part of technology."

As an example, he recounts that "I have myself watched in Hungary a new, imported machine for blowing electric lamp bulbs, the exact counterpart of which was operating successfully in Germany, failing for a whole year to produce a single flawless bulb." Hence, "an art which cannot be specified in detail cannot be transmitted by prescription, since no prescription for it exists".

Classifications of Technology Transfer

Technology transfer is classified according to the way it is knowledge is exchanged to formal (direct or indirect) and informal.

Direct technology Transfer is linked to specific technologies or ideas ant to more visible channels such as contract or cooperative research projects.

Indirect technology transfer concerns the exchange of knowledge through such channels as informal meetings, publications or workshops(Kingsley et al., 1996).

Another way to clarify the objective of technology transfer is according the Technology characteristics, the most common of which are:

Type (e.g. product/process, hardware/software), scale (e.g. entire plant, sub - system etc), assessment, market demand, legal demand, project's technical goals, risk (technical, commercial, political).

Authors talk also about "hard" and "soft" technology transfer.

Technological transfer in the strict sense of the term

This activity generates a process of formalised or tacit communication of new ideas/concepts from the knowledge source to user, or indirectly through interface, with the aim of resolving a problem/need. This activity includes four typologies: research projects, prototyping (design and development of new products and/or processes), training (courses, stages aimed at increasing the scientific preparation and/or training of subjects in given fields) and know-how (the activities of design–instruments, methodology, techniques, algorithms, software programs–and specific consultancy).

Technological transfer in the wide sense

This is a service to the users, who require scientific instrumentation, skills and experience available from the institutes. This activity, like the previous one, is formed of four parts: (1) Homologation, evaluation of the performance of a product /process/ service according to the national and international regulations. This activity is carried out by the agricultural mechanization institute. (2) Analysis and testing is carried out by the wool research institute (analyses of textile properties) and by the metal machinability institute (abrasion resistance on metals). (3) Calibration, setting or checking operations for the correct use of equipment or devices, comparing the indications of the instruments being examined with a sample instrument, is carried out mainly by the metrology institute and to a lesser extent by the metal machinability institute which measures surface roughness of metals. (4) Accreditation and certification, when an important institution (in this case Cnr institutes) recognize the firms, by certificate, authorized to carry out specific activities or produce certain products, is generated by metrology and agricultural mechanization institutes.

The *education-oriented technology transfer* is a transfer of knowledge that does not generate financial revenues for research bodies. It is represented by trainee personnel and teaching courses held by researchers in outside institutions. These activities are, generally, tacit because for transfer a process of social interactions within of a certain environment is necessary (lessons, face-to-face conversations, etc.) and capable of being learned through practice 'learning by doing' (Dosi, 1982). *(M. Coccia, S. Rolfo / 2002).*

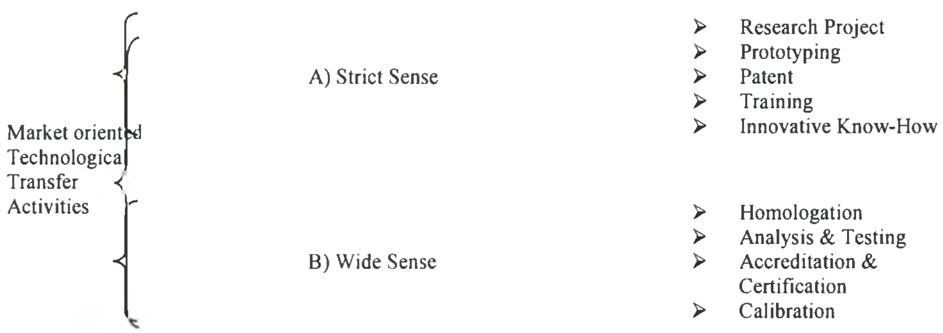


Fig. 3. Market oriented technology transfer activities carried out by the Car Institutes operating in Piedmont (Italy). Source: Ceris – Car [2000]

Almost all authors adopt the definitions for "hard" and "soft" technology:
"Hard" technology: the product technology and the equipment to produce them. This type of technology can be purchased, licensed or copied.

"Soft" technology: management systems and organizational structures that implement the hard technology and make it effective.
Respectively,

"Hard" Technology Transfer is called the R&D cooperation that consists of contract research by third parties (companies, public or industrial research facilities, universities, technical colleges, engineering offices) and joint R&D with or without a contractual basis.

Technology - related activities ("soft") include informal contacts for the purpose of information exchange, performance of technoeconomic studies, joint utilization of laboratories and other testing instruments and facilities, employment of university students as trainees or interns and the preparation of a graduation or doctoral thesis (Norman et al., 1997).

Finally, a broad distinction in literature is made based on the nature of the donor and the recipient. Accordingly, there is an almost different literature referring to the technology transfer between donors and Less Developed Countries (LDCs), from firm to firm, and from university / institutions to industry, including in all cases the formation of consortia.

Transfer scope

Another element of the technology transfer process is the transfer scope, which answers the question of "what is transferred" (Rebentisch, 1997). The term refers to the technology width and depth, i.e. what knowledge needs to be transferred and what its complexity is. In a simple case (e.g. a lock hoop), the transfer scope might involve a single blueprint mailed to the receiver. In more complex cases (e.g. an engine), the transfer scope might involve prototypes, test methods and results, as well as documentation regarding alternative concepts. Hence, the technology intended for transfer might be represented in different forms.

Rebentisch presents a simple model of technology scope, without any discussion about level or nature of knowledge (Rebentisch, 1997). The categories of technologies transferred are: General information, Specific information, Hardware, Procedures or Practice. Aoshima (1994)makes a similar classification when he discusses two possible modes of technology transfer, output transfer and know-how transfer. Output transfer is simply codified in a tangible form such as blueprints, while know-how transfer represents a more complex process.

Know-how transfer is a form of tacit knowledge transfer, often requiring intensive communication between the involved parties. It can be further divided into system and component knowledge transfer, in line with Henderson and Clark's (1990) discussion. According to Aoshima (1994), cross-functional work generates system knowledge, while component knowledge typically is generated within a specific function. Therefore, the retention and transfer of system knowledge are more difficult than for component knowledge. The transfer of system knowledge, according to Aoshima (1993), is a very important aspect that has been neglected by researchers.

Transfer management

Transfer management answers the more operative question of "how to transfer the technology", i.e. both the transfer process and the transfer method. This dimension is vital since managing hand-offs between units has long been considered troublesome, both in the literature and in the industry (Trygg, 1991; White, 1977). For example, in the computer mainframe industry, Iansiti and West (1997) has observed the creation of a "technology integration team" solely responsible for the forthcoming transition. Eldred and McGrath (1997a) stress the need for a structured management process with clear definition of individual and team roles and responsibilities.

When viewing approaches for overcoming potential barriers, three different types of "bridges"are proposed: procedural, human, or organizational bridges. These approaches might be illustrated by Harryson's (1998) examples of mechanisms used by Canon, Sony, and Toyota. Canon focuses on commercialization of unique technologies, Sony on product innovation through corporate synergies, and Toyota on management of complexity and heavyweight projects (Harryson, 1998). They do to some extent share a strategic base concerning approaches to technology transfer. They use certain mechanisms in order to create an understanding of the forthcoming development stage, with commitment and interest from the people involved in the next stage, and they all try to increase the system knowledge gained by the personnel. Human bridges are exemplified by the transfer of researchers from development further down the road all the way to the factory floor, an approach stressed as "*...the only effective route to commercialization*" by a manager at Sony (Harryson, 1998).

Further, an organizational bridge used by the three companies is strategic rotation between the functional departments. This strategic rotation occurs at Toyota when managers change position every 3 years, engineers do so every 5 years, and new recruits spend 3 months selling cars and 3 months in a plant. The extreme in this case is Canon, where 200 employees are relocated every 6 months in order to receive new neighboring colleagues—and of seven to eight participants in the earlier research stages, approximately five project members remain at the latter production stages (Harryson, 1998). Finally, examples of procedural bridges used to ease a forthcoming transfer are to require sales experience among the R&D people, and to use research-sponsoring mechanisms as internal market forces (Harryson, 1998).

When discussing these three bridges relative to each other, the use of human bridges has been widely regarded as the most effective mechanism.

Synchronization

The number and sources of new technologies are increasing at the same time as the product life cycles are decreasing. Consequently, in order to manage applied research, the timing of the technology development and transfer is vital. The limited window of opportunity raises the requirements for decisions concerning the technology development speed, the match between technology and product strategy, and the readiness level of the transferred technology.

Managing the transfer scope of applied research

The transfer scope of applied research deals with decisions about what to transfer. The chosen transfer scope is compared with what is actually perceived as lacking in the transfer from the counterpart, thus identifying a potential "project scope gap".

The natural basis of transfer scope consists of the chosen concept together with the test results and recommendations. Apart from those dimensions, a description of the applied research task as a whole (including aim, vision, and resources) is also frequently transferred.

If the transferred result-oriented information is considered inadequate for the receivers, they have some obstacles in finding the persons or suppliers who are knowledgeable about the project—and the know-who information is seldom included.

Here arises the need for more implementation-oriented advice, such as suggestions for appropriate commercialization dates, recommendations, estimate of start-up costs, and the foundation for decisions taken within the project along the way. This highlights the problems that the product developers have to deal with, problems that seem not to be focused upon by the applied researchers. These problematic issues are connected with the implementation and adaptation of the new technology; i.e. the product developers need to fully understand the vital choices being made when developing the technology in order to be able to make the necessary adjustments to fit the technology into the whole system (Buratti, 2001).

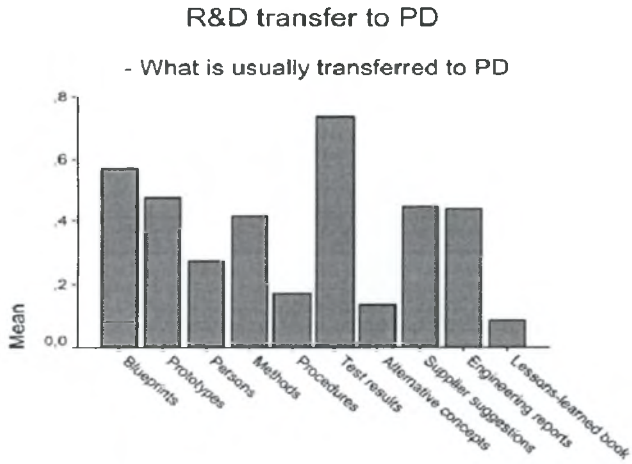


Fig.4. R&D transfer – what is usually transferred to product development (Boolean scale: Checked or not checked).

Organizational capability in Technology Transfer

The implications of the points raised above for technology transfer policy are clear. Firms differ not only in their technological competence but also in their capability to absorb and assimilate new inputs of technology. Managing such a complex process requires high levels of managerial skills and innovative capabilities on the part of the firms.

1) Recognition of requirements for technology through a systematic and regular audit of its current competencies and a comparison of those which it needs to develop or acquire in order to become or remain competitive. Essentially firms should have a technology strategy and be able to plan its growth and development.
2) Exploration of the range of technological options available (i.e. different technologies, different machines etc) and search widely for these so as to get a good fit with their needs.
3) Comparison between all the options available which can be achieved through some form of benchmarking.
4) Selection of the most appropriate option based upon this comparison.
5) Acquisition of the technology (either through direct purchase or via some form of license, collaboration, alliance etc). This is a likely to involve extensive negotiation around price, specification, transfer of knowledge, property rights etc.
6) Implementation of the technology within the firm. This may involve extensive project planning and management activities and require configuration of both technology and organization to get a good and workable fit.
7) Operation of the technology and learning about how best to use it. Over time this may involve extensive learning and development; competence is very much the product of this last stage of accumulation and incremental development, and much of what is represented by technological competence is highly firm - specific and often tacit in form.

The lack of the above managerial capabilities represents one of the main barriers to technology transfer and is a key area towards which external policy support might be directed. One possible element in such policies is the use of consultants as intermediaries to assist and advise firms, effectively to compensate for a lack of capability. Examples of such intermediaries include technology brokers, university liaison departments, regional technology centers, innovation agencies and cross - national networks such as The European Association for the Transfer of Technology, Innovation and Industrial Information. Their inputs can be direct, offering transfer of specific technological competence, but they are often involved more in a wider and more flexible interaction in the process by providing a number of information and related services which help to bridge the gap between technological opportunity and user needs.

USER NEEDS	BRIDGING ACTIVITY	SUPPLY SIDE
Technology	Articulation of specific needs Selection of appropriate options	Sources of technology
Skills and human Resources	Identification of needs Selection Training and development	Labour market Training resources
Financial support	Investment appraisal Making a business case	Sources of finance-venture capital, banks
Business and innovation strategy	Identification- development Communication - implementation	Environmental signals threats, opportunities etc
Knowledge about new technology	Education information - implementation	Examples of best practice
	Locating key sources of new Knowledge	Emerging knowledge base
	Linkage with the external knowledge system	
Implementation	Project management Managing external resources Training and skill development Organizational development.	Specialist resources

SMEs are a vitally important source of industrial development and hence of employment generation and economic growth. In particular, the simplistic model of linear transfer from the university research to industrial application has given way to one which recognizes the high variety of needs and the necessity of working in more interactive mode.

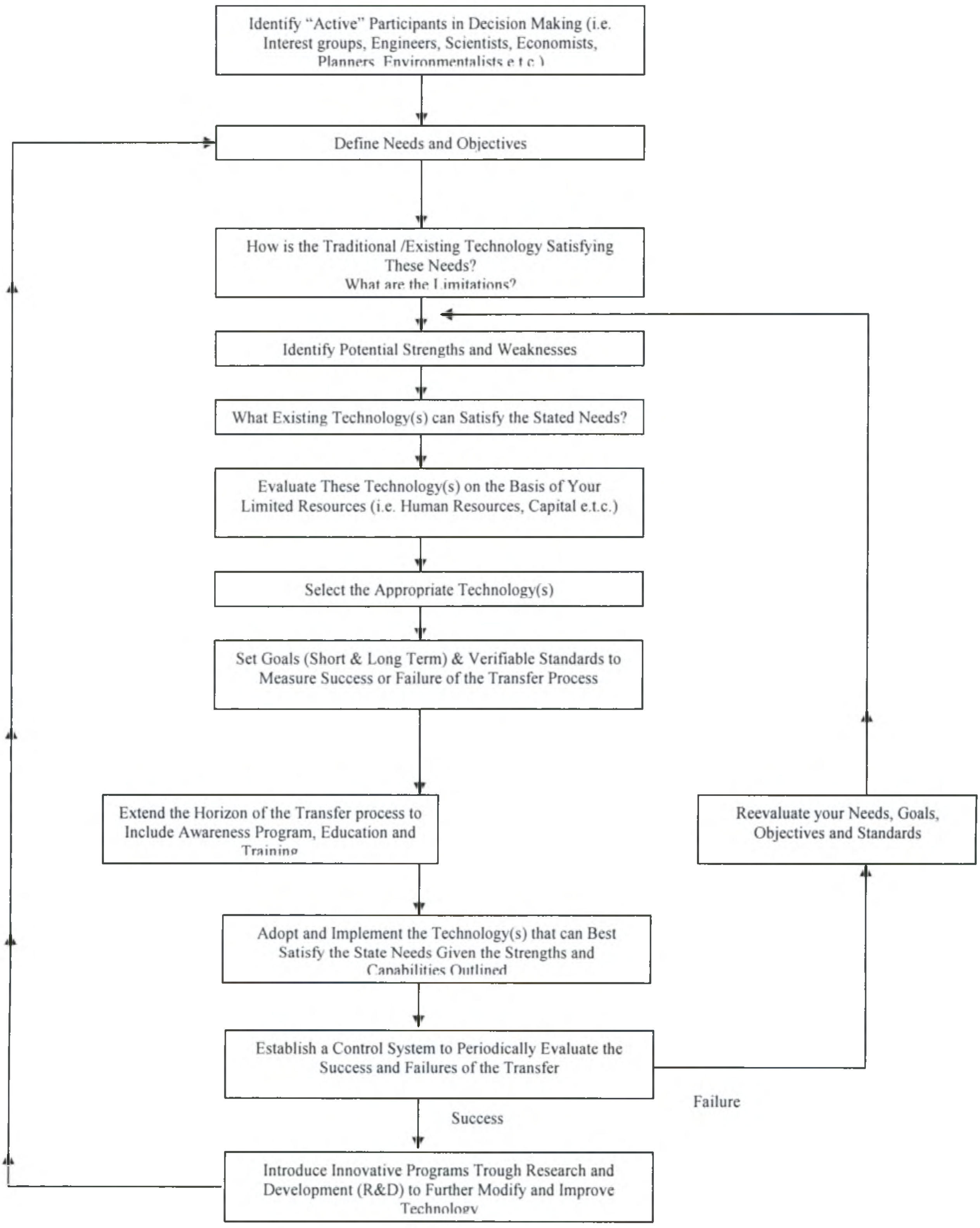


Fig. 5 The technology transfer process (adapted by Madu, 1989)

TECHNOLOGY TRANSFER MECHANISMS

A mechanism is a medium of transfer. The most commonly used are:

- Vendors and Suppliers of technology, although usually interested in selling their equipment.
- Professional and trade associations (particularly engineering associations). They produce and market newspapers, academic journals, trade magazines, newsletters, video - based training programs and reference books etc. They own databases and libraries.
- Consultants and service firms: They are analyzed below.
- Supplier development programs. The nature of these customer - led programs varies widely from general reviews of supplier progress and advice to comprehensive customer - mandated programs to help suppliers meet mandated quality and other standards.
- Institutes Universities, Technical Schools etc.
- Blueprints, drawings, designs and technical assistance in the form of training of personnel, training programs, personal assistance in assembly, special equipment, the supply of critical components, etc.

Seaton and Cordey - Hayes (1993), in a selection of mechanisms in Britain refer to the

- Regional Technology Centers with a mission to improve access and to facilitate acquisition of known technologies,
- Science parks, an attempt to reduce the problems of access through physical proximity and support,
- Joint ventures that reduce the financial risks and improve the channels of transfer.

In their book, Technology Transfer systems in the United States and Germany, the authors of the U.S report define the term technology transfer broadly, incorporating the following mechanisms:

- Formation of new technology - based companies from R&D organizations (spin - offs and others)
- Licensing of patents, software and technical know - how, prototype, biological materials
- Performing contract or subcontract R&D for clients and transferring the resaults
- Sharing information in interactive events (conferences, workshops, briefings and visits)
- Cooperating in product development
- Performing cooperative R&D
- Forming R&D or technology transfer consortia
- Providing technical assistance
- Employing unique R&D facilities and capabilities
- Activities that catalyze or facilitate any of the above.
- Training, transferring of people.

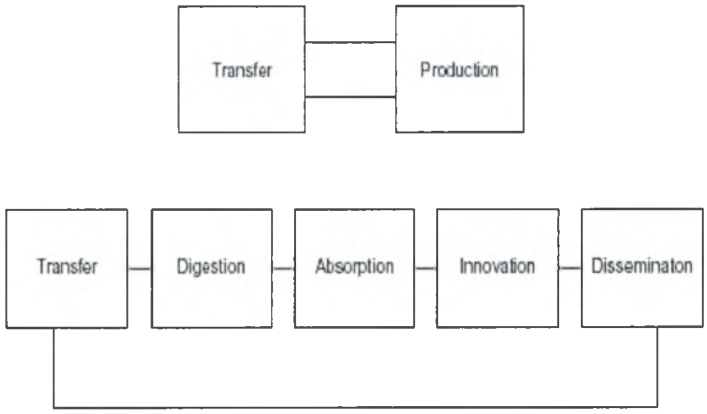


Fig. 6 Traditional and new mechanism for transferring Technology

Limitations and deficiencies in technology transfer mechanisms

Most current technology transfer mechanisms exhibit one or more of the following limitations or deficiencies:

They fail to recognize adequately the significance of recipient organizations' needs and therefore fail to address service delivery aspects of the technology and knowledge transfer process. That is to say, mechanisms tend to emphasize the marketing and selling of technology as products to organizations that have explicit needs and requests rather than provide a business service that aids the process of diagnosis, searching for and matching the available technology to implicit needs.

The mechanisms tend to offer 'technology' primarily in terms of technical and economic attributes, i.e. as a product, thus failing to consider the responses of organizations and the individuals within them to the opportunities and threats generated by technical change. They therefore fail to understand the actual, and generally more limited, cont~bution of a candidate technology to competitive advantage or effectiveness.

They underestimate the importance of the interactive processes and mechanisms between the donor (vendor, intermediary, R&D organization etc.) and the recipient, necessary for successful transfer. They fail to recognize that successful transfer seldom involves just a simple one-off transaction but is a process or dialogue between a variety of actors in the two parties and involves a continuing relationship to the point where real benefit accrues to the recipient.

They assume that technical change is a priority as far as the organizations are concerned and, even when this is not so, that organizations are readily able to diagnose their problems in terms of technical change and subsequently to articulate their needs in well-specified technical terms.

The tendency is to assume that organizations have a well-defined shopping list rather than a set of ill-defined business problems of which technical change may only be one.

The deficiencies outlined above arise because many transfer mechanisms and organizations fail to apply a sufficiently 'client need' oriented approach. The noticeable characteristic of technology transfer in the UK is a preoccupation with:

- creating new technology;
- making technology available;
- increasing information about what is available;

and

- facilitating transactions between supplier and potential user.

CHANNELS OF TECHNOLOGY TRANSFER

When talking about channels in technology transfer, one refers to the connection between two or more entities (countries, companies or even persons), through which several mechanisms can be activated (Autio & Laamen, 1995). Turning to what kind of information channels are used to spread the end results of applied research, the most frequently used channels are organized and informal ones, while written information is used less. Examples of frequently used organized channels are department meetings, applied research focus days, and applied research seminars.

Two broad types of technology transfer channels are the:

1. the trade channel which includes sale of technology, licensing and franchising arrangements (Zhu *et al*., 1995); and
2. the investment channel encompassing coproduction agreements, project or equity joint ventures, company acquisitions and transfer to own subsidiaries by multinationals (Bruijn and Jia, 1993).

As to the question of what channels are used when searching for applied research work, the views are somewhat different, with more focus on informal channels.

The main sources of applied research information are involved colleagues, group and department meetings.

Hence, the more formal channels are used for spreading results, while more informal ones are used to search for the same information.

What is also notable is that written information is not used as a frequent channel for spreading information, or for accessing information about applied research.

Other typical channels of technology transfer are on - the - job training, active patent policy, for - profit "innovation centers" - each associated with a non profit institute. R&D consortia (bottom - up approach) (Norman et al., 1997), dense networks of non - R& D - performing institutions, chambers and industrial associations. In 1995, in Germany there were more of 650 industrial and more than 400 other - type associations, which among other tasks, facilitate the transfer of knowledge between the scientific world and industry. Universities develop closer ties with industry through establishment of patent licensing and technology transfer offices, affiliated institutes and research centers, high - tech incubators and research parks. Informal contacts via meetings, telephone conversations and so forth, are critical to successful technology transfer. Such contacts promote the discussion and exchange of research results and lay the groundwork for more formal types of cooperation such as grants or contracts.

Consulting (for example on the solution to a problem), technical assistance, the exchange of the research staff are important channels of technology transfer. Faculty consultancy is also promoted. In USA regular consultancy by professors with multiyear contacts seems to be an effective means for establishing long - term relationships with industrial partners. While in Germany it has a more of a short term orientation.

Patents, spin -offs and licensing of intellectual property rights are also used. The establishment of spin - off companies by scientists presently working for others - usually much larger industry or university research units is one of the most effective channels of technology transfer.

Formal cooperation on projects of common interest - joint implementation of R&D projects, subcontracting, sharing of laboratory and equipment, directed search for R&D personnel or graduates.

Min Chen concentrates on licensing, franchising, direct foreign investment, sale of turnkey plants, joint ventures, subcontracting, product in hand contracts, cooperative research arrangements and co- production agreements, export of high - technology products and capital goods, reverse engineering, exchange of scientific and technical personnel, science and technology conferences, distance learning, trade shows and exhibits, education and training of foreigners, commercial visits, management or marketing contracts, open literature (journals, magazines, books and articles), industrial espionage, end - user or third country diversions, government assistance programs, etc. He adds shareholder site demonstrations, receptor organizations, tutorials, representatives, and technical videotapes. He considers the first seven ones as formal.

A. Efstathiades et al.(2000) recognizes three types of technology transfer under the joint venture category, based on the level and type of contribution of the firms (Djeflat, 1988; Edosomwan, 1988). These are:

1. supply of machines from the foreign firm;
2. supply of patents, licenses or manufacturing processes;

and

3. supply of personnel to oversee the start-up of the machines and provide technical assistance.

Specially, types of Knowledge Transfer from Academia to Industry are referred by Herden (1992) to be consulting on problem solution, training of qualified personnel at universities, joint implementation of R&D projects, subcontracting of R&D projects, sharing of laboratory and equipment, information on the market potentials of new products, directed search for R&D personnel, directed search for recent graduates (non R&D personnel), licensing and short - term assignment of R&D personnel to universities

Summarizing the above, the channels can be classified as cooperation between men, companies, research and educational institutions and countries.

LITERATURE REVIEW ON FACTORS INFLUENCING TECHNOLOGY MANAGEMENT

Transfer is a highly complex and dynamic process and it has to encompass a crucial consolidation stage, which often includes adaptation, modification, and sometimes reinvention (Saad, 2002).

The changes in technology (e.g. technology intensity, shifting role of technology users) and the changing institutional systems (market regulations, tax laws, intellectual property rights protection, financial infrastructure development) have significant implications on technology transfer policy.
As an example, skilled labor in Hungary, e.g. is about half the cost of Ireland's. Using the skilled labor as a powerful leverage, Hungary recently lured away a multimillion - dollar high tech U.S. investment from Ireland.
These countries have also been developing their legal systems to protect intellectual property rights, an important consideration of technology transfer.

Research on technology transfer has traditionally concentrated on effective linkage and information movement usually to the exclusion of management theory (Levinson and Moran, 1987). An exception of this tradition is Creighton et al. (1985), who isolated nine elements that were repeatedly stated or implied in descriptions of technology transfer models. These elements were:
organization; project; documentation of information; distribution of information; linking; capacity to transport or receive and to act; credibility of parties or organizations in the transaction; willingness to transmit, receive or implement ideas; and reward.

Other variables such as risk, cost, and timing of the transfer process are also cited as being important to successful technology transfer (Inman, 1987; Pinkston, 1989; Gibson and Rogers, 1991).

The Technology Transfer literature discusses a range of factors, such as culture, economic and political issues, knowledge, and strategic, operational and supply chain arrangements (Eldred and McGrath, 1997; Gupta et al., 1997; Tyre, 1991). The literature deals extensively with the sociocultural dimension, and cultural proximity between supplier and adopter (Hemais, 1997). Kuper (1999) suggests that cultural differences persist in a changing world: "distinct ways of life once destined to merge into 'the modern world' reassert their difference, in novel ways". Gergen and Whitney (1996) see technology as a mechanism for transformation, creating new forms of social construction arising from the "adoption of alien beliefs, values and practices...undermining of traditions, colonisation of perceptions, attitudes and actions" by the dominant party in a business relationship. Bowmaker-Falconer et al (1998) believe that "a failure to understand cultural and other differences can lead to misguided assumptions, poor working relations, underperformance and discrimination". Mbigi and Maree (1995) agree that "cultural dimensions seem to have a significant impact on the management of transformation".

In considering the transformation brought about by technology in DCs, Lessem (1996) refers to "crossing the north-side divide, where the three interrelated facets of society, namely authority, economy and community, form an interrelated whole...the authority pole stands for the rationality of the north, and the community pole for the humanism of the south, the economy represents a force of pragmatic integration". Pragmatism would accommodate competing cultural identities in their quest for dominance (Oliver, 1998), and supportive distinctiveness, where, for example, "African modernity complements the European and the new world modernity, yet it cannot be identified with it" (Matustik, 1998). There is a balance between ignoring culture and allowing the study of technology management to be subsumed by it (Kuper, 1999). Peppard (1996) ascribes the divergent findings of researchers to the different contexts in which research is conducted, and claims that wide differences in opinion do not permit simple and definitive conclusions to be drawn.

Differences in cultures, industries and individuals are compounded by diverse political and economic systems, requiring the transfer of core techniques as well as business and management philosophies. Several authors (Adjibolosoo, 1994; Kahen, 1997; Kim, 1998; Lado and Vozikis, 1996) emphasise the influence in technology planning of social and political factors, government policies, the acquiring country's level of economic development, the absorptive capacity of local firms, the lack of research and test centres, IT infrastructure, and other industry linkages. Technology Transfer is an interorganisational process with multiple outcomes (Spann et al., 1995), requiring an assessment of costs, benefits, and tangible improvements, (Hackman and Wageman, 1995; Wilkinson and Wilmott, 1995; Wilson, 1991). Assessments of success vary because objectives are ambiguous and inconsistent measurement standards render evaluation difficult (Armistead et al., 1995; Dixon et al., 1994). Less directly measurable are the non-quantifiable merits of TT, such as compatibility features of the technology, and the technical and commercial effectiveness (Bennett et al., 1999).

Lall (1993) sees many 'implicit' elements in technology that need a long period of learning to master. These are a function of experience, but are enhanced by investment in training by the technology owner and acquirer, the search for new technical and knowledge solutions, and developing organisational capacities to create, communicate and diffuse knowledge internally.

Successful technology transfer depends on the cumulative experiences of key personnel. Explicit knowledge, in the form of hardware, procedures, and practices may form only a small part of the sum of knowledge to be transferred (Nonaka and Takeuchi, 1995), since the transfer of some technologies requires subtle skills and knowledge that are difficult to codify (von Hippel,1994). The overall technological characteristics are the easiest to transfer (the explicit issues), with operational fine-tuning presenting the greatest challenges (Katz et al., 1996).

Knowledge creation requires an understanding of all products and processes. The technology owner is frequently reluctant to reveal all about a technology, whereas the acquirer is keen to gain as much understanding as possible. The result is described by Marcus (1992) as an uncompromising sense of paradox between resistance and accommodation, with the sophisticated acquirer demanding greater access to codified knowledge and insisting that the owner makes tacit knowledge more explicit.

Knowledge transfer depends on the ability to evaluate and learn all aspects of a technology. One functional discipline where this is particularly important is maintenance, which now demands greater attention for a number of reasons: intensified competition requires strict cost control, with maintenance accounting for an increasing share of operational costs (Paz and Leigh, 1994); safety and environmental disasters are increasingly attributable to equipment failure; maintenance itself is changing, with substantially different ways of understanding the nature of failure (Moubray, 2001); automated facilities operating in a just-in-time regime require higher availability and reliability from plant and equipment; new technology has introduced equipment and systems where no operating and maintenance experience exists. High levels of production competence and an understanding of equipment failure patterns are essential before maintenance requirements can be determined (Jaikumar, 1986; Cleveland et al., 1989; Ferdows and De Meyer, 1990).

Leonard-Barton (1995) sees technology activity between countries as a flow of technological capabilities, or knowledge-creating activities. Along a continuum of technological capability Leonard-Barton (1995) identifies four levels in a "technology capability ladder":
(1) assembly or turnkey operations,
(2) adaptation and localisation of components,
(3) product redesign, and
(4) independent design of products.

In DCs the first two levels are more likely to predominate. The first level is "a process of converting or transferring scientific or technological knowledge directly into the satisfaction of a customer need; the product...(is) the carrier of the technology" (Twiss, 1986). For example, an automated system installed as a turnkey project may obviate the need for skilled operators and ensure consistently high quality, although it may not necessarily be suitable in a DC environment. Since it is not always possible to capture and describe all activities in procedures, and the appropriate degree of proceduralisation (and hence automation) depends on the level of knowledge of a process (Bohn, 1994), too high a level of technology can be extravagant and may render the process unworkable or worthless as intricate operational procedures cannot be followed or breakdowns become irreparable.

The challenge at Leonard-Barton's second level is to identify appropriate technology and to assess the extent to which an owner's technology needs to be modified for adaptation to local situations (Platt and Wilson, 1999). A facilitating feature of TT is the robustness of the technology, where transfer to any environment takes place without adaptation to local conditions: robustness is "recipient-independent" (Grant and Gregory, 1997).

Incorporating technological considerations in strategic decisions requires a balanced assessment of product complexity (for value maximization) and process complexity (for cost minimization) (Sharif, 1997), but resources, and financial and competency-based constraints will restrict DCs in their selection of technologies.

Lennon (1997) discusses the need for continuous updating of equipment and processes, and the relevance for developing countries of attaining technological parity, achieved in part, by skills and infrastructural development, research, and education in a knowledge context (Davies, 1993).

A resource-based view of knowledge management identifies distinct capabilities and knowledge as the basis of differential firm performance. Helfat and Raubitschek (2000) speak of the "*coevolution* of knowledge, capabilities and products". As supply chain management becomes part of technology policy, local adaptation of technology invariably means greater involvement with networks and sourcing at second or third tiers in the local supply chain, requiring a network of capabilities, rather than networks of facilities (Leonard-Barton, 1995).

The transformation of collaborative agreements into productive and strategically effective relationships will be the real challenge of strategic alliance management in the 21st century (Irwin et al., 1998). The way in which technology is transferred depends on the technology, the strategy of the owner and the capabilities of the acquirer.

South Africa a country in a "dual world" (Wang, 1993), exhibits some favourable attributes of a developed economy as well as the negative characteristics of the poorest countries.

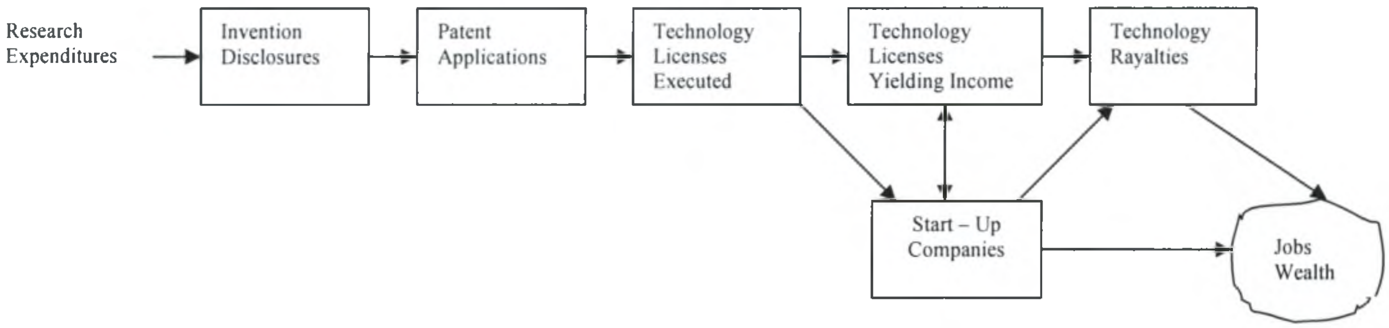


Fig. 7. The process of technology transfer from a research university.

Seaton and Hayes (1993) regard Communication Interactivity as a very important factor, examining the four dimensions of communication, distance, motivation and equivocality.

Interactive technology transfer links are defined as being person-to-person media-rich interactions. Examples of active links range from cooperative research activities to on-site demonstrations. Interactive links encourage interpersonal communication in terms of fast, focused feedback, i.e., researchers learn from the potential users and vice versa.

The more interactive the communication links between technology developers and users, the more likely there will be successful product/process application.

Distance involves both physical and cultural proximity (Rogers and Kincaid, 1982; Hatch, 1987). However, as important as the variable of physical proximity is to technology transfer, spatial distance has not correlated with technology transfer success. Cultural differences loom as the more important dimension of distance than geographical separation (Albrecht and Ropp, 1984; Pinkston, 1989).

Being physically close may or may not increase cultural proximity. Technology developers and users can be physically distant but culturally close thereby facilitating technology transfer. On the other hand, they can be physically proximate, but if they are culturally distant technology transfer will be inhibited (Elmes and Wilemon, 1991).

According to the authors, the more technology developers understand the values, attitudes and ways of doing things in the user company and vice versa the greater the chance of successful technology transfer.

In a related manner, Pucik describes another critical cultural dimension: the learning ability of a society. Cultures that master new technologies quickly derive the greatest benefit (Scheraga et al., 2000).

Equivocality refers to the level of concreteness of the technology to be transferred (Weick, 1990; Pinkston, 1989; Avery, 1989). According to Pinkston (1989), it takes more learning and understanding to acquire know-how than to learn to use a tool. This difference results in qualitatively different problems in getting new technologies used. The challenge is one of encapsulation - the more the user only has to deal with the externals (as in the case of tool), the easier technology transfer tends to be. The less encapsulated the package, the more the user has to understand and master details of what is going on within the technology and the more difficult technology transfer becomes.

Highly equivocal technology is harder to understand, more difficult to demonstrate, and more ambiguous in its potential applications. While such ambiguity may facilitate different users perceiving the same technology as suitable for unique needs, such ambiguity is not seen to facilitate technology transfer.

Motivation involves incentives for and the recognition of the importance of technology transfer activities. Personal motivation for actively participating in and supporting technology transfer processes, as a developer or a user, can range from positive to hostile. Both technology developers and users may ask, "What's in it for me?" Successful technology transfer is most likely to occur in "win-win" situations. Personal motivation for technology transfer varies by such things as the importance of the transfer activity to the individuals involved to whether the organization's culture rewards those who engage in technology transfer activities (Badawy, 1988; Drnbusch and Scott, 1975). The authors claim that successful product/process application is more likely to occur when research and user organizations support and reward those involved in the transfer process.

Existing conditions in the recipient country / organization have been found to influence the technology transfer process. These include the existence of innovative perspective for the recipient such as innovative climate, technological ability /structure /culture, R&D activities, strategy, resources and company size.

The process view of technology transfer, therefore, is also concerned with creating or raising the capability for innovation. This requires an organization, and the individuals within it, to have the capability to:
scan for and *recognize the* value of ideas, knowledge, devices and artefacts which are new to the organization;
Communicate these and assimilate them within the organization; and apply them for effectiveness or competitive advantage.

Such a definition also implies that there is a need for: the technical functions (such as product development, R&D, manufacturing, engineering, training and management information systems (MIS)) not only to support current business priorities but also to create new opportunities such integrated functions to be part of well-designed external and internal networks;
the development of employees so that they are capable of comprehending and functioning effectively within such activities; and the development of managers capable of shaping organizations to achieve these objectives.

An organization's overall ability to be aware of, to identify, and to take effective advantage of technology is referred to as receptivity (Seaton et al, 1996). Other writers have recently described such a notion, specifically in the context of R&D, as 'absorptive capacity'.

The ideas of accessibility, mobility and receptivity serve as a framework for a process view of technology transfer and provide a simple conceptual device that emphasizes a client organization's own view of its needs and problems.

The two-way flow of information provides a simple interactive model of technology transfer, while the receptivity model provides an orientation for investigating an organization's internally based technology transfer processes.(Seaton et al., 1996). Adaptive behaviour in organizations is also critically dependent on managerial style and organizational culture. An organization evolves as a consequence of the accumulation of decisions and positions taken up by individuals and groups on their own behalf and on behalf of the organization.

Other factors, long discussed by the writers refer to (1)donor's ability to transfer technology: i.e. experience, willingness, cooperation temper and company size, while the very technology transferability consists one of the first parts of the decision process (Radosevic, 1999). (2) The absorptive capacity of the receiver (this is an application of the old adage that says to teach only the 'teachables'); (3) the investment made by the sender in the process of transfer; (4) the credibility of the sender; and (5) the investment in the intangibles of technology: apart from the tangible know-how described in specs and drawings we need also to invest in the transfer of the tacit know-how, the enthusiasm for the technology and the authority to adapt and transform the technology. (Meyer, 2001).

Meyer in his article about Technology Transfer in China (2001), notes that there is a lack of practical understanding of the Chinese workers and engineers, and an inability to go beyond 'linear thinking'. This can be illustrated by two comments: 'how can you expect Chinese workers to understand what a car is, if less than one out of a hundred have a driver's licence' and ' Chinese engineers are well trained and have sometimes brilliant minds, but they have difficulty with conceptual thinking, cannot treat problems in parallel, worry too much about today and cannot think about tomorrow'.

Like all comments taken out of their context they are probably extreme, but they illustrate the point that sheer quality of minds is not sufficient to absorb technology which has been developed in a different economic context and culture.

Usual factors that make managers feel rather powerless are the adaptability, complexity or robustness of a technology (Nobelius, 2002).

Adaptability of technology is scored high in importance, followed by sensitivity of the technology in terms of design and operation. This is in line with the general comments of Grant and Gregory (1997) regarding adaptability to local conditions.

Technology has the best chance of being transferred successfully if it is co-ordinated at strategic level and aligned with corporate goals and internal capabilities with the purpose of achieving competitive advantage (Leonard-Barton and Deschamps, 1988; Martinsons and Schindler, 1995). According to Burcher et al. (1999) and Grant and Gregory (1997) technical interface management requires integration of systems and human resources with the technology itself.

Meanwhile, transferability is particularly related to the level of knowledge and tacitness of that knowledge that has accumulated in the environment (Bohn, 1994; Contractor, 1991; Faulkner, 1994). The level of knowledge is related to the transferor's experience of using the process and experimenting with it (Bohn, 1994). The degree of tacitness of experiential knowledge is a function of its speed, contextuality, diffusion, and expressibility (Boisot, 1994; Polanyi, 1966). Resistance to the codification of tacit knowledge on the part of the knowledge owners should also be considered.

Kim (1980), in relating technology transfer to the development of host technological capability, suggests that the technology must be packaged in some way if the host is in an early stage of development. Other authors, discussing technology transfer, have suggested further dimensions to transferability, namely: adaptability (Robinson, 1991), ability or necessity to pilot (Rebentisch *et al.*, 1993), documentation completeness or obsolescence.

According to Nonaka and Takeuchi, tacit knowledge is not easily visible, not easily expressible, highly personal, hard to formalize and difficult to communicate. Still, it has to be identified and captured, documentation improved, obsolescent equipment replaced, machine integration reduced, and so on.

The dimensions that characterize the nature of a technology to describe its *transferability,* according to Bou and Wen (2001) fall into three main categories: *complexity, maturity and codification.*

Complexity of a technology is a measure of whether or not a technology is easy to develop, diffuse and utilize. Robinson proposes that the skill and education level required to adopt a technology be the recipient is an indicator of the complexity of the technology.

Maturity of a technology will affect the degree of success of technology adoption. Technical details of a mature technology can be packed as standard operation procedures, specialized equipment and well - defined subsystems. Industrial standards emerge when the technology becomes mature.

Codification : A Technology Transfer project to transfer a standardized technology is likely to achieve its planned goal and have lower risk. A technology is often codified in terms of documents, drawings etc.

Prior international experience is helpful for the transferee to gather relevant information from different sources, in order to select the appropriate partner, choose the technology that fits its domestic environments and manage communications and conflicts during the TT process. On the other hand, it facilitates communications of the transferor with the transferee and it increases the bargaining power of the transferor and therefore limits technical information that can flow from donor to recipient. Rogers suggests that if both parties have previous collaboration experiences, personal connections and informal communications are helpful in technology diffusion. Trust between the two parties can lower transaction costs, accelerate the learning curve and thus enhance communication efficiency.

Saad (2002), names the following critical factors of technology transfer:

1) the technology transfer modes : FDI, licensing, franchising, joint ventures, R&D collaboration, turnkey plants.
2) The stage of technology life cycle: introduction (innovation), growth, maturity - specialized sophisticated products due to highly skilled labor, process technology transfer, adoption of and incorporation of the latest machinery, equipment and processes.
3) Compensation : reinvestment within the state, R&D, ability to repatriate funds, open tax system, market share, ability to develop competitive barriers and increase capital.

While a collection of literature (Teece, Contractor, Robinson and Porter) results to :

Size : The size of the recipient firm, which is measured in volume of sales, is a conventional but less compelling variable as a determinant of technology transfer. Teece found that the gain on technology transfer increases with firm size because larger firms generally have a wider spectrum of managerial and technical resources for assistance during the transfer.

Government: Robinson asserted that the commercial success of an International Technology Transfer project is greatly influenced by the intervention of government. In the case of an LDC recipient, government quite often provides assistance in various ways such as capital, labor, infrastructure, foreign exchange, and technical support. The government may also vary its assistance through regulations, taxation, and import/export duties in accordance with its national economic and social interests and its priorities of development..

Market Competition: Porter presumes that the effective use of a new technology may be triggered by market competition. The more competitive the market, the more a firm will want to gain competitive advantages from introducing and utilizing foreign technology.

Supply: Contractor found that large US licensers typically face competition from other suppliers of technology.

Doinakis (2003) underlines the importance of existence of innovative prospective for the recipient which is recognized by the Innovation climate, relevant technological capability, structure and culture, R& D activities, available resources and the very strategy of the organization.

Mason *et al.* (1981) identified the variables affecting technology choice for transfer as: market size and growth, labour and capital costs, range of technology available and prospect of technology obsolescence. In these examples, the authors have listed both host-dependent and host-independent issues.

Main adaptation influencing factors are suggested by authors identifying obstacles to the adoption of Japanese manufacturing methods in LDCs, namely: employee and supplier participation (cultural and infrastructural), educational level, labour costs, unionization, and firm size (Baldwin and Gagnon, 1993; Hendryx, 1986; Lawrence and Lewis, 1993). So, in fact, some Japanese methods are perhaps not appropriate for LDCs, requiring either adaptation of the methods, or extensive training, and infrastructure and capability building at the host site.

Many of the above factors have been characterized as crucial for the success of a technological transfer, depending on the type, the way, the participants and the scientists the dealt with the subject. Table 1 summarizes a list of them, while table two specifies the ones that influence the management of the technology transfer, as collected from the related literature review.

TABLE 1

FACTORS AFFECTING TECHNOLOGY TRANSFER
Conditions in the recipient organization / country
The existence of innovative prospective for the recipient
Cultural distance
Learning ability
Human capacity (technical, business, skills, training etc)
Organizational capacity (networks, assessment, management, financial, communication infrastructure etc.)
The donor's ability for technology transfer
The absorptive capacity of the receiver
Host organization's capabilities (technical, support, and structure)
Host infrastructure
Transferability of the technology

Adaptability, complexity, robustness of a technology.
Appropriateness of technology - the actual level of the technology transferred
Proactive search for projects and partners
Person-to-person contacts
The credibility of the sender
Allocation of resources
Mechanisms for the transfer
Shareholder "pull" for the technology
Management commitment
Product champion
Awareness of importance of technology transfer
Cooperative activities
Knowing who to contact
Good preparation procedures before negotiations
A sense of common purpose
Shareholder representatives
Concreteness of the technology
Understanding of shareholder's business environment
A service/customer-oriented attitude
Market demand
Current incentives for technology transfer

TABLE 2

FACTORS INFLUENCING THE MANAGEMENT OF T.T

Technology and operations strategy
Assimilation of technology
Technology as strategic resource for competitive advantage/business success and defence core competences
Technology implemented because of market demand (demand-pull)
The internet
Greater output through technology
Lead time to acquire technology/spares
Better quality through technology
Alignment of business goals, systems and technology

Political and economic issues
Socio-economic aspects: governmental control of industry versus industrial control of government (developed countries), disturbance of indigenous culture, habits and environment; individual perspectives, ethical issues;
Legal environment: dealing with conflicts and their resolution, patent laws, the regulation of knowledge transfer and status of 'proprietary knowledge';
Crime levels
Government regulations and bureaucracy (planning permission, work permits, etc.)
Low educational levels of labour

Overall level of economic development and infrastructure
The national economic cycle: employment structure, unemployment, education and qualifications, commercial reciprocity, goodwill.
Pressure from labour unions, affirmative action and employment equity policies
Tax concessions for foreign firms
The brain drain—skilled people leaving the country
Effects of globalization
Frequent changes in policies and commercial laws.

Knowledge and human resources
Labour commitment and productivity/ability to take responsibility
Communications and IT systems for data analysis
Understanding complex technology through direct interaction and observation
Empowerment
The learning organization
Understanding hardware and software
Cost of training and developing local workforce

Maintenance
Availability and reliability of equipment
Understanding of how technology works and how it fails
Failure data
Effects of failure on process
Appropriate maintenance action (time/condition based)

Planning and infrastructure
Promoters/champions of the technology
Belief in need for and commitment to technology, and establishing clear objectives for technology
Establishing supplier networks and accessing local infrastructure
Internal infrastructure to integrate/formalise technology throughout org; create feedback mechanisms
Process optimisation systems to support technology

Supply chain and partnerships
Assistance from technology partners
Contractual arrangements
Compatibility between supplier and user
Appropriate technology base established from partnership

Financial
Cost of technology acquisition
Short term profitability required from technology
Hidden costs of technology (including TT, HR development, environmental, etc)

Justification of technology on a cost/benefit basis (lower production costs)
Availability of government funds or bank loans on favourable terms for priority industrial sectors

Technology and technology transfer
Adaptability of technology to local conditions
Use of expert systems/intelligent machines
Robustness of technology: installation without adaptation
Sensitivity of technology in terms of design, fabrication, operation and maintenance

Technology management interface
Capacity of recipient company to manage change and new technology with technology partners
Complexity of technology
Shortage of skilled personnel

Resistance to new technology
Difficult to accept other ways of working
Resistance to technology because it is not local

Host environment (temperature, humidity, air quality)

Efstathiades et al. (2000) have devided the above factors in four groups: company related, technology supplier related, government related and factors considered during the selection and the transfer process.

In fact, among the most relevant external effects on technology transfer may be factors of the institutional environment, such as the local laws, regulations, rules, norms and customs which can constrain the actual transfer and/or the application of the technology once it has been transferred. Thus the institutional development of a country could play an important role in the success of technology transfer .The institutional context, often called the "national innovation system" is considered as the set of exogenous factors that conditions technological change and economic development.

The complexities of advancing technology, intricacies of government policy and rapid changes in organizational structures all present challenges to technology transfer.

1. The assessment of a country's institutional development is critical for successful technology transfer. Specifically, the macro issues that affect the technology transfer in both the short and long - term should be examined with respect to the company's goals. A representative's set of questions could be the following: What are the current environmental conditions (e.g. financial, political etc) of the host country? What is the host government's position with respect to the technology? How does the host government view foreign investors? Are there effective laws in place to protect intellectual property rights? How would these circumstances influence the entry mode?
2. Once the decision is made regarding the best country to enter, the type of transferred technology should be evaluated. Developing a means to determine the

strengths and weaknesses of each category of countries is a critical dimension of successful technology transfers.

3. The transfer recipient's capabilities will - in large part - determine how and what mode of transfer will be utilized. E.g. Is the technology compatible with the target market? Whatr type of technology would be easily or best transferred, given the receiving firm's capabilities?
4. The financial goals of the transferring organization should be considered *ex ante* in light of the host country environment and the capabilities of the transferee. The risks associated with transferring technology also include receiving a "fair" compensation. Will the technology be able to provide a foundation for further growth? Would the technology provide good compensation and value in the long term? Will it be costly to monitor the recipient's actions? Will the recipient actually commit to the relationship enough that the costs are mitigated?
5. Actual implementation of the technology transfer is a question of operational efficiency and effectiveness. A country assessment will provide an indication of the infrastructure (i.e. finance, distribution, legal, political) and a study of the receiving firm will address the micro issues (i.e. skill level, financial soundness, process capability and flexibility). Together, these issues might indicate some of the potential financial problems associated with the technology exchange. For instance, excessive imbalances in cost structures may reveal poor management and mishandling of production processes. Also, high inventory may indicate poor coordination within and external to the receiving firm.
6. The transferring organization must develop a capability to continually monitor the exchange, in order to identify potential problems and resolve them before they become unmanageable. A solid and continual auditing process will also help to ensure that the technology exchange is accurate and provide long - term mutual benefits.

Successful technology transfer is a continuous, interactive process where individuals exchange ideas simultaneously and continuously (Badawy, 1988). Feedback is so pervasive that the participants in the transfer process can be viewed as "transceivers" thereby blurring the distinction between the source and destination of information. Feedbacks helps participants reach convergence about the important dimensions of the technology (Rogers and Kincaid, 1982). Different sets of functions, activities, and networks must occur simultaneously to overcome obstacles and barriers to the transfer process (Rogers, D., 1989; Kozmetsky, 1988a, b). The model is not unidirectional. The technology to be transferred is often not a fully formed idea. Technology often has no definitive meaning or value. Researchers, developers, and users are likely to have different perceptions about the technology. As a result, technology transfer is often a chaotic, disorderly process involving groups and individuals who may hold different views about the value and potential use of the technology.

Given such an orientation, technology transfer can be viewed as a particular case of the "garbage can model" of decision-making, proposed by March and Olsen (1976). Transferred technology is then more the result of an unplanned mixture of participants, solutions looking for problems, choice opportunities, and problems looking for solutions. Both problems looking for solutions (technology pull) as well as solutions looking for problems (technology push) are encountered.

COMMON BARRIERS TO TECHNOLOGY TRANSFER

The business environment is made up of political, economic, legal, cultural and institutional factors which may affect business prospects in general or have more specific effects on business transactions. Zhu et al. (1995) separate environmental factors into macro and micro aspects. The macro aspects include performance of the economy, government macro economic and industrial policies and political and social conditions in the country. The micro aspects include the more specific influences on developing and maintaining business relationships. Aspects of the micro-environmental obstacles to conducting technology transfer transactions are separated into four groups. The institutional obstacles broadly represent management and organizational aspects, the difference obstacles represent problems that might arise because of differences between firms, efficiency obstacles represent the problems posed to efficient conduct of negotiations and completion of transfer transactions and legal obstacles include the possible problems created by legal regulations.

Bennett et al. (1997), having adapted the theory of Zhu et al. have classified he following micro-environmental obstacles to technology transfer:

Institutional
Excessive bureaucracy
Unsatisfactory management
Low industrial performance
Differences
Commercial habits
Language
Technical systems
Efficiency
Time-consuming negotiations
Inconvenient communications
Insufficient information
Legal aspects
Unsatisfactory protection of technology
Inadequate legal regulations
Restriction of profit repatriation

Cook and Mayes, in their book "Introduction to innovation and technology transfer" (1996), note a list of 9 important barriers:

1. Management attitude is crucial to technology transfer. It must embrace change, not be complacent and rely on a successful product, encourages continuous R&D. Adequate information flows, positive response to suggestions, constant review of formal and informal information networks. Specially in SMEs, additional reasons for not using technology transfer, in descending order of those most commonly cited are:
   No time, too expensive, current products meet needs, unsure how to achieve transfer, too much red tape.
2. R&D effectiveness, short - term pressures, resistance to change, poor information flows, weak links with customers and suppliers.
3. Structural barriers to small and medium firm level, such as lack of financing, lack of awareness of available proven technologies, fear of change, insufficient time to

study and implement changes, lack of skills, prior bad experience with new technologies and inability to select the correct product and vendor.
4. Lack of awareness - many companies - particularly the small ones, is often unaware of who or what can help in the process.
5. Lack of knowledge and/or funds
6. Lack of common interests - this often leads to lack of motivation and a difference in opinions about the options. It can also lead to individuals putting the interests of their own company ahead of the alliance.
7. Conflict of interest - this leads to adverse effects on the competitive advantage of the companies. Even when an excellent relationship exists, it has been found that collaboration between competing companies does not work.
8. Lack of trust
9. Poor communications

With regard to collaboration on projects, there are some additional factors that can prevent success. The four main factors have been found to be:

Σ Technical problems that can add time, cost and frustration to the project. Serious difficulties arise in the comprehension and utilization of the technical documentation transmitted by the suppliers, or as received by the recipients.
Σ Resource limitations due to uncertainty about funding or poor budget control,
Σ Problems caused by changes in the project's structure - either by the withdrawal of partners or the loss of key members of the staff. This is a factor that requires particular emphasis.
Σ Organizational problems, due to a partner losing or changing interest in the technological area.

PEREZ (2002), adds the:
Lack of financial resources
Small size of market
The case of a too risky technology transfer effort
Lack of information on market features
Lack of time
Lack of information on potential business partners
Lack of information on know-how
Lack of trust among partners

While, collecting from literature, the following barriers can also be added:
Lack of a champion for the specific technology
Different research goals between the participants
Lack of support for technology transfer
Technology transfer is seen as somebody else's job
"Not invented here" syndrome
No clear definition of technology transfer
Not knowing who to contact
Elitist attitude
Secrecy

Lall (1993) includes further barriers such as a lack of acquirer skills and education, inadequate technical and managerial know-how, poor infrastructure, inadequate intellectual property rights, government requirements and "commercial habits" (Grant and Gregory, 1997).

Cultural difference is argued by many to be the major barrier of technology transfer. However, the effects of cultural difference can interact with the nature of technology. It is not necessarily a bad thing to have cultural difference when transferring certain types of technology. Sometimes, it may not be an important issue if the technology is easy to transfer but it is crucial for the success of transferring a complex and innovative technology that requires intensive interpersonal communication among working groups from both firms.

TECHNOLOGY TRANSFER EFFECTIVENESS

The effectiveness of a technology acquisition can be seen from three main points of view (Chen, 1996):

- *the ability to choose the right technology*: the main point is - what technology, while other topics are then linked to the discover of the choice of know - how: how to discover who possesses it; how to evaluate its importance before engaging in the deal; how to create competition, if possible, among different suppliers; what basic knowledge is needed to start a process of technological acquisition, given that is neither a public good nor a simple, standardized item on sale in the market at arms' length prices.

- *the ability to require it*: this point rises two issues: the effective willingness of the partner and the time horizon of the deal. Why should a firm give away a part of its technological knowledge? Basically, to gain something in exchange. Money, lump sums paid for, experience, knowledge, and market access. The other key is the time horizon. The application of the know - how must be tested and sometimes modified. The acquisition, the real learning and implementation of a new know - how needs time, interaction among partners, trial and errors.

- *the ability to use (and improve it):* the ability to *learn* a technology must be transformed into the ability to *use* it. When a new process is introduced it must work, possibly as well as in the supplier. The competitiveness of the transferee must be increased. Three cases have shown up in real life:

  1. the transferee continues to use the original know - how as such and the competitiveness steadily declines.
  2. The transferee is able to receive from the transferor a continuous flow of information (often after a time lag) regarding its improvements
  3. The transferee is able to improve the technology by itself.

Rosenberg and Firschtak (1985) pointed out that criticizing only the supply side could not provide complete answers to the problems on the recipient side, because the effectiveness of a technology transfer project might greatly depend on the ability of the users to absorb it. Simon argued that "the crux of the problem usually is . . . the inadequate institutional structure and the lack of an indigenous technical capacity to direct foreign technologies toward the solution problems" . Thus, infrastructure support and access to international technical and commercial information are very important referring to the absorptive capacity of the recipient.

Several Technology Transfer effectiveness measures were proposed by scholars, such as satisfaction suggested by Wu and technical effectiveness, costs and schedule, suggested by Might and Fischer. Technical effectiveness is evaluated by comparing the final technical performance of the transferee after the project is compared with four technical performance benchmarks: the technical performance of the technology provider that indicates how much the transferee learns, the degree that the transferee has received the planned technical performance in the beginning of the project, the technical performance of the transferee's major competitors and similar Technology Transfer projects.

Therefore the knowledge set that can measure effectiveness ca be embodied in four inter - related dimensions:
1) employee knowledge
2) technical systems
3) managerial systems
4) values and norms.

ORGANIZATIONS THAT TRANSFER OR FACILITATE THE TRANSFER OF TECHNOLOGY CREATED BY OTHERS

They are often called technology transfer intermediaries. They perform a wide variety of functions that assist the technology transfer process in some way, mostly by providing information, expertise, and/or money. A combination of the relevant information in the books of Cook - Mayes (1996) and Norman et al. (1997) reveals that four types of intermediaries are most common:

ORGANIZATIONS THAT PROVIDE TECHNOLOGY TRANSFER REFERRALS AND INFORMATION: institutions and individuals that facilitate technology transfer among technology suppliers and buyers. In most cases the parties have met and got to know one another through a variety of mechanisms (e.g. personal relationships among technical employees and managers, membership in common organizations). They create databases, publish technology newsletters, and promote technologies and expertise from universities, private firms and laboratories. They can be government funded or private.

TECHNOLOGY BROKERS, TECHNOLOGY TRANSFER CONSULTANTS, LAW FIRMS AND CONFERENCE ORGANIZERS: The category includes nonprofit and for-profit organizations mostly small organizations. The technology brokers market or assist in marketing technologies developed by others, primarily through licensing and/or formation of new companies. Consultants bring considerable expertise about one or more parts of the technology transfer process to their clients. They perform technology evaluations to estimate relative values in technology portfolios and assist in patenting decisions. They do market assessments and surveys, carry out marketing function, help locate potential licenses and assist in negotiating and executing licenses and intellectual property transfer agreements. Law firms provide services related to technology transfer, including patenting, licensing and other traditional business -

related legal advice. They further conduct educational programs, joint research projects, study sessions and exchanges of information and materials. Conferences, finally, introduce suppliers and buyers of technology and help initiate the process of technology transfer.

Examples of types of consultancies

Management consultancies, traditional engineering and manufacturing consultancies, software and systems houses, hardware and systems suppliers, human resource management consultancies, process industry contractors, universities and colleges, training consultancies, early users, contract and research organizations.

These would have access to industrial networks to enable rapid diffusion of good practice, links to international networks and partner institutions and links to R&D and academic research networks would represent valuable strengths.

TECHNOLOGY BUSINESS INCUBATORS AND RESEARCH PARKS: Business incubators are defined as " assistance programs targeted to start - up and fledgling firms. They offer access to business and technical assistance provided through in - house expertise and a network of community resources: shared office, research or manufacturing space, basic business support and common office equipment. They support early business during their early, most vulnerable stages." (National Business Incubator Association, 1997). Research parks are real estate developments, designed to serve the needs of research as part of their services. They cluster growing high technology firms together and have a contractual and/or operational relationship with universities.

ORGANIZATIONS NOT OTHERWISE CLASSIFIED:

a) Technical/ Professional Associations,

b) Engineering - Design and Architectural Firms which specialize in process and production technologies, facilities design and construction and are important conduits for diffusing new technologies developed by others. They act as gatekeepers for new technology.

c) Venture Capital Firms. They invest in the growth of new start - up or spin - off technology companies. Most of them perform their own analyses before making a commitment to invest. They assist their clients with the recruitment of key team members, create networks, assist with finance and accounting, organization and office space.

d) The Internet. Most institutions and companies have home pages on the Web, establish networks and mediations. Potential providers and purchasers, problems that seek solution and visa versa, outsourcing and outplacing etc are facilitated by on - line databases.

Specially referring to SMEs, they are considered important pillars of the technology transfer and innovation systems. Although they contribute to new and emerging areas, their specific strength is the rapid diffusion and adaptation of existing technologies. In this regard, they can draw upon the resources of a variety of R&D - performing, transfer - oriented institutions. Furthermore a dense network of non - R&D - performing institutions supports technology transfer through innovation - consultancy and the organization of knowledge - exchange among firms. All Chambers of Industry and Commerce offer consultancy services. Usual partners of

SMEs, according to Wolff et al. (1994), are suppliers (raw materials, subproducts), polytechnics, public testing laboratories, suppliers of machinery - equipment - tools, customers, (export-) dealers, companies in same technology firms, universities / research institutes and consulting engineers.

COLLABORATION STRUCTURES : There are many organizations worldwide known for there technology transfer operations, such as the Ministry of International Trade and Industry (MITI) in Japan, the Department of Defense (DoD) in U.S.
On the international level rather well documented technology transfer operations are carried out between industrialized and Third World countries, e.g. in solar technologies.
Multinational and publicly funded basic research centres, such as CERN (the European Laboratory for Particle Physics).

The behavior of agents of technology transfer
According to Scheraga et al. (2000), the transferring agent must:

- effectively communicate ideas for the planning and implementation of the new technology.
- establish a positive image through language capabilities, cultural understanding, technical competence and official affiliations.
- demonstrate the new technology to recipients in a manner that provides strong evidence of a high probability of successful implementation.
- solicit voluntary participation from recipients in planning and implementing the new technology.
- implement the technology transfer in a manner that does not disrupt local cultural patterns.
- be aware of whether or not the local environment is a critical part of the successful technology transfer. Where it is, the environment must be used actively and positively.
- introduce the new technology at an advantageous time vis-a`-vis the local culture or a local occurrence.
- be flexible enough to alter the technology transfer process to meet conditions which were unforeseen at the outset of the project.
- provide consistent follow-through of the implementation plan.
- facilitate the means of maintaining the new technology within the abilities and cultural facilities of recipients.

Wicklein suggests the following seven criteria for "designing appropriate technology in developing countries" :

- *Systems independence*: the transferred technology needs to be functional withoutelaborate supporting devices or infrastructure.
- *Image of modernity*: the transferred technology must have perceived sophistication so as not to appear patronizing but rather promoting the user's social status.
- *Individual technology versus collective technology*: the transferred technology must reflect the degree of individualism versus collectivism apparent in the receiving culture. The more collectivist the culture, the more likely the transferred technology will be system-dependent.

- *Cost of technology*: the transferred technology and its implementation must be locally affordable.
- *Risk factor*: the transferred technology must be not only appropriate to the user's environment but adaptive to it as well. Nevertheless, a transferred technology that provides a reasonable and healthy challenge to the growth and development of the local environment is desirable.
- *Evolutionary capacity of technology*: the transferred technology must possess design characteristics that allow for continuation of its development.
- *Single-purpose and multi-purpose technology*: Ideally, the transferred technology will possess characteristics that enable its application to a variety of applications.

Such transferred technology reduces the range of local skills necessary to perpetuate its functionality.

TECHNOLOGY AGREEMENTS

Regarding the time period of the agreements, the most usual case is a 5 - year contract as a minimum, which is generally considered as reasonable for the transfer of know - how in industries, such as capital goods. The link with the suppliers are considered as long - term relationships, involving not only the transfer of the original designs but also the supply of improvements and new developments in the product line.

With respect to payment, royalties on sales are the most common form of remuneration, but lump sums are frequently stipulated as an initial payment for the disclosure of know - how.

Territorial limitations as to the use of the technology are usually mentioned. They are related both to the presence of patents or trademarks, or with the equity participation of the supplier.

Another agreement, often met in firms of developing countries is the obligation of the recipient to import parts, components or inputs from the supplier. Literature also refers to some limitations on the freedom of the recipient to introduce modifications in the technology.

R&D CONSORTIA

There are many motivations for forming R&D consortia such as: (1) to allow member firms to leverage their R&D investments, (2) to reduce the amount of duplicate research, (3) to promote long-term basic research, (4) to leverage costly and scarce intellectual resources and talent, (5) to better monitor the proliferations of new technologies and the research activities of competitors, (6) to reduce risk by allowing participants to diversify their portfolio of research projects especially given increasingly short product development cycles, (7) to increase the ability of smaller companies to compete with giants like IBM, AT&T, and NEC, and (8) to enhance corporate image by emphasizing access to state-of-the-art technology (Murphy, 1987; Fausfeld and Haklisch, 1985; Gibson and Rogers, 1988; Evan and Olk, 1990; Gibson et al., 1988).

Within any single R&D consortium several research programs, using different technologies and research methods, are often being pursued simultaneously. Consortia

are commonly composed of personnel from different research and managerial (company culture) backgrounds. Consortia are supported by a range of member company investors with different technology and strategic priorities. These member company investors may have a long history of competition with one another (Gimpson and Smilor, 1991).Consortia researchers and the member companies which fund these researchers are separated by a variety of professional, technological, strategic, distance, cultural, and competitive barriers. These barriers also exist in technology transfer between Federal labs and industry, universities and industry, and between a firm's research laboratories and the market-
place (Bopp, 1988; Kenny, 1988; Williams and Gibson, 1990).

Broadening the idea of point-to-point transfer to include the profitable use of the technology is especially appropriate in the case of R&D consortia. The motivation for such consortia has primarily been foreign competition. U.S. consortia will ultimately be judged in terms of their benefit to the nation's industrial competitiveness (Inman, 1988; Noyce, 1989).

Smilor et al. (1990) emphasize the importance of differences between consortia and their member companies in terms of academic and business values, networking and information sharing, long versus short-term perspectives, universal versus particular research objectives, and performance evaluation. Differences in these dimensions are seen to inhibit the flow of technology between these types of organizations even when communication linkages are established.

A. TECHNOLOGY TRANSFER BETWEEN R&D AND INDUSTRY

The technology transfer in this category can take place among university or laboratories (public or private) or other kind of institutions and research centers and industry.

Industry to Science Relations (ISR) differ largely by fields of technology and types of science institutions and enterprises. ISR are highly important, particularly in those fields of technology where new breakthrough innovations can be achieved and transferred to new products and processes (i.e. radical innovations) such as biotechnology, new materials & ICT. In these fields, high levels of ISR can be observed even in countries with low overall ISR intensity.

There are more than 800 federal laboratories in USA, while there are many cases reported where technology transfer occurs from Contract research institutes.

A well-known example is the Semipublic Fraunhofer Society, a significant bridging institution between academic and industrial research. They have an active role in the establishment of spin - off companies and establish for profit "innovation centers"

Saphira (1990) surveyed state industrial extension programs for information about the types of assistance that they provided to client firms. The most frequently offered services are: (1) improve/solve problem with existing production technology, (2) identify vendor of new technology/ software, (3) specify new production/ process technology, (4) refer client to training source, (5) improve quality control/ statistical process control, (6) improve existing plant/layout operations, (7) identify new markets, (8) address waste management/ environmental problems and (9) improve / debug and existing product.

Scott Shane names four dimensions of university–entrepreneurial firm collaboration:
(1) industry-sponsored contract research, (2) consulting, (3) technology licensing and (4) technology development and commercialization.
In some areas, university research and technology transfer has been linked to the needs of local industry.For example, technology, the University of Oklahoma was a valuable participant in the development of the petroleum industry.

In view of industry, the reasons for collaboration with university research centers are considered to be lack of in-house R&D, shortening product life cycle, cutback in R&D budgets, and changing nature of research priorities.University research centers also want to collaborate with industry when the government intents to reduce R&D fund (J. Lee, H.N. Win, 2003).
It is also discovered that firms enter into university –industry relationships to gain access to students as potential future employees and to aid on product development (Link and Rees, 1991).

Moreover, there are four possible ways to initiate a university–industry relationship (Sanchez and Tejedor, 1995):
- firms may look for the research centers who might resolve whatever problem they have;
- they may directly receive collaboration proposal from suppliers of technology, the research institutes;
- firms may also ask for assistance through a third party, which will then look for the best university research center available;
- they may also receive proposals from liaison third party to initiate collaboration with the local R&D institutes.

The advantages of technology transfer process go both ways, to the research centers as well as to the industry (UN, 1974; Sanchez and Tejedor, 1995).

Advantages to university and its research centers
The advantages could be listed as follows:
√ the opportunity to access the needs of the economy and to develop its activities accordingly through income from the sales of technology;
√ the opportunity to place students in industry so that classroom learning can be related to practical experience;
√ access to industry for both fundamental and applied research;
√ access to the protected markets;
√ business stature enhancement;
√ improvement in new technology implementation;
√ creation of goodwill;
√ new product development and spin-offs;
√ cost savings (lower production cost);
√ patenting.

Advantages to industry
The following are the advantages to the industry:

- √ a supply of better qualified graduates having more relevant training because industry's needs have been identified;
- √ access to a variety of post-experience training facilities it has helped to design;
- √ access to the university's physical facilities and the expertise of its staff;
- √ access to research, consulting and data collection of the university;
- √ an improved public image in the society in which it operates, which means that more talented students will be attracted to the industrial sector;
- √ gained technical knowledge;
- √ gained technology services not available before;
- √ quality improvement;
- √ cost savings;
- √ new markets;
- √ manufacturing and lead time reduction.

Mechanisms of technology transfer (adopted by J. Lee, H.N. Win, 2003)

Different mechanisms can be applied in technology transfer between university research centers and industry according to their motivations and available resources.

Collegial interchange, conference, publication
This is informal and free exchange of information among colleagues, which includes presentation at professional and technical conferences and publication in professional magazines. It is widely used and the first step of linkage between academic institutes, their research centers and industry.

Consultancy and technical services provision
One or more parties from the university or research center provide advice, information or technical services. They have formal written contract, generally short term and specific. Faculty members or senior researchers can be hired to consult during the time they are allowed to work outside (OECD, 1990). It can be of different forms as follows:
Advisory committee: consists of faculty members and practitioners to examine curriculum in detail, to help place students in jobs, to assist with faculty development and to provide some kind of feedback for evaluation (UN, 1974).
Informal grouping of companies: where member companies can involve more closely with the university.
University center or industrial liaison units: established to encourage more linkages between the academia and industry.
The management foundation: it expresses the commitment and the involvement of practitioners in the task of improving the quality of management.
Exchange program
A transfer of personnel can be used to exchange expertise and information either from industry to laboratory or from laboratory to industry. In this mechanism, conflicts of each party's interest must be avoided and laboratory must approve of the lab personnel consulting arrangements.
Joint venture of R&D

A contract is drawn between university research center and a contractor in which costs associated with the work are shared as specified in the contract. The two parties can work together from the stage of R&D to commercialization. It must be of mutual benefit to industry and the research centers, and commercially valuable data may be protected for a limited period of time. It provides some assurance that the best brain in the business will be brought together to bear on the problem, and that there will be a balance between long term, high risk research and short-term work which can be promptly commercialized (Moses, 1985).

Cooperative R&D agreement
This is an agreement between one or more university research laboratories and one or more firms under which the university side provides personnel, facilities, or other resources with or without reimbursement. The industrial parties provide funds, personnel, services, facilities, equipment, and other resources to conduct specific research or development efforts that are consistent with the laboratory's mission.

Licensing
Licensing is the transfer of less-than-ownership rights in intellectual property to a third party, to permit the third party to use intellectual property. It can be exclusive or non-exclusive and is preferred by small business. The industry as a potential licensee must present plans to commercialize the invention.
Licensing is encouraged when entry barriers exist for foreign direct investment, particularly wholly owned subsidiaries (Caves, 1982; Telesio, 1979), when the licensor lacks some assets including knowledge and experience about foreign markets and managerial skills (Caves, 1982; Contractor, 1980).

Contract research
It is a contract between a research center and a firm for contract R&D to be performed by the research center. Industry usually provides funds, the university provides brains with the time frame ranging from a few months to years (NEDC, 1989). Through contract research, the industry wants to utilize the unique capability of the research centers that works for commercial benefit.

Science park, research park, technology park or incubators etc
These are installations on a given site area, normally close to a university and collaborate with a member of high-tech firms that receive official assistance in the early stage (Quintas et al., 1992). The main fund providers would be the commercial firms participating and the researchers include both from the university research centers and the industry. This is a kind of form especially adopted by the high-tech firms.

Technology transfer and commercialization activities at university technology incubators have ranged across the spectrum—from half of the tenants in one incubator actively transferring university technology, to none in others. These disparate differences in the level of activity may be attributed to differences in the legal structure for technology transfer and commercialization at universities.
There were approximately 42 technology incubators focused on technology transfer and R&D sponsored *primarily* by universities in the United States as of 1993 (Phillips, 2002).

Spin-offs are one, although not necessarily the most important, means of technology transfer. Nevertheless, spin-offs represent one potential mechanism for technology transfer from universities, as they increasingly seek to contribute to their region's economic development (Mian, 1997). Start up companies play a critical role in the transfer and commercialization of fast moving, science-based technologies via movement or "spin - out", of researchers and technology from universities, large established companies and government laboratories.

Technology Transfer Offices (TTOs). TTOs facilitate technological diffusion through the licensing to industry of inventions or intellectual property resulting from university research.Many institutions established a TTO in the aftermath of the University and Small Business Patent Procedures Act of 1980, otherwise known as the Bayh–Dole Act.

Training

Technology transfer through training could be in the form of practical training where students are exposed to the working methods and requirements of jobs at industry or at the institutions. The capability of staff in the particular field is improved by further training. Special training is also useful when potential managers are given lectures on administrative issues and the employees are trained for adoption of a new technology (Gander, 1987). Many university research centers have training programs to transfer the research results. It is also a way of reducing risk for the research centers. It sometimes accompanies the licensing or contract research projects.

High levels of industry-science interaction occur when:

- industry demand is high as a result of the prevailing innovation strategies in the enterprise sector, and due to market incentives to engage in new technologies and apply new scientific knowledge,

- there are well-developed incentive schemes in science institutions to get engaged in ISR including individual remuneration, institutional mission and objectives, administrative and managerial support, balancing with other major objectives of science, i.e. education and fundamental research,

- there are special programmes which facilitate small and medium-sized enterprises (SMEs) by raising awareness in science, increasing innovation management capabilities and increasing R&D activities,

- legislation does not constitute as a barrier for interaction,

- there are public initiatives to foster ISR (via financial support, information provision, networking through intermediaries, training) on a sufficiently large scale,

- science and technology policy follows a stringent and long-term oriented approach of strengthening ISR, taking into consideration the various channels of knowledge interaction and technology transfer and fostering an overall favourable climate towards ISR.

- Joint research programmes which promote direct collaboration between industry and science are a well-established policy intervention mechanism which has a significant effect upon the level of ISR. In this area, good practice particularly refers to thematically focussed programmes which apply a bottom-up approach of defining joint research themes, have a long-term perspective of co-operation and rely, at least partially, on an 'infrastructure' approach, i.e. the establishment of institutions and/or facilities that are operated both by enterprises and science institutes and maintain co-operation after funding has ended.

- Involvement of SMEs in ISR activities is a major issue in broadening the use of scientific knowledge in the enterprise sector. Good practice follows a two-side approach: First, absorption capacities of SMEs with respect to R&D, innovation management capabilities and the use of external knowledge and advice, should be strengthened and detached from any specific involvement in ISR. Secondly, SMEs with a sufficient in-house capacity for establishing science links may be stimulated to take up direct research and consulting contacts with science.

- Reforms of institutional settings in public science are particularly successful when the following issues are considered: implementing ISR as part of the institutions' mission; considering ISR activities in evaluations; providing both individual and organisational incentives; and linking industry and science through advisory boards.

- In many countries, a successful way of strengthening ISR was to establish transfer-specialised institutes either in universities or within public research laboratories. Key success factors in these institutions include: keeping together basic and applied research within one research team; regular auditing of the research strategy in order to cope with changes in economy and society; direct transfer between researchers and industry (i.e. avoiding intermediaries); and individual remuneration of successful transfer activities.

- Personnel mobility and interaction in graduate education have received attention in some countries as being a major issue in ISR. Good practice is often related to: exchange programmes which specifically address the personnel needs of SMEs; joint graduate education programmes that involve enterprises in the definition of the theme of a thesis, and allow students carrying out practical R&D work in the enterprise; and qualification programmes for industry researchers in HEIs.

Taking a broad view, science (i.e. higher education and public sector research establishments) contributes to innovation in industry via four major channels:

(i) Industry receives inputs from science in the form of well-trained individuals. Although these individuals may require further training (which may also be supplied by higher education institutions), university education is the backbone of the production of human capital engaged in research activities in firms. Personnel mobility of researchers between science and industry (and vice versa) contributes, not only to the dissemination of coded knowledge, but also to the exchange of tacit knowledge.

(ii) Knowledge produced in science institutions is disseminated as coded knowledge through publications, conferences and patents, and serves as a stock of knowledge which is available to the public and might be used by industry as a 'public good' input to commercial research. However, the use of the public good knowledge requires certain adoption and absorptive capacities. The increasingly complex and specialised nature of modern science makes it difficult to use potentially fruitful knowledge, especially by SMEs.

(iii) Universities and public research institutions are increasingly involved in co-operative R&D projects with industry. Although these collaborations are varied in type, they are all characterised by an exchange of knowledge among participants with science usually in the role of the most important supplier of basic knowledge.

(iv) In recent years, the creation of technology-based enterprises by researchers from science or by graduates has received increasing attention (see OECD 2000b, Bania et al. 1993). So-called start-ups or spin-offs are regarded as an important instrument for rapidly transferring new technological developments and innovative business ideas created in science, to commercial use.

Table A.3: Types of Knowledge Interactions between University and Firms

Types of knowledge interaction	*formalisation of interaction*	*transfer of tacit knowledge*	*personal (face-to-face) contact*
Employment of graduates by firms	+/-	+	-
Conferences attended both by industry and science	-	+/-	+
New firm formation by researchers from science	+	+	+/-
Joint publications	-	+	+
Informal meetings, talks, communications	-	+	+
Joint supervision of PhDs and Masters theses	+/-	+/-	+/-
Training of employees of enterprises	+/-	+/-	+
Mobility of researchers between industry and science and v.v.	+	+	+
Sabbatical periods for researchers at both sides	+	+	+
Collaborative research, joint research programmes	+	+	+
Lectures at universities held by employees of enterprises	+	+/-	+
Contract research and consulting	+	+/-	+
Use of public research facilities by industry	+	-	+/-
Licensing of patents held by science to enterprises	+	-	+/-
Purchase of prototypes developed at science	+	-	+/-
Enterprises reading of publications, patent disclosures etc.	-	-	-

+: interaction typically involves formal agreements, transfer of tacit knowledge, personal contacts

+/-: varying degree of formal agreements, transfer of tacit knowledge, personal contacts

-: interaction typically involves no formal agreements, no transfer of tacit knowledge, no personal contacts

Source: Schartinger et al. (2001)

Most important are those types of knowledge interactions between industry and science which are based, at least to some degree, upon formal and personal interaction and allow for the transfer of tacit knowledge which is regarded as a critical success factor in learning and successful innovation (see also Schmoch 1999, Abramson 1997, Cohen et al. 1995, Schartinger et al. 2000, 2001, Schibany et al. 2000). These include:

- *Collaborative research*, i.e. carrying out R&D projects jointly by enterprises and researchers in science.
- *Contract (commissioned) research and technology consulting*, i.e. the placing of R&D contracts by enterprises in science institutions and the use of technology advice by enterprises.
- *Personnel mobility*, i.e. the permanent or temporary move of researchers from science to industry and vice versa;
- *Co-operation in graduate* education such as temporary practical studies in enterprises or the joint supervision of thesis.
- *Vocational training for employees*, i.e. further education for enterprise staff in research and innovation related topics.
- Use of *Intellectual Property Rights* (IPRs) *by science* both as a tool for indicating technological competence and as a base for licensing technologies to enterprises and receiving royalties.
- *Start-ups of technology-oriented enterprises by researchers in science*, i.e. transfer of new research results into commercial value by creating new enterprises.
- *Informal contacts and industry-science networks* on a personal or organisational basis, including informal consulting and information exchange, Alumni meetings, mutual memberships in advisory boards, sponsoring of professorships by industry etc.

Of course, there are additional ways of exchanging knowledge between enterprises and public research organisations which represent important transfer channels and these will be considered in the benchmarking exercise on a qualitative level. These include, amongst others: the employment of graduates in enterprises (who may transfer new knowledge from universities to industry); the reading of articles and scientific papers; joint scientific publications by researchers from enterprises and public research institutions (which often coincides with collaborative research projects); and lectures by employees of enterprises at universities.

Main barriers for technology transfer

- Data, information, knowledge, awareness
- Transaction costs
- Access to capital, especially for the smaller firms
- Risk aversion in financial institutions
- Trade barriers (e.g. tariffs)
- Human - institutional capabilities
- Understanding of local needs
- Missing codes and standards
- Low, subsidized conventional energy prices
- Absence of full - cost pricing

Donald S. Siegel, David Waldman , Albert Link (2002), have identified some more barriers in the technology transfer between university and industry, the most important of which are:

- Lack of understanding regarding university, corporate, or scientific norms and environments
- Insufficient rewards for university researchers
- Bureaucracy and inflexibility of university administrators
- Insufficient resources devoted to technology transfer by universities
- Poor marketing/technical/negotiation skills of TTOs
- University too aggressive in exercising intellectual property rights
- Faculty members/administrators have unrealistic expectations regarding the value of their technologies
- "Public domain" mentality of universities

B. TECHNOLOGY TRANSFER TO DEVELOPING COUNTRIES

Technology transfer between countries is probably responsible for one of the most important trends in world economic development over the last century, namely. the convergence of productivity levels of the world's most industrialized countries. It is an unmistakable fact of economic development in the industrialized world that the countries with low productivity levels ('laggard countries') tend to have higher productivity growth rates. whereas the countries with high productivity levels ('advanced countries') tend to have lower productivity growth rates. This is because the laggard countries. which are technologically backward, can borrow technology from the more advanced countries relatively cheaply. and thus can grow rapidly. The advanced countries which are closer to the technological frontier must more often rely on developing new technology which can be slow and expensive, and thus grow slowly.

The productivity levels of the laggard countries thus tend to converge toward the productivity levels of the advanced countries.

The process of technology acquisition by developing countries is one of learning and improving their technological capability. This is a complex, long-term, process with various levels of technological competence such as the ability to use the technology, adapt it, stretch it, and eventually to become more independent by developing, designing and selling it (Barbosa and Vaidya, 1997). It very much relies on the effort of technology acquirers.

China No. 1 Automotive Works is a good example. It created a joint venture company with Germany to produce Audi cars. At first the Chinese partner organized a team of experts who were from universities and institutes as well as from its own organization to translate and read all the technical documents provided by the foreign partner. Then, the members of the team ``learned by doing" how to use the technology. They used, adapted, and changed existing technologies, and finally they combined the newly acquired technology with their own experience to develop new products under the ``Red Flag" brand.

On the other hand, in Shanghai Volkswagen, people have complained that the German partner has not provided the technology for localization of its new model and almost all the locally produced parts had to be developed by the Chinese partner rather than through technology transfer to the company. This assessment may be wrong because the capability for localization has been acquired through actual experience of operating the technology that was previously supplied by the partner.

Licensing agreements are not always the best channel for technology transfer. Many articles concerned with transferring technology to China mention that licensing agreements are the best channel for transfer and the percentage share of licensing agreements within FDI can be regarded as a criterion for measuring the extent of technology transfer.

However, as was outlined above, developing countries mainly acquire standard technology and licensees may concentrate their efforts on approaching smaller firms, more diversified firms, and firms with relatively little foreign manufacturing experience. Licensees may find that an ability to offer technology in return is necessary to obtain access to state-of-art technology in industries that require heavy R & D investment. Moreover, while the host government finds licensing an attractive alternative, it needs to be realistic with regard to the types of technology it obtains because of the concern of the foreign licensor to retain control of the technology. This is especially the case in industries that require heavy R & D investment and in developing countries that are likely to obtain little access to advanced technology. In these cases it is unlikely the acquirer can offer valuable technology in exchange, so licensing agreements are not always the best channel for technology transfer. For example the Ministry of Machinery Industry in China was advised that software transfer constituted the best type of technology transfer.

In China, the electronics industry mainly makes use of co-production, joint ventures and wholly foreign owned companies to attract foreign capital for investment in certain key sectors of the industry. The comparison between two types of technology acquisition provides substantial evidence of the superiority of FDI for technology transfer. From the 1980s, both licensing agreements and FDI have made substantial contributions to Chinese technology acquisition; however, comparatively speaking, the effect of FDI is better than of other types of technology transfer.

An LDC firm may acquire foreign technology to serve two strategic purposes: one is to improve direct economic returns and the other to strengthen its technological competence. Therefore, the effectiveness of International Technology Transfer projects should be measured from these two aspects.

A recipient firm may expect two major economic outcomes from the transfer of foreign technology: to expand production capacity and to improve production efficiency.

The transferred technology can be a device to strengthen the production system for higher output levels. In addition to the economic returns, technology transfer can serve as a stimulus for local technological learning and further local R&D; it can contribute to the accumulation of industrial technologies and the capability to generate technological innovation (Yin, 2002). Technological competence can be observed from two aspects: (a) the level of absorption of the technology transferred and (b) the level of diffusion of the technology. The level of absorption refers to the degree that the recipients understand, master, and adapt the imported technology with certain modifications ; the more the technology is absorbed, the more the ITT project contributes to the increase in the recipient's technological competence. The level of diffusion refers to the degree that the imported technology was diffused to relevant production lines and applications . Major modification and even redesign of the technology may take place in the diffusion process.

A higher level of diffusion indicates a higher level of indigenization of foreign technology and a greater contribution to local technological competence (Yin, 2002).

On-the-job training reflects the efforts of a firm to update technological knowledge and upgrade skills of its employees to meet the challenge of technological change.

The training of the work force is necessary to provide the knowledge and skill base for technology transfer (Salami, 1997).. The level of innovative activities reflects a firm's commitment of resources and its capability to modify and improve its existing technologies (Samli, 1992).

Regarding technology transfer on the recipient side, five variables were identified by Plenert (1994) as the most important factors:

- forms of transfer,
- the size of the recipient,
- the assistance from government,
- the intensity of market competition, and
- the rivalry among suppliers

Part of the nature of technology includes imperfect understanding, incomplete availability, and tacit ness. Technology can only bc partially transferred. A recipient enterprise needs to learn both the transferable parts of a technology as well as the parts hich cannot be transferred. Further, adaptation, diffusion, and reconciliation of foreign technology is an indigenous task. There is no substitute for learning. The incompleteness of the transfer process makes it almost impossible for an LDC enterprise to find a substitute for MC as an instrument to indigenize acquired technology.

Doinakis, in his PhD thesis (2003) notes that part of the donor's know - how will never be transferred. The obtained know how during a technology transfer will derive from the Donor's know how available to transfer and more precisely the programmed know - how to transfer. In reality, a smaller part will be actually transferred and obtained, according to the recipients existing know-how and what is obtained by internal efforts.

Government plays a critical role in the process of indigenizing foreign technology. The government coordination and assistance facilitate absorption and adaptation of foreign technology and enhance its contribution to the accumulation of local technological competence.

It is vital for LDC recipients, after their technological capacity grows, that they should gradually redirect their technological efforts for intensive growth (to improve economic efficiency) rather than extensive growth (to expand production capacity). An extensive growth strategy, with emphasis on acquiring foreign machinery to replace the old machines to expand and upgrade production capability, quite often has little to do with absorption and adaptation of technology itself. Consequently, the recipients may gain little technological competence from the transfer projects and their production will continuously depend on foreign machinery and technology. An intensive growth strategy, by contrast, focuses on productivity and economic efficiency and, thus, technological capability and technological development. Firms following an intensive strategy will give more attention to acquiring know-how and adaptive R&D and engineering to upgrade their own technological level.

Just like the Japanese experience of technological development, those LDC firms at a certain point in time may begin to create their own technological strength to be able to compete in the international market.

Second, the accumulation of technological capability is a process of learning. The recipient enterprises should give higher priority to investment in human capital development in order to update the knowledge and skills of their scientists and engineers as well as their workers. Foreign technology should be acquired to provide a basis for learning. A strategic plan should be formulated to coordinate the learning process with the process of technology transfer. LDC recipients should take a positive measure to ensure that foreign technology is used to promote local learning efforts rather than to replace them.

Christian N. Madu in his article "Transferring Technology to Developing Countries Critical Factors for Success" (1989), declares that some of the failures of technology transfer may be due to the lack of effective leadership and commitment to successful technology transfer in the LDCs. 'Decision-makers in LDCs are often not certain of the technology they need, and hence, inappropriate technology is transferred.'

Ito notes that a successful transfer can occur only if the recipient is suf-frciently capable of maintaining an introduced production system. Without this capability, it isdifficult to modify or improve technology. Gee suggests that managers must be both oriented toward innovation and sensitive to their environment in order to successfully implement new technology. Wallandei suggests the need for managers in LDCs to develop managerial skills such as the ability to plan, organize and solve problems.

Other problems confronting technology transfer can be considered internal. Factors such as socio-political and cultural value systems affect technology transfer. Hill identifies some of the effects of technology transfer, including the break-up of social structures, and suggests analysing these effects at a conceptual level. . Madu goes on suggesting the following techniques for technology transfer:

Stakeholder Analysis/Co-optation : The recommendations made by the interest groups will be used by the decision-maker in arriving at the final decision on transfer of technology.

Scenarios : Various environmental conditions that may influence the transfer process are specified. The most probable future conditions are stated and used as the basis for making the final decision.

Delphi : The environmental uncertainty can be best managed through the use of external experts. The judgement of these experts on probable events and responses, and their innovation can be used as a basis for selecting the appropriate technology.

Social Judgement Analysis (SJA): Those affected by technology transfer use different judgement processes to arrive at conclusions. The logic behind these judgements is studied by group members. A consensus for the resulting decision is arrived at.

Morphology: Technology transfer is composed of several complex factors ranging from socio-economic to political. These factors need to be integrated into the overall decision-making process. The decision-maker acts on these to arrive at a conclusion.

Analytic Hierarchy Process (AHP): This requires the development of priorities for the different technologies based on the decision-maker's judgment. The appropriate technology is selected, based on a quantitative solution to these rankings.

Optimization: Though difficult to achieve in the technology transfer-type environment, it can be applied at a micro level for the allocation of limited resources.

Simulation: Experimental analysis uses a prototype model to test the effect of the technology and how it can enhance the LDCs' development objectives.

Problems of technology transfer through Foreign Direct Investment and alliances

1. From the RECIPIENT'S point of view

1.1. Fear of the 'Maquiladora' phenomenon

'Maquiladora' factories, set up in northern Mexico on the basis of US FDI, are characterized by low wages, low levels of investment in training, and weak networking within the host region. It must be emphasized that the Maquiladora phenomenon is not a wholly negative one. Its operation in Mexico has improved levels of technology and capability, increased productivity and created new jobs (Ellingstad, 1997). But it is not calculated to maximize the impact of FDI on the Mexican economy as a whole, it fails to transfer benefits on a large scale to workers, and it tends to reinforce Mexico's colonial status vis-à-vis the USA.

2. From the Donor's point of view

2.1. Unsatisfactory legal framework

This is one of the principal obstacles to the maximization of the volume of FDI in Russia. Tax is a central element, with Western investors unhappy about levels of tax and also the speed with which the effective tax burden can change.

An additional complication affecting Western companies operating in the regions of Russia is the penchant for local political bosses to impose their own, arbitrary charges on foreign companies. Such volatility in the tax regime makes investment planning impossible, especially for firms with long time horizons.

Company law, intellectual property rights, property law, bankruptcy law and legal recourse also present a whole range of difficulties

The intellectual property rights situation is unsatisfactory, a serious obstacle in sectors like pharmaceuticals, where the cost of investing in the development of new drugs makes companies particularly sensitive to IPR risks;, the lack of a proper legal framework for production-sharing, the most common basis for FDI from the oil multinationals.

2.2. Fears of political instability
2.3. Firm-specific 'technology culture'

Factors for Successful Technology Transfer in LCDs

Many authors have investigated the success factors for technology transfer in an LCD. Reviewing the literature, some major factors identified are discussed to some extent below:

Needs and Objectives

The active participants will identify agreeable needs and objectives. They identify the problems and the ability to satisfy and solve these problems. The causes of the problem should also be isolated. The needs generated should be prioritized using a scale, since the constraints on the system due to limited resources, may make it difficult to satisfy all needs. Objectives are then formulated in light of these needs and the ability to satisfy them. Thus, the objectives have to be realistic and achievable.
Clarity in the objectives further improves the ability to implement and evaluate.

Capabilities

The capabilities identified can be in terms of human resources, capital natural resources, land and others. Some of these capabilities will enhance the growth of particular industries and make it cheaper to transfer certain forms of technology. A nation should also consider its weaknesses and explore the possibilities of improving them over time.

Education, Training, Research and Development Ito" mentions that in order to be able to modify and improve technology, the recipient of the technology must be sufficiently capable of maintaining an introduced production system. From these comments, it becomes apparent that the capability to modify and improve technology can only be achieved through proper education and training.

Innovation and technology modification can only exist if those concerned have a full understanding of the technology.

Andrews and Miller suggest that the training of local manpower is necessary to provide the knowledge base for technology transfer. They further argue that this will permit productive work and the transfer of skills to take place simultaneously.

Maier attributes the failure of the transfer of computer technology to China to be the result of a poor understanding of software and the small number of trained personnel in the computer field. Similar results were obtained in Latin America and Kuwait.. Wigglesworth stresses the barriers of culture and language differences in training. He further hypothesizes that the value system of the country to which technology is being transferred should be given adequate attention if the technology is to succeed and thrive in the LDCs. By this is meant the management of processes (i.e. production processes), of human resources, and of capital. An effective management will lead to an efficient utilization of limited resources. Tsumurij further points out that the effectiveness of technology and skill transfer is a function of the corporate culture and management culture of the parent firm.

Technology

Komoda notes that the issue of appropriateness of technology to an LDC may well be the most important issue in technology transfer. This issue has received great attention; as has often happened, the MNCs are blamed for transferring inappropriate technology. This is because the technology is often capital intensive and ill-suited to the local production needs. The success or failure of technology transfer also depends on the ability of the receiving nation to identify the right technology for its needs. Todd and Simpson mention that the inappropriateness of certain technology transfers may be as a result of dependence on existing technology for regulating development in the LDCs. Technology, which is structurally dependent, has to be designed to suit the needs of the receiving countries. Thus, at the design stage, the joint participation of local and MNC experts is needed to arrive at an appropriate technology.
Madu shows how appropriate technology can be selected and re-evaluated using both the analytical hierarchy process and modified general systems theory.

Management Process

Wallender, concludes that managers in developing countries need to develop the ability to plan, and diagnose and solve problems. Rodrigues also notes the need for managers to be familiar with organizational behavior and the dynamics of organizations.

The management process is a very important aspect of technology transfer. An effective management of technology and the technology process is necessary
The issue of technological change also requires the ability of management to manage change. Change has to be anticipated and planned for in any growth or deciine process. Futurologists like Toffle argue that a system may restructure itself over time since it may collapse into chaos and anarchy if change is not managed. The ability of management to forecast the future will greatly enhance the ability to manage change and avoid a crisis situation.

The Role of Public Policy

Some have argued that public policy in LDCs makes it difftcult to transfer technology successfully.

Coughlin, in showing how public policy affects the transfer of technology, notes the case of Yugoslavia, where foreign exchange restrictions, the inflexibility of joint ventures, and minority ownership restrictions have deterred foreign investments.

Baransot P points out that public policy can promote technology flow if administrative controls can be replaced with market mechanisms. He suggested a shift of public policy from supply-push to demand-pull, the encouragement of indigenous design and engineering capabilities through financial mechanisms, and the allowance of local enterprises to negotiate foreign collaboration agreements. Millman notes that governments views technology transfer as part of the foreign policy arena. Governments can therefore have a significant impact on promoting or hindering the transfer process. Capstickj' points out the need to analyze government regulations, political history and economic stability before MNCs engage in joint ventures in LDCs.

The LDCs face a multitude of socio-political and economic problems. Some of these factors have created an unhealthy business atmosphere and in themselves make it difficult to transfer technology.

However, it is important for the MNCs and DCs to recognize that they can play an effective role through technology transfer if they are willing to commit themselves to the needed research and development processes. It is hoped that effective technology transfer can help through its role in improving social and economic conditions to transform and change the atmosphere in LDCs and genuinely improve the quality of life.

Benefits of Successful Technology Transfer

Successful technology transfer will help to uplift both the social and economic conditions of developing countries. These benefits are often cited in supportive literatures. Benefits such as long-term economic growth as a result of technology progression and the increase in direct foreign investments are often cited. Thus, technology transfer should not be viewed as a one way process but rather as a symbiotic and synergistic process. Because these benefits also improve the quality of life of LDCs they may lead to an increase in productivity. The individual governments further achieve stability through the expansion of the economy.

Technology transfer is not without its disadvantages. Problems such as social inequality, social retardation, economic stagnation and environmental pollution are often cited. Some of these may be as a result of poor planning for technology transfer. Problems such as environmental pollution may not be avoided but can be controlled. Madeufh and Bosworth presented economic models to measure transfer profitability. Such models do not capture the intangibles that have to be taken into consideration in technology transfer.

It is common belief that the advantages of technology far outweigh the disadvantages. More stands to be gained if technology is appropriately transferred.

TECHNOLOGY TRANSFER AND SMES

The most difficult problem in technology transfer is that of bringing new technology in the form of product changes or new manufacturing techniques to the relatively small, less sophisticated companies that make up the majority of firms in any country. These firms generally support no research or development themselves and usually have no one on their staff with anything resembling an engineering or scientific education. In trying to bring new technology to this type of firm, governments have tried many strategies, few of which have been successful.

Small, less technically advanced firms, such as these, simply do not have the internal resources necessary for generation of new ideas. They are, therefore, just that much more dependent on the outside world for their technology.

This is as true for subsidiaries of multinational as it is for domestically owned firms. The two do not differ significantly (77% versus 84%) in the degree to which innovative ideas originate outside.

First of all there is the usual discovery that nearly all of the information is obtained through direct personal contact, half of that being trade journals. Once again technology is found to primarily flow through informal channels. Documentation plays a role secondary to that of direct personal contact. More striking than this however, is the extent to which information comes directly from other firms, particularly competitors, and the degree of international contact shown by this sort of firm. came from other firms.

Most of these firms are outside the country of the innovating firm. Foreign contact, by these mostly small firms, is extremely high. Even with foreign parent firms excluded, other foreign firms are responsible for nearly half of the innovation-producing messages.

The most surprising result is that so many of the firms supplying new technology are apparent competitors in the same industry. It seems surprising that so much information would be so freely available from apparent competitors. Most of these apparent competitors however, are outside of the country, that most of them did not consider themselves to be direct competitors. Remember that these are mostly small firms, and lack the highly developed distribution networks required for penetrating foreign markets.

In a typical scenario, the manager from one of these firms might visit a trade show in another country, and be invited on plant visit by representatives of a foreign firm. While there he would encounter some new manufacturing technique that he would later introduce into his own firm. In other cases managers approached apparently competing firms in other countries directly and were provided with surprisingly free access to their technology.

Less used from trade fairs, research institutes or industry associations. These sources serve only domestic firms. The universities however, are more useful to foreign than to domestic firms. Other government agencies serve the two sectors about equally. The research institutes and industry associations are established primarily to serve domestic industry. The universities and possibly even some other government agencies do not see themselves constrained in this manner. The reason for the greater flow of ideas from universities to foreign firms, probably lies in the fact that these firms are more likely to have technically trained staff with whom the university researchers can more readily communicate.

Consultants are more helpful in initiating product innovations. Foreign vendors areas to be expected, of greater value in initiating process innovations. This results, primarily, from the sale of manufacturing equipment. What is more surprising than the degree to which foreign vendors influence process innovation is the fact that they were involved in so many product innovations. This resulted in many cases from new manufacturing machinery enabling product improvements. But it also resulted, in atleast a few cases, from foreign vendors passing along information on industry developments, which in turn stimulated new or modified product designs.

The most important category outside of the firm is, not surprisingly, the supplier or vendor. The manufacturer of production equipment is normally bound under warranty agreement to solve any problems which arise with the use of this equipment. Private consultants are also engaged frequently at this stage. However, there is still precious little resort to the research institutes and nearly as little to the universities.

In SMEs personal contact is strained in transferring technology. Information networks have developed in many industries, for the express purpose of disseminating technological information. The textile industry is a case in point. Managers of textile firms seem to be a migratory breed. Such movement of key people leads to the development of informal networks among themselves and the people with whom they become associated in different parts of the world. This has resulted in a very extensive technology diffusion network within textiles, which is, of itself, worthy of much further study.

Sources (external to firm) of technology transfer
Supplier or vendor, Domestic or Foreign
Firm in same industry, Domestic or Foreign
Firm in different industry
Parent firm
Customer firm
Private consultant
Government sponsored research institute
Other government department
University
Industry association
Trade fair
Domestic
Foreign
Trade journal
Publications other than trade
Journals

..... AND SOMETHING NEW

Teltech's system of technology transfer

The new approach to technology transfer was developed by Teltech. Inc., of Minneapolis, Minnesota, a private company which sells its technology transfer services mostly to mid- and large-sized companies across the country. Its clients include more than half of the Fortune 500 companies. Most clients are 'high-tech' or 'medium-tech' as measured by their R&D to sales ratio. Teltech provides two services to its clients - access to a network of technical experts and access to interactive literature searching.

The expert network

Teltech's'expert network' service puts a company with a technical question or problem in touch with a leading authority in that technical field within 24 hours. The expert network consists of several thousand technical experts which Teltech has recruited from universities, federal laboratories, technical consulting groups, and the ranks ofretired industry scientists and engineers. Their areas of expertise range from theoretical to practical.

Teltech identifies potential recruits primarily through peer recommendation and if they are willing to be recruited, interviews them. Final selection is based on a number of criteria, including specific area of expertise (the candidate must be a recognized expert in one or more technologies), broad area of technical knowledge, the needs of
Teltech's clients, the candidate's practical experience and his ability to communicate.

The interactive literature search

The second feature of Teltech's service is the 'interactive literature search' capability, which allows a business to keep abreast of all relevant technical and business literature in its field. To access this se&ice. the business calls an information scientist ('searcher') at Teltech, who has search proficiency in the complete range of major and minor on-line systems and tiles, encompassing local, national, and international technical and business information.

The interactive searching service overcomes the high learning costs that make it impractical for many businesses to perform their own searches of the technical and business literature. The first of these costs is the time and expense of learning what data base resources exist. Most businesses do not even know of the existence of many of the relevant data bases, do not know the quality of the various data bases and do not know what information is contained in each data base.

CONCLUSION

Technology transfer and collaborations between companies are very important dimensions in the strategy of firms, especially when attempting technological innovation. Collaboration provides a means by which companies can observe novel technological developments without having to undertake the expense and risk of investing in speculative research. It can also mean that a company can produce a product that it would otherwise be unable to do because it lacked the necessary technology.

CHAPTER III

BENCHMARKING IN TECHNOLOGY TRANSFER

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"What gets measured gets managed"

INTRODUCTION

Fierce competition, globalization and the development of new information and communication technologies have forced organizations to continuously search for and adopt new configurations (processes and structures) by which to exist. In other words, organizations are undergoing changes to evolve, survive and compete in their respective industrial environments. The explosion of management tools and techniques in the 1990s to help organizations successfully change is evidence of this situation. Among these techniques is benchmarking, which has proved to be valuable in helping individual companies evaluate their competitive position relative to their competitors.

Effective acquisition and utilization of new technology from an outside source can contribute greatly to the operational success of a firm, though acquiring and assimilating new product and process technologies is often quite difficult. For example, at one computer electronics firm, the transfer and utilization of a new core product technology led to substantial delays and cost over-runs in a product development effort. In this case, the firm had limited interaction with the technology vendor, even though it was a risky and critical technology. In contrast, at a medical equipment manufacturer, the acquisition and utilization of a new flexible manufacturing system led to production of high quality parts in sufficient variety and volume within a reasonable timeframe. In this case, the firm worked closely with the vendor throughout the transfer process and even had, as planned, vendor personnel on the shop floor for several weeks. Clearly, some transfers are more successful than others.

Technology transfer into the firm is a challenging and — we believe — a more often recurring operational problem. Organizations are emphasizing "focus" on selected core conversion activities that are their key competitive competencies. This results in the need for more interfaces with external organizations to source technologies as fewer product and process technologies are developed or produced internally.

Several philosophies have taken hold, suggesting that some firms need practical skills in upstream technology transfer, if they wish to routinely achieve functionally effective, low-cost, time-efficient transfers. And some firms are actively responding to the increasing rate of technology innovation and technological options, meaning they could more often source "risky" technologies, which have greater uncertainty from external organizations.

For all these reasons, in many firms technology transfer is no longer an occasional activity, which can be managed in an ad-hoc fashion; rather, it is a recurring process, which requires purposeful management supported by a well-developed portfolio of organizational skills.

How should companies actually go about conducting the transfer of individual product and process technologies? In addressing this question, the technology transfer literature primarily considers governance forms, such as direct investment, joint venture, direct sale or licensing (Oxley, 1999; Kumar et al., 1999; Davidson and McFetridge, 1985; Teece, 1977). This literature typically takes the perspective of a source nation or firm, which wishes to gain economic value from sharing or selling proprietary technologies, and generally considers the political, corporate or strategic level of analysis rather than an operational, project level. Reddy and Zhao (1990), and Contractor and Sagafi-Nejad (1981) focus heavily on legal, contractual, and ownership issues regarding technology transfer. Finan et al. (1999), Reddy and Zhao (1990), generally following a transaction cost framework. The transaction cost approach, however, has shortcomings in many practical contexts because it does not deeply examine the work-level inter-organizational issues involved in technology transfer.

A smaller subset of the technology transfer literature does adopt an inter-organizational focus (Galbraith, 1990; Rebentisch and Ferretti, 1995; Gibson and Smilor, 1991), but this literature typically examines inter-organizational factors, such as communication, only on an individual, unidimensional basis. The technology transfer literature also does not fully consider the nature of the technology to be transferred, as it generally only considers a single technology attribute, if it does so at all.

Accordingly, this thesis aims to contribute to the operations management and technology transfer literatures by developing a conceptual framework of effective benchmarking the technology transfer at the whole project level. The conceptual framework captures the nature of the technology to be transferred, the activities and interactions across organization boundaries, and contingent relationships between technology and organization, searching for the "best practice" in every step, action and best management approaches for transferring a technology from or into an organization. Technology transfer is an inherently multidimensional task characterized by complex and interrelated relationships among many variables. This multidimensionality and multivariate complexity is explicitly considered in the development of the model.

Section I and II have provided key concepts regarding technology transfer, benchmarking and effectiveness. This discussion was necessary because considerable terminological confusion arises due to the diversity of meanings applied to similar words in the extant literature.

To have a successful startup and result when transferring technology, not only must the technology (in both its "hard" and "soft" elements) be properly selected, but also the implementation process must be carefully planned out. All the above, when following world class practices, consist steps of a benchmarking methodology, which if properly implied will contribute so, that the technology transfer will finally lead to competitive advantage for both the donor and the recipient, which is eventually the ultimate purpose of benchmarking.

THE CYCLE OF THE TECHNOLOGY TRANSFER PROCESS

As it has already been discussed in Chapter II, technology transfer is a fragile social process that involves a particular kind of interaction between two groups of people: the transfer and adaptation of knowledge. Like most processes, technology transfer has an inherent sequential character to it: it naturally involves a series of steps, and the usual penalty for attempting to "short circuit" any step is that the following steps are delayed, lengthened or made impossible. For the purposes of the analysis below, we adopt the model by Goldhor and Lund (1983) with four steps to the path over the technology transfer bridge: searching, learning, adapting, and using.

Searching involves not only finding a source and target technology that match, but also a donor and recipient organization that can work together, and that have the requisite characteristics. Ideally, sufficient effort will be spent by both donor and recipient to make sure that they have the skills, motivation, and resources to make the transfer succeed.

Learning is the vital second stage of technology transfer. It is the most important transfer mechanism. Interestingly, it is an activity that universities should be expert in. However, donors, recipients, and sponsors must realize that it is expensive both in time and money. One approach by which learning can take place is via an exchange of personnel between recipient and donor organizations.

Adaptation is the third stage of technology transfer. Once the recipient organization has internalized the relevant knowledge about the source technology, it must begin adapting it to its own needs. This stage places special requirements on both the recipient and donor organizations. The recipient organization must realize that it is time to try its own wings; they cannot continue to depend on the donor indefinitely. Especially as they move toward the target technology, there will be more and more technical questions that the donor will not be able to answer. The donor, on the other hand, must be willing to "let go" of the technology; allowing the recipient to modify. expand, simplify, and otherwise corrupt what has been regarded as an elegant piece of work representing many years of research and feelings of personal pride and ownership. An ideal attitude would be for the donor to view the adaptation process as a source of ideas and stimulus for further research.

Utilization of the target technology is the ultimate test of success of the transfer attempt. It is, unfortunately, the step in the transfer process that seems to be most often missing, and hardest to identify. The result of technology transfer often will not be a product per se, but rather a series of related products ("cousins" of the intended product), or an increase in expertise, or the acquisition of personnel. Eaton Corporation's first venture into micro-processor applications produced such a result. The target product was not marketed, but a series of simpler versions were produced and technical know-how was substantially enhanced. An important implication of this is that it may be a mistake to try to measure the success of technology transfer efforts by a simple determination of whether the originally-envisioned product was ever put into production.

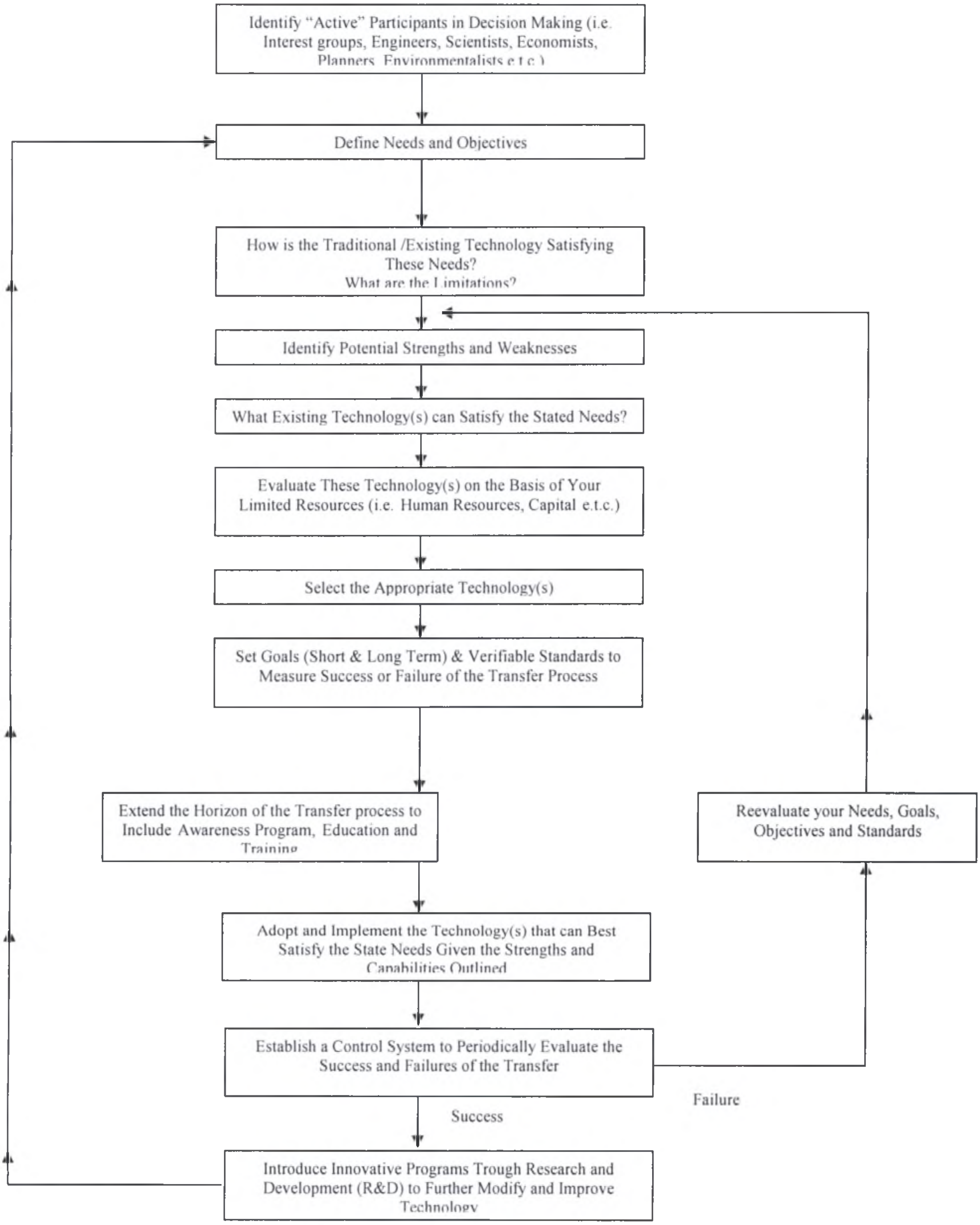


Fig. 1 The technology transfer process (adapted by Madu, 1989)

OVERVIEW OF A SELECTION OF TECHNOLOGY TRANSFER MODELS

Technology transfer represents one of the most knowledge intensive and problematic relationships in a firm. Typical problems encountered here include business units not interested in R&D developments, which could be due to cost factors or poor communication between technology senders and receivers, or as a result of the 'not invented here syndrome' and problems simply arising from lack of resources. De Meyer (1991) contends that maintaining an effective MNC global R&D network might require the creation of a 'family atmosphere' through using mechanisms such as: *temporary assignments* to other laboratories; *constant traveling*; *rules and procedures* to reinforce company culture; and through *training*.

Szulanski's (1996) investigation into why knowledge transfers can be so difficult points to issues such as: lack of motivation; lack of absorptive capacity; lack of retentive capacity of recipients; formalized structures and systems; lack of numerous individual exchanges; and an arduous (i.e. laborious and distant) relationship between the transfer partners. Jain and Triandis (1997) provide a useful set of general approaches that can help overcome some barriers to technology transfer. These are the *personnel approach* (temporary or permanent transfer of the owner of knowledge to the user group), the *organizational link-pins approach* (specialized transfer agencies used as intermediaries) and the *procedural approach* (early user involvement by means of procedures, e.g. multifunctional project teams).

Technology transfers inside firms will have different levels of expertise or know-how transfer, as much knowledge may already be embedded in the technology. This gives rise to the issue of making distinctions between tacit and explicit knowledge. Howells (1996) concludes that more elements of *tacit knowledge* may in reality be, if not formally liable to codification, at least able to constitute an 'organizational routine' that can be transferred between individuals or groups in a more structured framework that forms part of the firm's *accumulated* knowledge base. Here, it is important to stress that technological knowledge is not the same as information. Knowledge is developed and organized out of a procession of information based on beliefs, values and commitment of individuals involved. Information only becomes knowledge once it is understood and its value is learned and this knowledge is a property of individuals. In the context of technology transfer here, information flows can be viewed as facilitating and developing a common understanding.

A number of technology transfer models have typically focused on transfers between firms, between public research establishments and private sector firms and collaborative agreements between educational establishments, industrial organizations and government.

Common features found in typical technology transfer models include the establishment of manufacturing goals and objectives and the alignment of policies and actions of the manufacturing infrastructure with these goals and objectives. The Bommer et al. (1991) model presents four components of technology, which have increasing levels of sophistication as follows: (1) *Technoware* - object-embodied technology; (2) *Humanware* - personembodied technology; (3) *Inforware* - documentembodied technology;
(4) *Orgaware*- institutionembodied technology facilitating integration of the previous three components.

Levin (1997) states that the major challenge for management is to use the technology transfer process as a vehicle for creating a *learning organization*. The inner workings of a technology transfer process, involving establishing relationships, communicating with people at the right levels and transferring the necessary know-how or expertise, can be viewed as a *set of routines* used in organizational learning.

Gilbert and Cordey-Hayes (1996) develop a model that follows the processes of knowledge as it might be transferred within an organization to lead to the development of a *set of routines*, which are reflected in the behaviour and practices of the organizational members and becomes part of the core routines, so that assimilation (or learning) occurs. The first step of this model is 'acquisition' of knowledge, the second is 'communication', the third is 'application' and the fourth is 'assimilation', where the key to the process of transfer is seen as the assimilation of results and efforts of applying the knowledge gained.

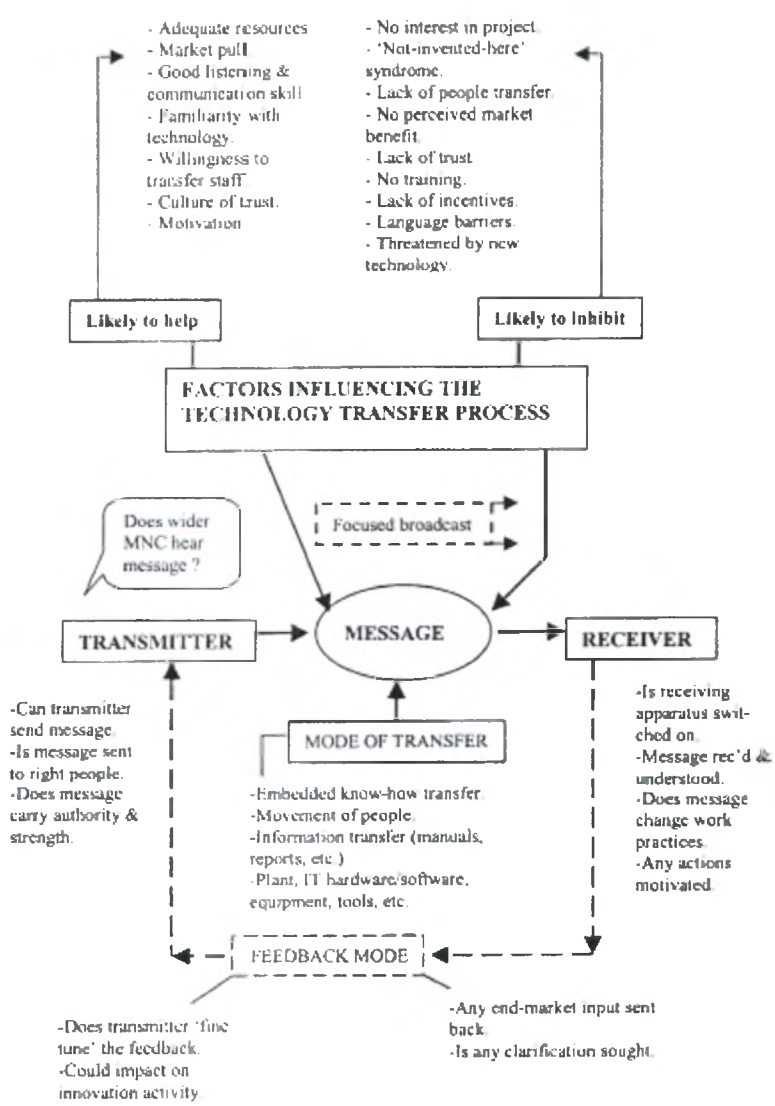


Fig. 2 Technology Transfer model *(adapted by Malik, 2002)*

TECHNOLOGY UNCERTAINTY AND ORGANIZATIONAL INTERACTION

Technology uncertainty is the difference between the level of knowledge required by the recipient organization to acquire and implement the technology, and the level of knowledge the recipient actually possesses. Many factors contribute to technology uncertainty and in turn increase the information processing requirements .

The second dimension is organizational interaction, which characterizes the nature of the inter-organizational relationship between the source and recipient. As with technology uncertainty, organizational interaction has many contributing factors. We synthesize these factors into three macro-factors, which constitute essential subdimensions of organizational interaction: communication, coordination, and cooperation between the two organizations.

Communication includes the methods of communication, magnitude and frequency of communication, and nature of information exchanged. Coordination refers to the nature of the planned structure and process of interactions and decision-making between source and recipient (Parkhe, 1991).

Cooperation is the "willingness of a partner to pursue mutually compatible interests rather than to act opportunistically" (Das and Teng, 1998). The subdimensions are conceptually different; nonetheless, they overlap somewhat. Higher levels of organizational interaction provide higher levels of information processing capability. Note also that these three subdimensions correspond to the three components of an interorganizational relationship described above in the discussion of interdependence theory.

The inter-organizational activities in technology transfer may be seen as constituting a "project". Key elements of project operational effectiveness are time, cost and technical performance (Meredith and Mantel, 1995) . These elements apply readily to the technology transfer context, making up three subdimensions of transfer effectiveness: the functional operation of the technology analogous to technical performance, transfer related costs, and the time taken to complete the transfer project.

Table 1
Inward technology transfer typology subdimensions

Subdimension /Underlying factors
(a) Technology Uncertainty Subdimensions
Novelty
Technological familiarity
Technology newness
Radical - incremental innovation
Discontinuous change
Platform - derivative innovation
Complexity
Internal system interdependence
External system interdependence
Tacitness
Tacit knowledge
Physical embodiment

Invisibility
Structureness

(b) Organizational Interaction Subdimensions
Communication
Magnitude and frequency of communication
Nature of information exchanged
Coordination
Quantity of planning
Relationship formality and structure
Length of time horizon
Cooperation Trust
Willingness to share information
Goal congruence
Commitment

TECHNOLOGY TRANSFER PROCESS TYPES

The first transfer process type is the arms-length purchase. For the recipient, the technology to be transferred has low levels of complexity, novelty, and tacitness. The technology can therefore be used by the recipient as soon as it is received with little or no difficulty. The recipient has all or virtually all the information needed to successfully move and implement this technology. Therefore, the level of technology uncertainty is low. The relationship between the source and recipient is a simple market transaction where the recipient utilizes the technology with little or no assistance from the source. There is little communication between the source and recipient; and little cooperation or coordination is required. The overall level of organizational interaction is therefore low. The information processing requirements posed by the technology and the information processing capabilities provided by the organizational approach are both low, and therefore are appropriately matched.

The second transfer process type is the facilitated purchase. Complexity, novelty, and tacitness are relatively higher for the technology in this category than in an arms-length purchase transfer. For example, the technology may be functional in its present form exhibiting a relatively low degree of tacitness . However, because of a lack of expertise or experience, the recipient does not know how to immediately utilize the technology a medium level of novelty, or the technology has a non-trivial number of components or interactions a medium level of complexity. In this transfer process type, as well as in an arms-length purchase, the actual movement of the technology in the transfer is likely to be trivial.

Organizational interaction is characterized by low to medium levels of communication, coordination, and cooperation. The recipient purchases the technology from the source in a traditional market transaction. However, the source provides guidance and information to the recipient in utilizing the technology. There is more communication between the recipient and source than in the arms-length purchase transfer mode, and this communication includes non-trivial technical information related to the functioning and implementation of the technology. The recipient may disclose information about the target use of the technology, so there would be two-way communication and cooperation. Still, most of the technical information comes from the source firm. There are low to medium levels of information processing requirements and information processing capabilities.

The third transfer process type is the collaborative hand-off. In this category, the technology is generally medium or high on two of the subdimensions of technology uncertainty, but possibly low or medium on the third subdimension. The overall level of technology uncertainty is therefore higher than in the facilitated purchase. Uncertainty arises both in the movement of the technology because it may not be clear that all knowledge embodied by the technology is actually moved to the recipient, or there may be uncertainty about how to move the technology, as well as in the utilization of the technology by the recipient. The organizational interaction between the source and recipient is higher than in the facilitated purchase. The levels of communication and cooperation are greater, and more attention is devoted to coordination activities between the source and recipient. Therefore, the collaborative hand-off exhibits medium to high levels of technology uncertainty and organizational interaction, and thus results in relatively higher levels of information processing requirements and capabilities.

The fourth transfer process type is co-development, which represents a match between very high levels of technology uncertainty and organizational interaction. The technology is high on the novelty, complexity, and tacitness subdimensions. Such a technology is likely to be poorly documented, incompletely specified, or perhaps not even available in its final form. The recipient may have some idea of what the technology should accomplish functionally but without a detailed design or set of specifications.

Such technology can reside in the source organization primarily as knowledge or procedures about a product or process. Technology in this category might even be a collection of functional elements that are to be combined together in a new way to form a system. In addition, for this technology, there is likely to be uncertainty regarding whether it is possible to move all needed information from the source to the recipient. The relationship between the source and recipient in a co-development transfer will be characterized by a very high degree of communication, cooperation, and coordination. The organizational boundaries between the source and recipient are effectively blurred or possibly even eliminated. The source and recipient work together, largely as one integrated albeit often ad-hoc organization, to move the technology to and utilize it successfully in the recipient organization. There is often, although not always, extensive and lengthy physical co-location of personnel from the source and recipient organizations. Co-development transfers could include deep supplier involvement in product or process development. Some but not all strategic alliances, joint ventures and joint R&D agreements are examples of the level of organizational interaction found in a co-development transfer.

The organizational interaction in this transfer process type provides the highest level of organizational interaction and the highest level of information processing capability.

These categories represent ideal types of the technology transfer process. There is an inherent contingency perspective here. If the information processing capabilities provided by the organizational interaction are appropriately matched to the information processing requirements determined by the technology uncertainty, the technology transfer should be effective.

An effective transfer is one that is accomplished on time, within budget, and fulfills the functional objectives of the technology within the recipient. If there is no appropriate match, then the transfer is likely to be ineffective.

A transfer in which the information processing capability is inadequate for the level of information processing requirements would result in a transfer that is likely to either take longer than planned and/or fall short of functional objectives.

Regarding it from the benchmarking point of view , "The process of identifying and transferring practices is trickier and more time consuming than most people imagine" (American Productivity and Quality Centre, 1998). A recent study by the European Centre for TQM (Jarrar and Zairi, 2000) concluded that the best practice process for the "effective transfer of best practices" is made up of six major stages:
(1) searching;
(2) evaluating;
(3) validating;
(4) implementing (transferring and enabling);
(5) review; and
(6) routinizing (Jarrar and Zairi, 2000).
One of the major stages, and arguably the most difficult, is the internal transfer of best practices.

Transfer is ``identifying and learning from best practices and applying them in a new configuration or new location" (O'Dell and Grayson, 1997). Success in transferring best practices means reducing the effects of inhibitors or overcoming barriers which include (Ashton, 1998; American Productivity and (QUALITY Center, 1997):

- top management's failure to signal their importance;
- little shared understanding of best practices;
- a non-standardized best practices process;
- organization structures that promote ``silo thinking";
- a culture which values personal expertise and knowledge creation over sharing;
- lack of contact and information exchange;
- over-reliance on transmitting explicit rather than tacit information;
- lack of time;
- employees and managers not being accustomed to seeking or sharing knowledge; and
- people not being fully aware of the knowledge they hold.

In addition to removing obstacles, organizations must create an enabling structure for the effective transfer of best practices. The European Center for Total Quality Management (UK) undertook a study that was aimed at identifying the critical success factors for the ``effective transfer of best practices".

BENCHMARKING IN TECHNOLOGY TRANSFER - THE CONCEPT

Owing to rapid technological changes, short product life-cycles, and increasing global competition, acquiring new technology becomes crucial to enable firms to develop new products more quickly. However, this development comes with costs and risks. Even firms with great financial and technological capability cannot conduct independent R&D activities readily. Thus, the ability to exploit external knowledge is a critical component of successful innovation. Still, how can a firm find the best way to acquire and exploit knowledge? What is the best practice in the technology transfer process, the one that will help the company save money and time and on the other hand, have the best possible results? How will it choose technology type, partners, channels, mechanisms? Clearly this is a benchmarking job. Still, no theory or research has been done on this matter, although technology transfer is considered to be one of the most sensitive and vital policies of today's companies.

Accordingly, no definitions have been given to this new concept till now. Actually, we are talking about a new type or branch of benchmarking that deals with the "finding and implementing best technologies in business, that meet customer requirements. So the flywheel on finding the very best, is 'Does this meet customer requirements?' The basic objective is satisfying the customer, so that is the limiter" (Linsenmeyer).

Besides the definitions that have been presented in the 1st chapter, J. Main1, in his article in Fortune (1992), defines benchmarking as "the art of finding out, in a perfectly legal and aboveboard way, how others do something better than you do - so you can imitate - and perhaps improve upon - their techniques". This can lead to a definition close to what is here presented, or otherwise, paraphrasing Spendolini (1992),

Technology transfer benchmarking is ``a continuous, systematic process for evaluating the know how, technology and processes of organizations that are recognized as representing best practices for the purpose of technology transfer".

A number of questions relevant to benchmarking and technology transfer will need to be answered by both researchers and practitioners before these two philosophies can reach full synergistic potential. Included among this list of questions are:

- Λ How can organizations avoid the pitfalls (trap) of benchmarking and what are these pitfalls from a technology transfer perspective?
- Λ What tools, processes, measures and metrics can be used?
- Λ Is there a benchmarking ``metaphor'' for technology transfer?
- Λ What will make benchmarking for technology transfer unique?
- Λ What effort is required for, and what benefits accrue from, benchmarking?
- Λ Is there a need for knowledge acquisition from practitioners and researchers from technology transfer and benchmarking?
- Λ Are more complete definitions and constructs for benchmarking and technology transfer required and available?

Gathering intelligence about competitors is hardly a new idea. Historically, industrial growth and development has been advanced by imitation of technology, business practices and organization in other countries. Many interesting examples of benchmarking in Technology Transfer can be found in history. Bolton describes how industrialization in the

USA benefited from imitating and exploiting Britain's knowledge of technologies such as metallurgy and the steam engine. In the mid- 1880's American engineers visited Britain copied and made major changes to British engines to adapt them to different fuel prices and the characteristics of North American rivers. Hurst also describes how, in the 18th century, Quaker entrepreneurs in Coalbrookdale in the UK formed an archetypal cluster of innovative small and mid - size firms, similar to present day silicon valley. Innovations in coal, iron and stream transportation technologies advanced rapidly, leading to the railroad boom and the industrial revolution. In the 19th century, Meiji restoration, the Japanese based their police, postal system and newspapers on chosen Western models from France, Britain and the USA.

However, impetus has come from increased global competition, development of information technology, databases and networks.
Drew (1997) relates the use of benchmarking and the need of Technology Transfer, making the following assumptions:

- The frequency of use and success of different types of benchmarking is related to the degree and type of change in the firm's industry and business environment.
- The frequency of use and success of different types of benchmarking is related to the industry, market position, strategy and capabilities of the firm.
- The degree and type of improvements and changes as a result of benchmarking will depend upon the approach adopted and choice of the partner.
- Firms will experience differing barriers to success in benchmarking projects.

Organizational learning, intellectual leadership and knowledge management are key concerns for strategic management. Benchmarking with firms outside the industry is significantly correlated with higher levels of innovation, confirming the observations of Von Hippel and others that innovation typically arises outside a given industry - through suppliers and lead users - rather than from within. Sharing and transfer of knowledge is also the tangible evidence of a learning organization - one that can analyze, reflect, learn and change based on experience.

Before one can transfer knowledge or best practices, it is necessary to define and find them. Of course, the organizations have always had mechanisms, from R&D experts and technical audits to internal conferences, intended to identify and spread practices. In their article, O'Dell and Grayson (1998) focus on the impact that benchmarking could have on the oil refinery business and lament on the short-sightedness of the people in this field. ``Research has good ideas, but they don't get used. The refineries don't always talk to each other enough. We re-invent the wheel everywhere, and there is no way to pass on the success stories". Executives tend to be close-mouthed about what they are doing in their respective organizations and the industry ends up investing many times over in the same things and the successes are not shared.

So, why benchmarking in technology transfer?
Benchmarking is a systematic approach to information and communication. The primary use when having to do with technology transfer is to identify areas of strength to further develop and areas of weakness to remedy or withdraw from.

- The process is motivating. It provides targets that have been achieved by others.
- Resistance to change may be lessened if ideas for improvement come from other industries.

- Technical breakthroughs from other industries that may be useful can be identified early.
- The process broadens people's experience base and increases knowledge.

Of course, as Arun Maua, VP at Arthur D. Little, mentions, ``You can't just impose a best practice. It has to be adapted to your own company's style". This refutes the assumption that all processes work for all companies (Boxwell, 1994). One cannot just pick up a ``best practice" and surgically implant it in one's own organization. One has to look at the way things are being done, the culture prevailing, the human resource employed to do the job, etc., before one can adapt a process. And that is what is the main crux of the benchmarking methodology, i.e. to adapt the process from the leading companies to one's own organization.

Problems occur even where benchmarking facilitates the technology transfer, when there are factors missing throughout the process. Szulanski (1994) describes how "stickiness" may arise in knowledge transfer due to factors such as the inability of the recipients to absorb the new technology, "causal ambiguity" (i.e. the difficulty of understanding existing cause and effect relationships) and poor relationships between organizational units. Camp, Spendolini and Bogan and English also discuss the problems experienced in locating information, establishing relationships with partners and transferring best practice.

Time is also viewed as a very significant barrier, as well as difficulties of resourcing and finding partners.

THE DYNAMIC CONTEXT OF TECHNOLOGY TRANSFER BENCHMARKING

"Benchmarking remains one of the true change drivers for an organization. There is nothing like seeing how others do things to take you from complacency, to a will to change, and providing some ideas on how to change."

Some useful insights form the godfather of the movement.

The model set in Technology Transfer benchmarking embeds the process with a dynamic context. It posits that benchmarking is affected by external forces and characteristics. Further the results have an impact on both short and long- term outcomes. The model points out to the fact that benchmarking is not an activity carried in isolation. Culture is expected to affect what outcomes or processes are benchmarked and what types of organizations are seen as relevant benchmarking partners. Even which organizational members are involved and to what extent will be culturally influenced. Culture should also impact what types of organizations are perceived as useful for benchmarking partners. While the organization "determines" what and how to assess technology, it is expected that this is significantly influenced by external forces such as the government (e.g. Securities & Exchange Commission filings) and the financial community. Benchmarking intentions may also be directly influenced by external demands such as a client organization that insists that benchmarking be done. Further, the benchmarking may be done in response to what another organization is doing, such as a direct competitor. There are also two difficulties that companies - usually small ones - would not turn to benchmarking. First, there might be a perception that the organization cannot carry out a successful benchmarking study (benchmarking efficacy), or a belief that benchmarking will not lead to valued outcomes (benchmarking instrumentality) (Fedor, 1996).

It is understood that what the organization intends to do and what actually takes place will tend not to be the same. The reasons fit into two categories. The first concerns the general issue of constraints in that unanticipated problems can arise, such as when resources are withdrawn or emergencies occur that divert participants' attention to more pressing concerns. New partners may have to be selected, or a new level of benchmarking may be necessary.

The second reason has to do with direct and indirect participants. Some may discover that what is being learned through the benchmarking process might threaten personally important power bases, while others may see the results as very favorable and push for other types.

Benchmarking may be conducted solely based on external requirements, hierarchical edict or mimicry.

For example, powerful customers might impose this step on the organization as part of a supplier agreement. Second, a sufficiently influential participant in the process (e.g. the CEO) might decide for the organization that this is a step that must be taken, like in the General Motors example. Third, there is also the possibility that regardless of how current performance is seen, the organization might engage benchmarking, just because their direct competitors or other organizations are doing the same.

Benchmarking requires exchange of information. In most cases, companies do not reveal secrets behind their success, in order to protect commercial interests. In the early days, companies carried out benchmarking exercises by extracting information through recruiting people who had the knowledge of best practices and suitable alliances. With the development of information technology such as Internet, EDI and WWW, the exchange of information has become more transparent. Benchmarking has become more active than ever before with the development of Information Technology. More interactive Web-based data collection and analysis facilitate the benchmarking process more effectively and can become the power tool in the search of technology transfer "best practices".

INFORMAL COMMUNICATION NETWORKS

The importance of informal communication networks for the diffusion of technical information is demonstrated by several studies. So, it is worth discussing it before entering the formal approaches of information acquisition.

Employees frequently give technical information or advice to colleagues in other firms, including direct competitors, while such trading is desirable from a firm's point of view. Furthermore, the data suggest a positive link between the participation of a firm's employees in informal information- transfer networks and the economic performance of the firm (Schrader, 1991).

Analyzing information transfer in the semiconductor industry, Rogers (1998) concludes that although formal, official channels exist for the exchange of technical information, "the most valuable information is communicated mainly via informal channels". Von Hippel suggests that employees actually trade information within these networks. Individual employees provide information to colleagues from other firms with the expectation of receiving valuable information in return, either immediately or in the future. Observing similar exchange relationships in the semiconductor industry, Rogers at least partly explains employees' willingness to disclose useful information to other firms by the fact "that information must be given in order for it to be obtained", and he gives examples of individual employees who trade information while keeping the economic interests of their firms in mind.

Several studies offer support for the strength and extent of the quid pro quo norm (Gross and McMullen and Miller and Berg). Even if a formal contract is used for governing the exchange of technology, informal information trading is likely to go on. As Hamel, Doz and Prahalad point out, management may set the legal parameters for exchange, "but what actually gets traded is determined by day-to-day interactions of engineers, marketers, and product developers".

Information trading creates incentives to innovate. Internally generated technical knowledge is used not only within a firm, but also bartered for further knowledge-as long as the benefits outweigh the costs. A firm that does not keep up with technical change loses its attractiveness as a trading partner. Thus, reducing internal technology development also inhibits the ability of a firm to acquire information externally. Internal technology development and information trading are not substitutes, but rather complements.

THE BENCHMARKING PROCESS IN TECHNOLOGY TRANSFER

The general frame

The process has to be considered as a cyclical process (Bogan and English, 1994) and will be twofold; that means it will refer to a potential donor or a candidate recipient as well, although transferors are usually the ones to be able to benchmark. It will generally be presented as following a frame made up of five successive phases:

(1) The internal diagnosis of the company's needs and gaps, so as to suggest different ways of possible additions and improvements to develop in-house, or to seek in some other company.
(2) The definition of the benchmarking application framework, as well as the identification and the choice of partner with whom to associate for comparative analysis.
(3) The analysis of differences between the benchmarking partners on the topic identified previously.
(4) The definition of technology transfer - objectives by partner, with the action plan which allows them to be realized.
(5) The appropriation of the benchmarking results (benchlearning) with, if necessary, an adjustment of the improvement objectives previously defined.

A process of benchmarking begins with an analysis of the internal level of performance of each company wishing to participate in a benchmarking operation. It is thus necessary to have a method of diagnosis which is on the one hand, sufficiently general to be applicable to sometimes very different companies and, on the other hand, whose results could then be used within the framework of a comparative analysis between firms.

Maire (2002) presented a method of diagnosis based on the OLYMPIOS model of organization (Braesch, 1989). The way in which this method is used in a benchmarking context is detailed in Buyukozkan (1999).

The choice of the subjects to be benchmarked, as well as the selection of the partners to be retained, then implies carrying out a comparative analysis of the performances of the various companies likely to take part in the benchmarking. This supposes that a characterization of these performances has been previously taken place.

Several types of methods can be used for that. It is the case for example with data factorial analysis methods (ACP and AFC) which, using a chart, help to isolate the distinctive characteristics of a company's performance. The use of these methods in benchmarking is detailed in Maire and Buyukozkan (1998).

Methods centered on the analysis of process (Biteau, 1998; Herniaux, 1990; Lorino, 1995) can also be useful in this characterization. In this case, the performance characteristics which are identified result directly from the characteristics of the company's processes. These methods offer the advantage of constituting a structured base for future comparisons (Bemowski, 1991) and are privileged in the majority of the benchmarking currently practiced.

From the identification of the characteristics of the performance of each company, it is then a question of determining what can be benchmarked and with which companies the benchmarking can be carried out. It should initially be checked if there are significant variations in performance between the different ones involved in this operation. A benchmarking is only interesting for a company if it enables the firm to foresee a radical improvement in its performance. Additionally, co-operation between companies has the chance to function only if the mutual contributions of these companies are equivalent (Ingham, 1991). That implies choosing a benchmarking configuration (subject and partners of the benchmarking) and maximizing and balancing the variations in performance between partners (Camp, 1995).

Performance representation

A benchmarking process includes a comparative evaluation of the levels of performance reached by various companies. Thus, it is necessarily based on the use of a single model of performance representation, shared by all companies involved in the benchmarking process, and having to respond to three great constraints:

(1) Be sufficiently generic to be usable by sometimes very different companies, as well as being sufficiently detailed so that the representation obtained by this model helps one to realize the elements of performance specific to each company.

(2) Not limiting oneself to giving the company only one vision of its performance, but on the contrary to provide it with different complementary visions of its performance, which are interrelated and likely to reveal the different possible entry points for some improvements to be made.

(3) Privilege, with the aim of limiting interpretation errors compared to the level of performance assessed, the use of as few a performance indicators as possible, and, ideally, those which are shared by all the collaborators of the various companies involved in the process.

The first question which initially arises is to know which, among the many existing models, are those able to respond to these three constraints. Many modeling approaches can be proposed to represent and evaluate a performance system such as, for example an enterprise, a department or an activity. These approaches, which privilege the analysis and the reorganization of structure of the system are generally based on some mechanism which is often dependent on a very global or very local system view (Jia and Pourcel, 1996). In other terms, whereas some approaches deliver a synthetic vision of the performance of the analyzed system (macroscopic analysis), other approaches are based on mechanisms of fine modeling in order to describe the detailed behavior of the system (microscopic analysis). These approaches, although complementary, generally do not offer the possibility of being simultaneously aware, as the benchmarking process demands a global and a detailed view of the performance system (Maire, 2002).

The question which then arises relates to the choice of the indicators to be used to evaluate the performances associated with these various views. The answer is not simple. It is enough for some to look at the impressive number of performance indicators which are presented in the literature as essential reading to be convinced. In benchmarking, it is fundamental that the indicator or the indicators selected can be applied as well to elements located at the strategic level as to elements located at a more operational level of the company, and which can be applied to sometimes extremely different companies.
The total level of performance reached by the company can easily be assessed by analyzing all of the satisfaction levels collected.

The activities, as well as their necessary inputs, form the most detailed level of the representation. It is thus with each pair (activity, input) that the first performance assessments of the company will be carried out. Each of these evaluations gives rise, depending on the case in point, to the characterization of a weak point on which an improvement can be made (a point to improve), or with the characterization of a strong point which must be maintained to preserve the current level of performance (a point to maintain). The method used for this is detailed in Maire and Buyukozkan (1998).

The points to improve and the points to maintain can be respectively gathered in axes to improve and axes to maintain (for example, while basing itself on an aggregation by subparagraphs of the quality assurance models such as ISO 9000 or on an aggregation by collaborator to set up the dynamics of continuous improvement).

The processes can thus be aggregated according to the types of process (for example, operational type or support and management type), (Porter, 1986) the fields of activity by function (for example, commercial, production, quality and purchasing), the resources (for example, material, informational, decision making, human, financial and time), and the axes of improvement and satisfaction according to the different categories (for example, by basing on a distribution "management", "workers", "machine", "material" and "environment").
Obviously, multiple approaches of aggregation can be adopted. The final goal being to deliver a representation of the performance of each company.

Selection of personnel to work in the project is critical to success. Specially in the case of technology transfer in Developing Countries (DCs), there are many arguments concerning the use of expatriate or host country personnel, which are not to be hosted in this thesis.

Preparing for the benchmarking process

The preparation stage defines functions and responsibilities. As in the classical benchmarking, there are several questions that need to be answered before starting. What is to be benchmarked (e.g. the organization, a process, a product)? What type of benchmarking should be used (e.g. internal, competitive, generic)? Which industry sector to choose for benchmarking? Which company/companies to benchmark against?

Prasad (1999) defines a process as a set of 7Ts (talents, tasks, teams, techniques, technology, time, tools) arranged in a particular manner so as to transform a set of inputs into a specified set of outputs (goods or services). There are six parts to winning this competitiveness battle:
(1) What to change (inputs, outputs, and process steps (tasks) including measures and decision points).
(2) How to change (techniques, tools, process boundaries and process flow).
(3) Whom to change (talents, teamwork, customers and supply chain).
(4) Why to change (techniques, process, purpose, function, and rationale for decision making).
(5) When to change (time, process order and structure).
(6) Where to change (technology gaps, process relationship and its context to the whole).

Knowing what information is required or what task to perform is one sixth of this battle. How this information or task satisfies the corporate goals is the second one-sixth piece. The examples of such pieces are (Prasad, 1996):

- What information is required?
- How this information satisfies the corporate goals?
- Who makes up the team? Who needs the information?
- Why is this information needed? Why will this technique or process not work?
- When is the optimum time to do this task? and
- Where will this information be used? Where are the right places to use this?

By knowing ``what we do" today and ``how we do it", a company will be in a better position to identify bottlenecks and barriers in the current system and possibly locate the product/ process that needs to be improved or changed, and relevant opportunities (Wheelwright and Clark, 1992).

Building the benchmarking team is the next of the preparatory steps. It will typically consist of a project leader and two to five people in charge of collecting and analyzing the data. It will also include staff from the legal or other specialized areas. Each member of the team should possess sufficient technical knowledge and a certain level of skills and abilities. Moreover:

- The CEO, or senior executive, is involved in the exercise from the very beginning. He initiates and drives it. This has the benefits of giving the exercise the impetus it requires and also sends the message through the organization about its importance.

- Staff are trained in process management and technology transfer matters. This results in their having the skills required to participate in transfer teams and also helps to overcome the resistance that might be experienced if staff do not understand what will happen.

- A root definition of the process is created. This ensures that the process is considered from all perspectives, thus helping to keep a focus on both the technical aspects of the process; inputs, transformation, outputs; and also its human aspects, taking the world view, customer view, and the actors into account.

- Testing that each proposed change is both culturally feasible and technically desirable – the other methodologies decide on the changes to be implemented solely on their technical merits.

- It places emphasis on the management of the transfer once it has been incorporated, particularly focusing on continuous improvement and regular assessment to keep it current.

- Benchmarking, defined earlier as the act of gathering information about external best practice, is emphasized and correctly positioned as a step in the BPI (Best Practice Implementation) methodology when the external perspective is sought prior to starting with the solution design stage.

- The human aspects of change are considered from the outset and plans developed to overcome resistance to change during implementation.

Composition of the group, which is primarily guided by organizational culture, could be based, among other things, on having appropriate technical skills and knowledge in both the function and benchmarking methods, interest in participating, personality characteristics, personal networks, and representation of others who are likely to be affected.

In general, it would be desirable to have a moderately large group to do the work, strong leadership, individual members with high task relevant expertise and members who possess interpersonal as well as task skills. It would also be helpful to have moderate team diversity so there are a variety of talents and perspectives, yet the team be similar enough to understand and coordinate with one another. All of these factors can affect the effectiveness of the effort. One great challenge for the team is the crossing of multiple organizational boundaries. They run the risk of not understanding the language and culture of the other organization. Although the Benchmarking Code of Conduct (American Productivity and Quality Center, 1993) specifies the "rules of the road" for conduct during the benchmarking exercise, the sheer novelty of the different environments may prove challenging. Best - in - class benchmarking would require greater heterogeneity of skills, better interpersonal skills and a broader professional network.

PLANNING PHASE

Usually, the decision for a technology transfer project is made after the location of some problem, which can be a short product life cycle and the urgent need of something brand new, a market niche or a new market area to be concurred , a new improved process, an effort of globalization and so on. That means that the decision of the objective of the transfer is already made, or otherwise the vital, for benchmarking, "what" has already been answered. The existence of the transfer scope can become the very first step in the Technology Transfer benchmarking model. So,

The first step is the **verification of the process to be transferred /benchmarked**. The focus of a project should be well defined, deal with a topic important to upper management that is critical to business strategy and that offers a clear mission. The organization should be willing to change and have a multifunctional group ready to participate.

Defining the object of technology transfer is fundamental, if the introduction of the new technology in any type (product, process, innovation or whatever) intends to boost competitiveness and business results. Therefore, the selection of a technology weakness must be preceded by a diagnostic of the current situation and an analysis of factors of success or top priority dimensions of its performance (which in turn depend upon strategic decisions about what market segments and dimensions it wishes to compete on) to deliver expected value to customers. A needs assessment team is formed to identify the critical issues (Vaziri, 1992). The selection can be done following the steps of Chapter I, in the relevant planning stage, referring to the Critical Success Factors and enablers. The specific needs, when talking about technology transfer is to:

- define the sector into which the benchmarker organization is going to search for its potential benchmarkees: R&D to industry, organization to organization or to LCD.

- Clarify the dimensions of the process of technology transfer and its outcome. These can include the form of technology at transfer [e.g., tangible - intangible, person-embodied or product-embodied (Hall & Johnson, 1970)], destination [product or process stage of the product transformation cycle (Dosi, 1982)], and duration [time required to complete transfer (Argote, Beckman, & Epple, 1990)]. Dimensions associated with the outcome of technology transfer include frequency (Abernathy & Clark, 1985), extent of change in technological sophistication (Meyers & Roberts, 1986), and the timing of technology transfer (Wernerfelt & Karnani, 1986).

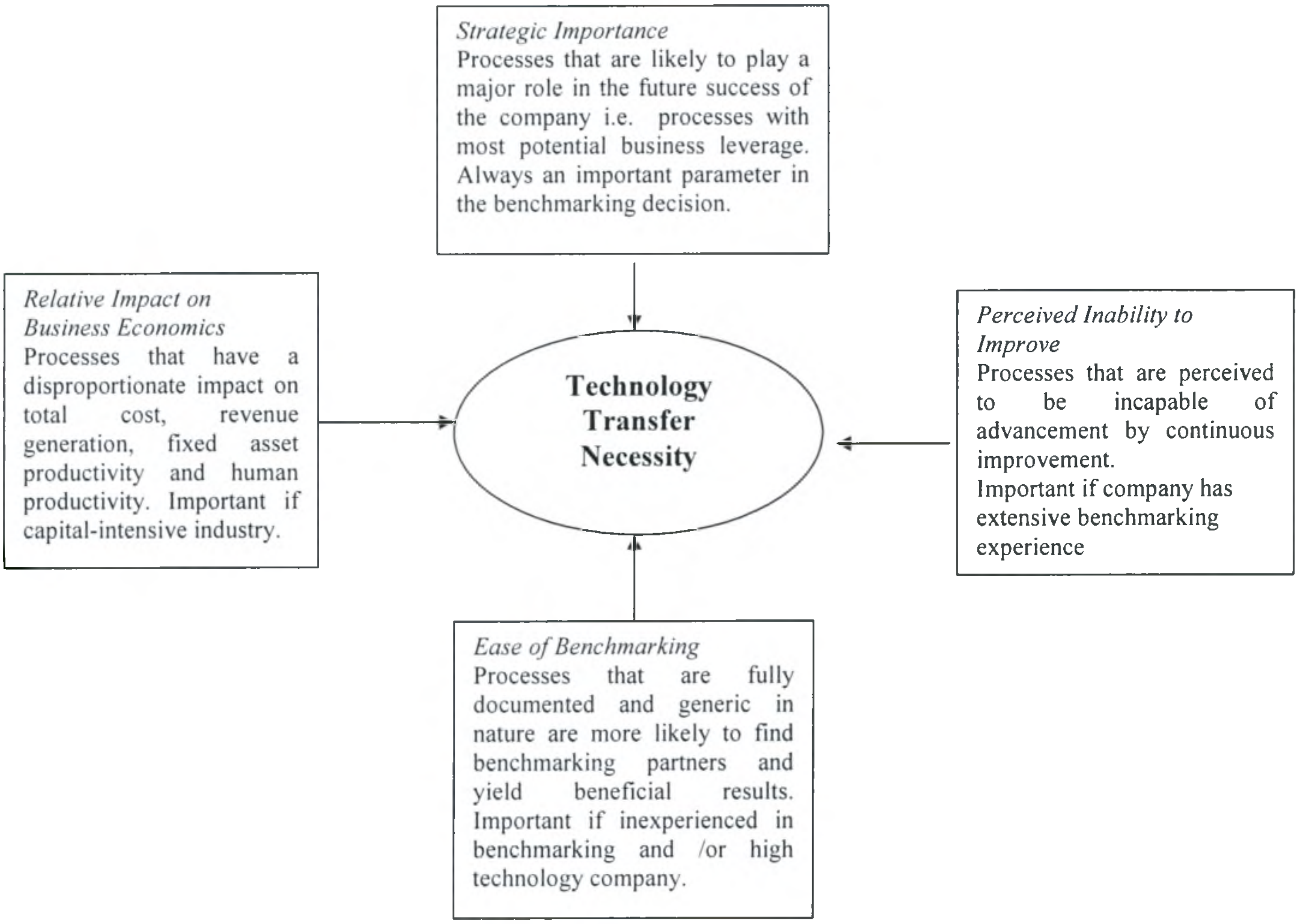


Fig. 3. Reasons that lead to a technology transfer necessity

The organization must be conscious that the ability to conduct technology transfer - both in assessment of technology uncertainty and in implementing various organizational interaction levels - is a valuable skill, competency or "resource", (Wernerfelt, . 1984; Leonard-Barton, 1995; Teece et al., 1997).

Organizational competence in technology transfer is for some firms a tremendously valuable skill. The explicit recognition that transfer process knowledge is a valued competence provides a motivation for the firm to institutionalize existing skills and develop greater skills in technology uncertainty assessment and organizational interaction. This suggests purposeful "knowledge management" and continuous learning. Theories of organizational learning can be applied to this end (Cohen and Levinthal, 1990; . Nonaka, 1994). Organizations can learn from transfer events through planned efforts such as use of appropriate project leadership, documentation of process activities, and post-project reviews. Finally, each transfer process type has unique organizational costs.

The theory of transaction cost economics (Williamson, 1975; Zajac and Olsen, 1993) considers the quantity and variety of organizational and market transactions to determine, which corporate structural form provides the lowest economic cost to the firm.
The transaction cost perspective, along with the notions of organizational competencies, can lead to identification of competitive strategies of the firm in terms of which transfer process types to focus on.

So, the first meeting of the team, in addition to agreeing its working methods, will also establish consensus on:

- the organization's goal for the benchmarking study;
- customers' requirements;
- current processes;
- current competencies, and
- critical success factors.

The second step is to identify **the best performers for comparison**. The benchmarking team must now identify benchmarking partners from whom information will be obtained by establishing the selection criteria and following with an intensive search of all persons and places that might be helpful in suggesting names: the literature, others in the firm, customers, suppliers, benchmarking clearing houses, companies outside the industry, etc.

The current practice of partner selection is relatively subjective and usually based on accumulated experience and judgement together with some recent business records, all of which cannot reflect the actual picture of the overall company performance. According to Limmerick and Cunnington (1993), a successful partners selection needs compatibility between members based on willingness to share, level of technologies, goals, and values of companies.

Benchmarking initiates a learning process triggered by looking at the *best technology* that can satisfy the stated needs, so that *the transfer scope* can be fully defined and described. The evaluation must be done on the basis of what the organization already has, so that the object to be benchmarked to be as clear and precise as possible. That will help eliminate the benchmarking candidates, to the ones that fit to the organization's purposes. Nevertheless, a common mistake in selecting the benchmarking organization will be the halo effect. This is the assumption that a famous organization should be exceptional in all aspects, has an overall excellence, and is the best in every success (Fitz-enz, 1993). Actually, this is not necessary. The best practice in the technology transfer may be present in every kind of organization, regardless of what industry or nation they are in. Bearing in mind that the procedure is the same for donors and recipients - seeing it of course of a different point of view - the best performer can be a Taiwanese firm than a famous big one of the developed countries, specially when talking about receiving some sort of technology.

The team can overcome the above problems by the following procedures:
First, the benchmarking team should identify the prime benchmarking candidates. For such a purpose, organizations should identify a list of all potential candidates, who have successfully performed that kind of technology transfer, including direct competitors and companies regarded as the best-in-class, based on the key critical characteristics and success factors. At the very beginning, there will be very few limitations, regarding the way, the method, channels, mechanisms and even country of the "best", no objective

limitations existing. The prospect organizations may not be limited to the same industry but be extended to unrelated industries. This method is especially useful for those organizations without apparent competitors, as in the case of public service organizations.

Through a brainstorming session, team members should collect information from all possible sources, starting from internal departments and extending to external contacts, such as professional associations, trade journals and business newspapers, business contacts, industry experts, consultants, quality award winners, books on well-run companies and customers.

Company employees are an excellent source of competitor intelligence through their professional and personal associations. Customers can provide information about competitors, product representatives about stories they have heard. According to several studies, customers are the primary source for market and competitor intelligence. Suppliers and distributors are also useful sources (Shetty, 1993).

According to Elnathan and Kim (1995), partner selection is very important, because the extent of learning can be very different with different groups of partner firms and because once the firm's operations have changed, the change often accompanies substantial sunk costs. In a survey of 45 leading benchmarking organizations, 87% deemed the selection of benchmarking targets (i.e. partners) to be of "great" or "very great" importance among factors contributing to the success of benchmarking.

Database benchmarking serves among others, two purposes: sharing technical information and identifying needs and opportunities that could lead to further benchmarking. The second purpose is that of exploratory information gathering.

As technology transfer takes place between different individuals, *the transmission of technological know-how from a donor to a recipient may be distorted*, as the efficiency of the transfer depends on in-depth understanding of the real needs of the recipient and minimization of language and cultural differences, which may hinder the flow of information from donors to recipients (Gibson and Williams, 1990).

For example, Welch and Mann (2001) refer to a searchable database of case studies (BPIR) that most often illustrate the use of some best practice and can be used to identify potential partners. In addition, a separate list of organizations that are recognized in industry by awards or are generally held to be outstanding performers in particular disciplines is also available to users. Both of these facilities can help if it is best practice benchmarking that is to be attempted.

Diebaecker (1999) takes into consideration that choosing partners who are too similar diminishes the opportunity for real learning, whereas choosing partners who are too dissimilar hinders comparative analysis. Therefore, certain criteria for the sample of enterprises must be established:

- they should be interested and willing to share and provide data;
- they should have the time to do so
- preferably, they should be export oriented; and
- at least one factory in each country should be a market leader and/or represent world-class performance in the industry.

Furthermore, Sylvia Coding (1996) describes the following three key areas which should be addressed when benchmarking partners:

• differences in processes;
• differences in management;
• differences in culture.

The importance of assessing both qualitative and quantitative data is reviewed, as is the need to set targets which result in a narrowing of the performance gap, while recognizing the capacity of partners to achieve further improvements in their own performance.

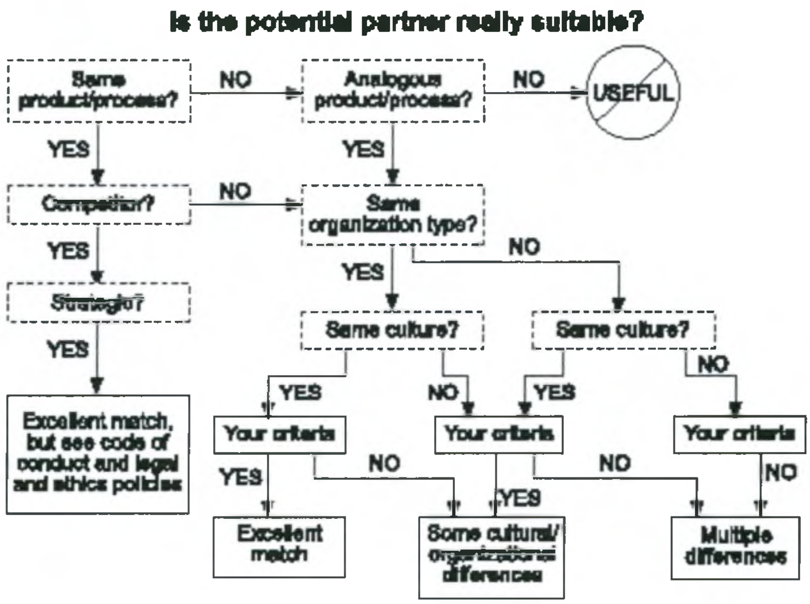


Figure 4. Xerox Benchmarking selection process

After compiling a list of potential candidates, the team should select three to five to shortlist, and make inquiries if they accept. Some candidates who look promising early in the process may need to be eliminated later due to the fact that they are not the best performer, not interested or having the time, unwilling to share information and practices, and suspected in giving true and updated information, or because of other factors such as costs, location and already established relationships. Moreover, refinement of the key quality characteristics and critical success factors should be continuous since the organization had improved in the understanding of its own strengths and weaknesses through the planning process. Key feature of benchmarking, is that essentially relies on co - operation between organizations.

Competitors rank at the top of possible benchmarking targets. This avoids unpleasant surprises. Among the various methods of approach are direct application through a senior manager, application through a correspondent bank and an approach to the benchmarking initiator's own suppliers through its material department.

In general, the blending of short-listing partner selection and benchmarking approaches creates a synergetic effect, which allows decision-makers to select the ``best'' partners available in the market, thereby improving the effectiveness and quality of successful partnership.

Special issues on the selection of benchmarking partners

Comparison is the essence of benchmarking. Comparison processes are involved in every step, except the realization of short and long term outcomes. Inclusion of best - in - class partners will be related to benchmarking experience and benchmarking self - efficacy. If you pick the best organization to benchmark against, there may be a potential motivational pitfall. Basically, if the gap in performance between your firm and that of your referent is extremely large, it may be deemed impossible to eliminate this gap. Therefore, it may be better to benchmark against second of third best, in order to stimulate action with results. "Even a hawk is an eagle among cows" (Wheeler, 1991).

Barlow et al. advances the view that there are two essential prerequisites to partnering. Mutually beneficial goals and a high level of inter-organizational trust. This must be supported by a mechanism that allows for dispute resolution and performance benchmarking.

However, there appears to be consensus, that there are some defining features of ''successful partnering'' (Naoum, 2001). These may be listed as follows:

- Λ mutually agreed objectives and goals;
- Λ inter-organizational trust;
- Λ mechanism for problem resolution; and
- Λ continuous review related to technology transfer benchmarking process.

In order to make a first assessment of the candidate partners, to see whether they can be within the organizations scope, organizational performance can be used. Performance is measured in numerous ways: current and/or change the levels of revenues, profit margins, gross and net profit, customer satisfaction, market share - just to name a few. Any of these measures can serve as cues for how efficient and effective an organization is at a particular point in time. This can be a first selection, since organizations that preset a weak picture, specially after a technology transfer project which might have been presented as a success can be excluded.

Mefford and Bruun (1998) suggest that the factors to be considered can be grouped in four categories:

1. Process factors
2. Supply factors
3. Management factors
4. Labor factors - the proper human resource policies (employee participation, flat organization structures, work teams and extensive training) are the key to instilling the proper attitudes and motivation in host country employees to allow continuous improvement programs for the adaptation of the product system to the local environment. A very important factor to consider is the microclimate created in the firm, that shapes relationships, attitudes and values. Through these influences a supportive culture can arise that may differ significantly from the indigenous culture.

Zairi (1992) discusses the power of economic data, such as profitability ratios, revenue ratios, productivity ratios, return on investment and value - added ratios and commercial competitiveness. The author also looks at the role of the firm's customers in terms of evaluating quality standards, as a provider of information on competitors and as a continuous source of information.

According to Kaplan and Norton (1996), measures include a mix of financial, operational, external and developmental sets. Besides financial measures ,operational measures include cost per employee, quality checks, while external measures the customer satisfaction, market share and complaints and finally, the developmental measures with IIP accreditation, employee satisfaction.

Kasul and Motwani (1995), consider also, innovation, advanced technology and flexibility as very important factors. Yip states that four main factors characterize the organization: organization structure, management processes, people, and culture.

Since technology and technology transfer are rather complicated concepts, an organization trying to select partners for a benchmarking study must take into consideration far more parameters, than just the ones that measure performance, which must converge to its real needs. Moreover, a technology transfer includes some kind of partnering, which involves the establishment of mutual objectives under the concepts of trust, co-operation and many more. Accordingly, trying to find the organization that presents the "best practice" in the related technology transfer means that there must be a concurrence both in strategic and operational level. The transformation of collaborative agreements into productive and strategically effective relationships is the real challenge of strategic alliance management in the 21st century (Irwin et al., 1998). The way in which technology is transferred depends on the technology, the strategy of the owner and the capabilities of the acquirer.

Strategy. The candidate's strategy must be regarded as a fundamental driver of technology acquisition because it determines both when a technology might be acquired and the type of technology sought. For example, firms are deemed to compete with low cost strategies or with differentiation strategies.

HRM Practices. The model argues a relationship exists between strategy, the acquisition of technology, and the human resource practices of donor - recipient firms. Following Madu (1989) and Keller & Chinta (1990), we argue that training and hiring practices have the greatest impact upon technology transfer. HRM practices (and ***cross-cultural*** training in particular) increase the absorptive capacity of the recipient firm (Cohen & Levinthal, 1990) and hence, the firm's ability to compete on a technological basis, which contribute to the success of the technology transfer.

Type of Technology. Two dimensions can be considered: where the new technology is utilized in the production process *(location of technology use)*, and the form in which the technology is transferred *(form of technology transfer)*. Technology and its characteristics and parameters (e.g. transferability, compatibility, complexity etc), have been long discussed in Chapter II . Its general features should be similar to the candidate's, while there is no need for the technology to be the same (e.g. an exact product, or a machine).

Government. Government is included in the model as a moderator of the relationship between strategy, HRM practice, technological choice, and the rate of technology acquisition. Government in LDCs often affects firm technological choice through regulation (Austin, 1990) or direct government participation in the marketplace. A firm might have more incentive to remain current with technological advance, for example, if it competed against private firms or were not protected by regulation. Therefore, in case of transfer to another country, several parameters from the relative literature must be cross-examined.

Industry Structure. Industry structure is important because it constrains the choices of strategy available to firms (Porter, 1980). Scale economies, for example, dictate minimum efficient plant sizes. Yet a minimum scale plant may permit an owner to exercise monopoly power in an LDC market, while such leverage would be unavailable to operators of similar sized plants in larger or more developed markets. Industry structure and strategy therefore interact to influence the timing and type of technology transferred.

Rate of Technology Acquisition. The dependent variable in the model is the rate at which recipient firms acquire new technology. New technology acquisition is defined as the frequency with which identifiable discrete new technologies are acquired and implemented by the firm. (Implementation, as opposed to adaptation, is emphasized since implementation is associated with experimentation and learning while adaptation is associated with other factors). Strategy, HRM, and technological choice affect the rate of acquisition of new technology. So, it is very important for the benchmarker - in the case of a potential donor - to have a clear picture of the recipient it would like to have, with a framework on the requirements and absorptive capacities and capabilities, or the abilities and willingness to transfer in the case of the recipient.

Existing conditions in the triangle donor-recipient-technology have been found to influence the technology transfer process. These include the existence of innovative perspective such as innovative climate, technological ability /structure /culture, R&D activities, strategy, resources and company size.

Investments made which has to do with the resources available. The financial support is directly relevant to the extent and the success of the technology transfer effort and the payback expected. This parameter depends of the size of the company and the potential sources (e.g. government funding, EC programs etc).

Size of the companies: It plays an important role in the selection of the benchmarkees, since an SME cannot expect to act as an MNC. Later in this chapter the role of SMEs in benchmarking in technology transfer will be further discussed.

Former experience: It is advisable that the partners should have carried out several technology transfer projects, as well as benchmarking studies, so that they can facilitate the benchmarking process and offer real help when the transfer process reaches its difficult points. The advantages of this factor differ according to the transfer side. For example prior experience for a recipient can facilitate the process of improving absorptive capacity and relevant training.

The following step of the benchmarking study is ***the data collection***. Here the methods and metrics proposed in the 1st Chapter can be used. That is questionnaires that can be posted or answered in personal contacts, or even a combination of both, the Internet, coded responses etc and tools for results analysis such as SPSS (Statistical Package for Social Sciences), which is one of the most widely used, comprehensive and flexible statistical programs.

A formal meeting is needed to define both parties' objectives, assess the types of information that the initiator and the target company need, determine the range of information to be shared, its characteristics (qualitative and quantitative - or "hard" and "soft") and the ways to use it. Mutual trust is very important for both parts (Ohinata, 1994). A usual way is the e-mail of the questionnaire and one or more personal visits, formal or semi-formal interviews, telephone calls and creation of personal contacts.

It is important that, although the benchmarkee will be either the transferor or the transferee, a contact to be made by both sides, so that the data referring to interactions will be more accurate and integrated.

After the organization has identified performance variables and measures (metrics) based on current operations and customers requirements, chosen the data collection methods, and collected the internal and external data, it can then summarize and document the findings. A benchmarking grid (see Vaziri, 1992,) is useful to capture the findings for further analysis.

Table 2
Critical capabilities for both benchmark partners (adapted by Lefebvre, 1998)

1. Technological capabilities
- R&D investments
- technological scanning
- level of employees' technical/scientific expertise
- level of adoption of computer based administrative applications
- level of adoption of advanced manufacturing technologies
- level of adoption of manufacturing improvement programs
- exclusive and unique know- how related to firm's products

2. Managerial capabilities
- management skills
- marketing skills
- stabilityof networks with customers/ suppliers
- financial stability
- reputation

3. Control variables
- size
- level of dependency on prime contractors
- level of expectations from prime contractors
- level of influence of prime contractors

In Table 3 the major points to be discussed by the two sides according Lasseve (2003) are presented.

Table 3
Subjects to raise for the evaluation of a partner

Strategic fit

(a) Strategic vision
(b) Strategic importance of the project
(c) Pressures (e.g. Is there any strong political or financial pressure to effectively transfer the technology?

Resource fit
(a) Previous experience
(b) Resources
-Technology and managerial
-Quantity and quality of technical expertise available
- The organization and management system conducive to industrial activities
- Finance:
(c) Amount of experience with technology transfer
(d) Technological resources
(e) Human resources
(f) Commitment from top

Competitive position
How competitive is this organization in this particular technology vis-a-vis others?

(d) Amount of Experience with Technology Transfer. Technology transfer is a process which implies the transfer of a lot of 'unlearning' and 'learning' (de Bettignies, 1980), especially in cultural and social behaviour. An enterprise which has already been exposed to several projects is likely to have adopted the internal mechanism and developed the personnel and organizational culture which makes the transfer of technology transmissible to other countries. The local partner needs to be aware of the amount of experience accumulated by his potential partner and know to what extent the technical and managerial expatriate in charge of the joint-venture has learnt from these past projects.

When talking for example about Strategic Vision, the purpose is to determine whether the project is really part of an overall strategy or simply an opportunistic move, and second, whether this project is a diversification move or in the main line of activities of the company.

ANALYSIS PHASE

As soon as the data are gathered, the benchmarking team will smooth the data by detecting any abnormal responses. For example, if the team discovers that an individual response is abnormally high and a further check reveals that the abnormal response is due to different industry standards, the scale will be modified to fit for the comparison.
The fixed data can yield useful information which helps the team select the best performer that suit the organization's specific interests.

Then, the team will calculate the difference between the company's current technology transfer policy (if any) and the desired (benchmarking) performance, based on any of the approaches usually used in normal benchmarking studies. The area here is open to researchers and scientists to form methods for the area of benchmarking in technology transfer.

Results will emphasize the gaps when implementing the process and future tactics can be structured.

INTEGRATION PHASE

Once benchmarking parameters of change are identified, the benchmarking team should integrate the findings into the organization, including sharing the idea of change with those who are involved in the transfer process and those who will be affected by the changes.

The team will do this by first communicating their benchmarking findings with and gaining acceptance from those who are involved in the transfer process as well as those who will be shaken by the changes. The purpose is to enhance commitment to the benchmarking plan. As Biesada (1991) stresses, the toughest part of benchmarking is to get people out of their routine way of working and get them to think about the underlying process. Benchmarking will shake people if they think that benchmarking is a device to get rid of them. To overcome their worry becomes a primary goal. Moreover, technology transfer literature supports the theory that the human factor is the most difficult to manage. The team also encourages feedback in an ongoing communication process. This will improve quality and minimize misinterpretations respectively.

Additionally, the team should pay attention in order to coordinate various activities effectively.

Any new or updated information on methodology, key findings, and recommendations should be explained to management and employees. Coordinating with them closely not only lets them know the progress but also ensures their continuous support. The earlier the detection of resistance, the greater the chance that the team can find way to break the wall.

The output of the previous step is the establishment of functional goals, which target the benchmarking practices that offer the highest potential benefits by describing the desired performance levels of such practices and the action plans to reach them.

The last task in this phase the team should do, is to have a formal presentation, to conclude the findings and improvement activities. The entire team, or at least a portion of it, will remain intact to work with additionally elected members from management to develop action plans to attain the objectives and goals.

In order to be ready to start conversations with the benchmarkee, lists with possible questions, misconceptions etc must be made, for the triangle donor - recipient -technology to be transferred.

An indicative list for any organization - candidate to be a recipient could be the following:

1. What is the current situation?
   - What are the key technologies and know - how that the company depends?
   - What is the company's status in these technologies? Does it lead or follow its competitors?
   - What technology may be developing outside which may adversely affect the current situation in the market?

- Λ How did the company acquire these technologies? Were they made in - house or brought in?
- Λ Has the current technology be exhausted? Are there no new things to do with it?
- Λ How do the company and its existing products compare with its customers' expectations?
- Λ How much longer is the current technology going to last?
- Λ What relative technological strengths and weaknesses are there in comparison to the competitors? Are there any products or technologies held onto merely for historical reasons?
- Λ How are business and technical decisions made for specific projects?
- Λ How is the product development pipeline managed, including resource allocation
- Λ between competing projects?
- Λ What tasks are necessary to bring products to market and how are they structured?
- Λ What is the structure of project teams including reporting structures and how is team members' performance assessed?
- Λ What is the degree of empowerment of project teams and how do they interact with senior management?

2. What does the company intend to do?
   - Λ What is the proposal for the new technology?
   - Λ Can the company sell the existing technology and gain from being "ahead of the game"?
   - Λ How will continuing with the new technology affect the company's status in the market? Will it enhance differentiation? Technological lead? Product or service uniqueness? First - mover advantages?
   - Λ How effective is internal transfer of technology? What communication networks are in place? Are they formal or informal?
   - Λ Have the barriers to effective transfer of information been identified and removed?
   - Λ Are the technical personnel available to fully exploit the technological opportunities?

3. Moving on the next stage:
   - Λ Is the full support of all the management of the company in place? This is a key milestone in achieving the goal of the new technology.
   - Λ Does the company fully believe in the technology and its success?
   - Λ Have the technology audits been effective in highlighting areas not previously covered?

In today's international market, managers should be aware of national and business cultures and organization. They will also need to know about the differences in the working practices between countries. The success of technology transfer and innovation depends increasingly on the manner in which companies collaborate with each other. The very own success of the companies will depend on the level and tempo in which they develop and implement technological innovations.

ACTION PHASE

The action phase inducing the desired changes consists of three steps: developing action plans to reach the functional goals; implementing specific action plans and monitoring their progress; and recalibrating benchmarking measures (Cheng et al., 1998).

The organization should establish specific action plans for the technology transfer process. This includes stating such issues as required resources, candidate transfer partners, organizational changes, and a time frame for the process. The action plans also address the action teams, which areas are to be focused on, what activities are set, and what support functions (such as training and external consultants) are expected.
If the links between the mission, objectives, and action plans are clear and have less or even no resistance, the implementation of the action plans will be more efficient. Further monitoring will resolve any conflicts appearing during the change process.

MATURITY PHASE

Actual implementation of the technology transfer is a question of operational efficiency and effectiveness. The effectiveness of a technology acquisition can be verified by:

- *the choice of the right technology*: how the organization discovered the donor /recipient; its evaluate methods; the creation of competition, if possible, among different suppliers; whether there was the basic knowledge to start a process of technological acquisition, the choice of the right mechanisms and channels, etc.
- *the ability to require it*: this point rises two issues: the effective willingness and capabilities of the partners and the time horizon of the deal. The application of the know - how must be tested and sometimes modified. The acquisition, the real learning and implementation of a new know - how needs time, interaction among partners, trial and errors.
- *the ability to use (and improve it) /exploit it*. When a new process is introduced it must work, possibly as well as in the supplier. For example, in the case of the transferee the competitiveness must be increased, while in case of a donor, the payback must have started.

Technical effectiveness is evaluated by comparing the final technical performance of the transferee after the project is compared with four technical performance benchmarks: the technical performance of the technology provider that indicates how much the transferee learns, the degree that the transferee has received the planned technical performance in the beginning of the project, the technical performance of the transferee's major competitors and similar Technology Transfer projects.

In case of problems, the organization can establish a problem-solving team to ensure the action plans can work. They should provide solutions for those issues identified during implementation and monitoring.

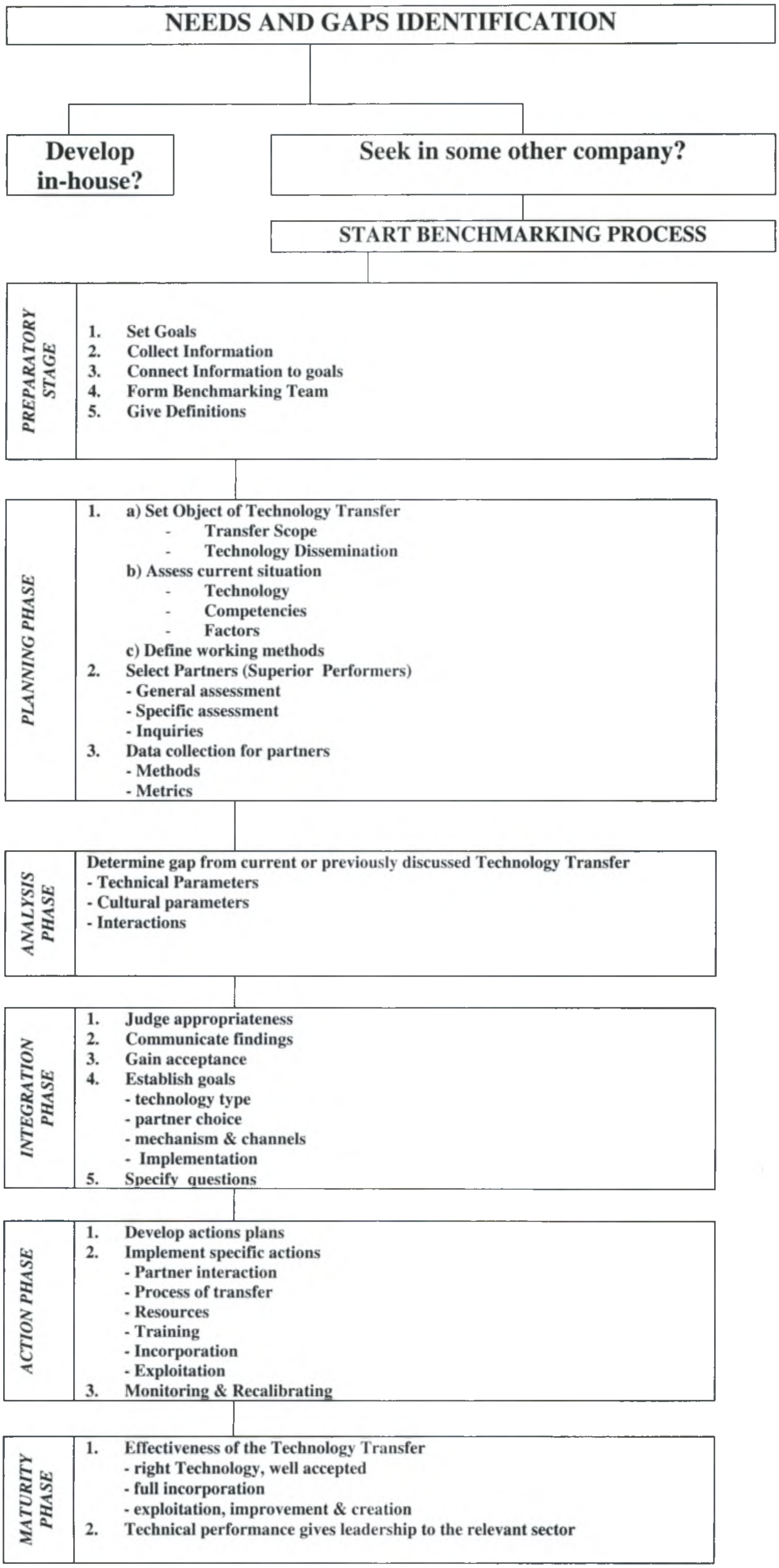


Figure 5. Technology Transfer Benchmarking Model

ORGANIZATIONS THAT FACILITATE THE BENCHMARKING PROCESS

Given the complexity of the process, already existing institutions — i.e., science parks, business innovation centers, public agencies — should act as an interface between potential donors/recipients and candidate benchmarking partners in order to effective analyze, plan and implement the process itself. These institutions, acting as intermediaries could be called *transfer benchies* and should be able to:

1. Make firms aware of their technological needs and of the existence and potential benefits of new technologies (Gertler, 1996);
2. Monitor the local, national and international technology markets, with the aim of identifying solutions to the technological needs. This task is critical specially for the SMEs, given that SMEs have limited resources available for independent gathering of information (Rothwell, 1994);
3. Monitor the local, national and international technology markets, with the aim of identifying case studies and best practices of technology transfer
4. Guide the communication process between donors/ recipients and paradigm organizations, to facilitate information exchanges, knowledge generation and data collection
5. Facilitate the benchmarking process, providing advice, methods and tools; and
6. Coach firms to minimize difficulties when implementing the adopted technologies.

In the planning phase, the *transfer benchies* can serve as matchmakers, not only matching the capabilities of the source technology with the requirements of the envisioned target technology, but also educating the donor / recipient as to the nature of technology transfer, and helping them develop a formal or informal "contract" with the benchmarkee that spells out the needs and commitments of both sides. In the next phases they can provide technical expertise, and can act as translators between the two cultures, provide process consulting, help smooth out legal problems, find financial support from government and private agencies, and provide general encouragement when, as will inevitably happen, the technology transfer hits some rough spots.

Usual benchmarking consultants can be used to prepare relative benchmarking studies, on the condition to have been occupied in technology transfer processes before. Summary information can provided to the companies without identifying from which company the information came. Consortiums of companies in the same industry are also used. This is particularly useful for expensive projects because it allows the companies to divide the cost. All of the companies participate in the study and then receive disguised summary information. There are many organizations worldwide known for there technology transfer operations, such as the Ministry of International Trade and Industry (MITI) in Japan, that could be used for data selection and further elaboration.

BENEFITS AND REASONS

What benefits will organizations get through benchmarking when transferring technology? Accepting the fact that a technology transfer costs money, time and human resources any organization seeking to start and end successfully such a process would need a message that would automatically provide a strategic roadmap i.e. ``How are we going to get there?''. The ability to inform managers about the required organizational changes is crucial to the transferability or implementation aspect of benchmarking, so much that Freytag and Hollensen (2001) coined the term ``Benchaction'' to emphasize the need to learn the answer to the question ``How are we going to get there?''.

Benchmarking provides a means to sustain a continuous superior performance, by providing an independent assessment of how well the process is operating through evaluation of similar processes across different organizations (Watson 1994).

Benchmarking facilitates cross-organizational learning. It is an efficient vehicle for transferring "learning" across organizational boundaries. It is really a learning process for taking lessons from one organization and translating them into the unique culture and mission orientation of a different organization. Benchmarking can create ideas for transfer or even design of new processes or products, and identify the product and process advantage competitors.

So, benchmarking provides a stimulus for making breakthrough change initiatives a reality by enhancing the creativity and innovation of teams who are working on process improvement (Watson 1994).

Moreover, benchmarking involves a goal setting process. To achieve these goals, benchmarking encourages the organization to empower employees and to effectively assign and integrate the responsibilities, work processes, and reward system (Camp, 1989c). Employees generally gain a sense of professional growth from benchmarking with the realization that they are taking on the best in their field (Weimer, 1992) and this is a major advantage in the case of technology transfer, where resistance to change is the main problem.

Benchmarking is a systematic approach to information and communication. The primary use when having to do with technology transfer is to identify areas of strength to further develop and areas of weakness to remedy or withdraw from.

When benchmarking, technical breakthroughs from other industries that may be useful can be identified early and modified or improved, leading to competitive advantage and leadership.

The process broadens people's experience base and increases knowledge. This, in turn can lead to the creation of further needs and gaps in technology, introducing the organization in a continuous cycle of information, knowledge and realization. Tucker's (1993) contention that the value of the benchmarking process is "from studying the process that produced the results and not from studying the results" proves the necessity to benchmark when working on a technology transfer project.

Benchmarking is a formal method. The more systematic the method, the more the benefits that the eventual outcomes will secure. Some authors (e.g. Camp, 1989c; Mittelstaedt, 1992) have suggested that the systematic method would lead to outstanding performance while other informal methods would not.

Benchmarking encourages the proactive search for change and new technology, while offering many different options securing the superior performance.

Spendolini (1992) adds the "seeing out of the box" - benefit , since benchmarking helps to change internal paradigms and according to Sedgwick (1995), it provides significant leaps in performance not always attained by other management techniques.

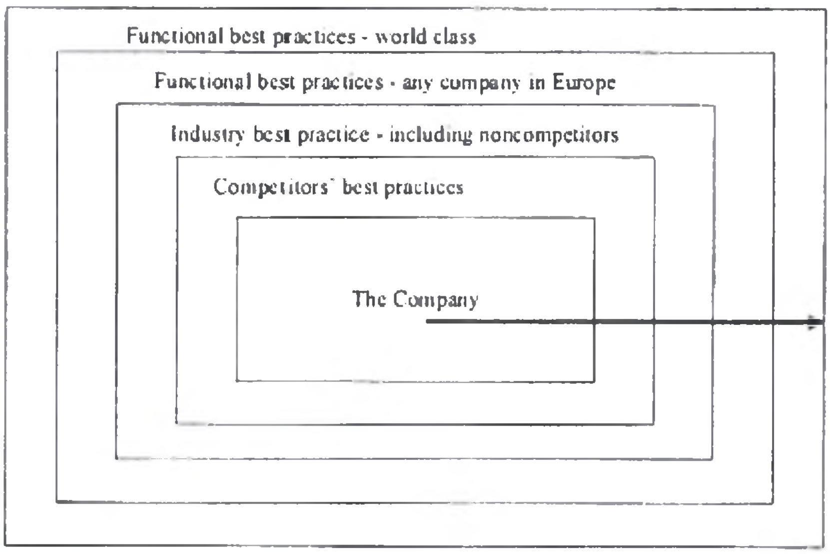


Fig. 6. Thinking is "out of the box" (Spendolini, 1992 in Korpela and Tuominen, 1996)

Through benchmarking, the technology transfer process can take place in a satisfactory time schedule, avoiding delays and unpleasant happenings and with important cost savings. Furthermore, costs can be justified in terms of benefits gained. Decision making is improved and the organization accelerates its pace to innovation, or new product development .

Of course, discussing the implementation level of any technology transfer process, benchmarking will provide strategic information and knowledge regarding technology types, channels and mechanisms, potential partners and locations, difficulties and pitfalls, laws and protection meters and so on. Questions will arise about the allocation of resources, the appropriateness of technology to be transferred and the instruments to integrate foreign technology into local technological development. Djeflat (1988) suggests that being properly informed and well prepared the technology buyer can strengthen its bargaining power by many ways including negotiations, breaking up the technological package as much as possible, securing troubles implementation etc.

But after all this is the ground reason for benchmarking in technology transfer.

CRITICAL SUCCESS FACTORS

What factors must be present for such a benchmarking effort to be successful? General organizational factors can be the following:

(1) senior management must support the effort; (2) it must be a flexible part of the function's strategy; (3) it must be a team activity and the team must include those persons who will be responsible for making the changes which emanate from the benchmarking analyses; (4) it must be well-planned, organized and managed, with a premium placed on appropriate up-front preparation; and (5) one's own processes, roles, or practices must be understood before embarking on the approach.

Longbottom (2000) in his article about benchmarking in UK, among others lists the following table:

Table 4
Critical factors for best practice technology transfer

Project determination	Clear link to strategic plan
Project emphasis	Focus on measures and methods process
Project participants	Cross-function, multi-skill teams, sponsor, facilitator
Organization culture	TQM programme
	Objectives clear
	Trust
	Emphasis on training
	Good communication
Measurement criteria	External focus on adding value to customer

In accordance with Rothwell (1992) and Cooper (1980) who provide good summaries of key factors that appear to emerge in many studies, in relation to firms that are technically progressive or associated with successful technology transfer and combining them with benchmarking success factors, the key set of factors underpinning successful benchmarking in technology transfer are:

Factor 1

- establishing effective linkages with external institutions and bodies of technical know-how;
- creating good internal and external communication;
- possessing a willingness to accept and adopt "external" ideas.

Factor 2

- treating technology transfer as a corporate wide task;
- functionally integrating and dovetailing;
- involving all departments in the benchmarking project at the earliest stage possible;
- Benchmarking phases designed for "marketability".

Factor 3

- implementing careful planning and project control procedures;
- making up-front commitment of resources to screening projects;
- regularly appraising projects.

Factor 4

- stressing efficiency and high quality work;
- implementing quality control procedures;
- utilizing effectively up-to-date production equipment.

Factor 5

- building a strong market orientation;
- emphasizing user-needs;
- building customer linkages;
- involving users in the planning phase.

Factor 6

- possessing the presence of certain key individuals: a strong benchmarking team, product champions; technological gatekeepers etc.

Factor 7

- having high quality management: dynamic and open minded.
- able to attract and retain talented managers and researchers;
- commitment to developing human capital.

Cooper (1980) suggests three additional variables which are also related to the context of innovation. Cooper suggests the nature of the product, the market environment and the existence of potential product-technology synergy.

Factor 8

- Formal approach
- Top management commitment/involvement
- No competition in the areas of information shared
- Information exchanges must be both ways
- A relationship should be formed e.g. a stakeholder relationship or an alliance

Factor 9

- The organizations' sizes must be similar
- Not too much work involved for the target organization.

Factor 10

- Well defined scope and a well documented set of goals.
- Organizational culture
- Effective communication of benchmarking findings
- Innovative adaptation of findings

Going a little further, as stated earlier, benchmarking is about ``learning'' from other organizations, with a view to adopting competitive practices. The key issue here is whether such practices in their entirety can be successfully adopted by the organization. This is an issue of ``*transferability*'' and part of the learning process is to understand whether the identified practices could conflict with an existing organizational culture, management style and structure.

Some benchmarking studies are performed using information from a large number of organizations.. Using a large number of organizations helps to ensure that relevant information is collected and that good practice is identified. It also helps to avoid the drawbacks of one-to-one comparisons that cannot ensure an eventual process improvement.

In reality, the number of partners involved in a benchmarking study can vary enormously and this is often due to issues such as cost, time and access to partner companies (Camp, 1989). For instance, there are organizations that perform large benchmarking studies using the Internet (e.g. The Benchmarking Exchange http://www.benchnet.com/). Whilst, on the other hand, there are benchmarking studies that are performed on a one-to-one basis such as the original Xerox study and the study performed by the Kodak Rochester plant in the early 1990s (Bhutta and Huq, 1999).

Personal contacts play a major role in bringing organizations closer together and in channeling information to and from their organizations. Personal contacts are often found to be the most accepted means. The prominence of the role of personal contacts has been referred to as the "lifeblood" of organization relations and benchmarking. Cunningham and Homse conclude that personal contacts: "...are the vehicle of communication, not only of factual information but ideas, impressions, attitudes, commitment, integrity, and sometimes of commercial or technical information provided only to the trusted and privileged."

Several other factors can contribute to the success of the benchmarking study, such as the form and culture of the organization itself; the integration and the kind of the project; the documentation of the information; the distribution of information; the capacity to transport or receive and to act; the credibility of parties or organizations in the transaction; the willingness to transmit, receive or implement ideas; skills in assessment and possible rewards.

Other variables such as risk, cost, and timing of the process are also cited as being important to success.

Another factor could be the importance the organization pays to *technological competence.* When engaging in technology transfer, firms should determine what technologies they need, which firms have the technologies that they want to obtain, and what resources they should prepare before importing new technologies. These abilities could be formed through the development of technology competence.

Lin et al. (2002) point out that firms with heterogeneous organizational cultures tend to adopt different diffusion channels for external technology, while care must be taken about the technology absorptive capacity impacts the effectiveness of technology transfer performance.

PROBLEMS, LIMITATIONS AND BARRIERS

The concept of benchmarking in technology transfer has not yet been practiced or even further discussed, so barriers and limitations arise from combining the ones of benchmarking with those of technology transfer. The use of the model in real world will unavoidably bring up the difficulties and weak points.

Benchmarking is a methodology intended to facilitate learning from outside. However, sound practices developed by one company often cannot simply be adopted by another company. Identification of best practices should be followed by the test of transferability in different contexts. What is needed is a methodology for the identification of elements that make a practice transferable with minor adaptation or, conversely, specific to a well defined context.

Because of this transferability problem, a recommended methodology is to identify contingency factors (Beretta et al., 1998).

Contingency limitations can be classified into three main classes:

1) *Environmental problems* – these are limitations imposed by the economic, political and social environment in which the company operates, and as such, cannot be modified in the short term by means of a direct intervention by the company. Examples include, for example, the constraints imposed by tax regulations, the limitations posed by the structure of the national transportation systems and the impact of an industry structure on cooperation among companies. In each one of these cases, the environment often creates limitations to the transferability of practices that are diffused elsewhere. Consider the case of Italian companies that until recent years could not adopt the best practice of self-invoicing with suppliers (to minimize control activities) because this practice was not allowed by national tax law.

2) *Strategic structure* – the adoption of best practices can be limited (or favoured) by company choices about vertical integration, plant localization, and strategic connections among businesses.

3) *Organization structure* – choices concerning HR management, centralization versus decentralization, diffusion of authority and responsibility, and the dominant organization culture, deeply influence the possibility to adopt best practices.

DeToro's (1995) list of common pitfalls could be repeated here: lack of management commitment, focusing on metrics rather than processes, and lack of follow-up to the benchmarking process, lack of adequate planning, establishing inappropriate performance measures, appointing inappropriate personnel to the benchmarking team, lack of depth in the benchmarking studies, inappropriate or inaccurate data gathering methods, failure to plan for implementation, failure to adapt the benchmarking partner's process to ones' organizational culture, and failing to involve the employees in decision making about benchmarking and its implementation.

Obstacles to benchmarking technology transfer can be separated into four groups. The institutional ones that broadly represent management and organizational aspects, the difference troubles that represent problems that might arise because of differences between firms, efficiency obstacles represent the problems posed to efficient conduct of negotiations and completion of transfer transactions and legal obstacles include the possible problems created by legal regulations.

Specially for the SMEs, there are some additional problems:

1) Structural barriers to small and medium firm level, such as lack of financing, lack of awareness of available proven technologies, fear of change, insufficient time to study and implement changes, lack of skills, prior bad experience with new technologies and inability to select the correct product and vendor.
2) Lack of awareness: many companies - particularly the small ones, is often unaware of who or what can help in the process.
3) Lack of knowledge and/or funds
4) Conflict of interest - this leads to adverse effects on the competitive advantage of the companies. Even when an excellent relationship exists, it has been found that collaboration between competing companies does not work.
5) Lack of trust
6) Poor communications

While a firm might wish to rely most heavily on one transfer process type, some firms particularly those in dynamic industries will require competency in all transfer process types. That may cause problems when the benchmarkee is a company with a combination of skills and competencies that cover all process types, while the benchmarker is rather new to technology transfer projects.

The way the firm organizes for new products can cause significant problem: Tom Poters notes that 75% of times slippage is due to the way projects are organized - due to siloing and sequential problem solving The key role of a project leader (or champion) has also been identified in other studies.

Another rather important disturbance is that the usual practice of many intermediaries is not to specialised in certain services but attempt to provide a huge package of support services which often do not correspond properly with their level of available resources. That makes their effectiveness rather limited.

BENCHGRAFTING BASED ON BENCHMARKING STUDIES

The concept of bench grafting is used to illustrate the vital role of the implementation of radical changes emerging from the benchmarking findings (Codling, 1998). In this study, the aim of bench grafting is to find areas where the change could improve technology transfer performance in the most appropriate way. In the earlier studies where various aspects have been benchmarked, bench grafting has concerned process (outsourcing, insourcing, integration, synchronization), technology (equipment, IT solutions such as EDI, intranet/extranet, ERP) or human resource (education, hiring)-related aspects (Tuimala et al., 2000).

In the case of technology transfer, benchgrafting should focus on all these three areas in order to achieve the best possible results. Agreeing on common technology formats, project management tools and the use of modern facilities for real time interaction, such as video conferencing tools could be possible benchgrafting solutions.

Codling (1998) suggests the introduction of the concept of "benchgrafting" – as in the grafting or insertion of shoots or tissues from one body to another in order that they may show improved growth or performance, as vital for the success of any project.

The objective of a successful benchmarking project is to adapt better processes or practices to a different organization in order to produce improved performance. As in plant or skin grafting the components must be compatible and free from contaminants if the transfer is to be achieved satisfactorily without withering, infection setting in or rejection by the hosts' antibodies and immuno-defence system.

SMES AND BENCHMARKING IN TECHNOLOGY TRANSFER

Small companies are feeling intense pressure to improve their performance, become more flexible, fast in presenting new products / services and innovative in order to gain competitive advantage. Customers are demanding better quality, faster delivery and lower prices. They are requiring small businesses to implement specific programs such as just-in-time inventory control, statistical process control and ISO 9000 to make these demands a reality. Pressures from the outside world, the MNCs, the globalization are forcing small businesses to change radically, often their entire enterprise operations.

SMEs faced with particular problems whose solutions require a degree of technology or expertise not available in - house, very often do not know where to ask for help. Large companies are generally self - sufficient in their R&D requirements. Smaller ones tend to rely on their suppliers when they need to solve a particular problem. Regardless of size, all companies may, at some stage need to go into an unfamiliar field and they may then resort to a directory or seek external help to find the appropriate information. The question is: how can this be done? What abilities and competencies do small organizations need in order to identify and acquire new technology?

In the SME - centric universe, SMEs relate most closely and intensively with their suppliers and customers and, to a slightly lesser extent, with their competitors. They have connections with the Trade Associations, exhibitions and trade shows. Less frequently they communicate with TECs, colleges and Universities. In general, however, universities fall well outside their focus of attention. These bodies sit at the metaphorical equivalent of the dark side of the moon (Woolgar P. et al, 1998).

Table 5

List of SME requirements for getting information on a technology transfer project :

1) to have a clear definition of aims and target audiences
2) to adopt a market needs approach
3) to include only concise, selected and up - to date information
4) to make the market aware of the presence on the Web and to use alternative dissemination routes
5) to provide a clear indication of what the user can / should do next
6) to provide contacts to ask for further information, to post requirements and ask questions
7) to implement follow - up mechanisms
8) to provide search and indexing facilities
9) to avoid sending the users into dead ends or black holes
10) to filter out info seekers.

Benchmarking is a strategy that can demonstrate to managers what is possible through technology transfer. The old adage ``seeing is believing'' holds true for many managers. Small company managers typically have fewer resources to explore current strategies and tend to ``keep to themselves''.

It is well established that benchmarking is a process that determines best practices, which can be utilized as a guide for improving an organization's practices. Arnold and Floyd (1997) present a case study that details the usefulness of benchmarking in the new product introduction process in the high-tech industry. The results of their study identified a set of best practices for new product introduction in high-tech environments. Electronic Data Systems Corp., which is considered to have effective accounts receivable and billing systems, has achieved successful results through reengineering and benchmarking efforts (Barr, 1996).

Most small companies recognize the need to transfer technology from the outside of their organization. An important customer might demand better performance, sales might drop significantly over a short period of time, or government regulations may require major changes to maintain compliance. Once the need to transfer is recognized, it must be established among top management, who must look for effective means to accomplish this. SMEs are unlikely to be in a position to call in the type of consultancy resource which has so far dominated the "best practice" books and guides. Fewer new employees enter smaller companies with knowledge of the latest techniques gained from large company experience. Several trade associations are starting to take a proactive role in providing benchmarking data but they remain a minority .

Since many small companies cannot afford private assistance, such as consultants, or to hire highly trained professionals, such as a full-time engineer, they often look to low cost public sources of help. Unions, associations, the WEB and relevant projects, programs and frameworks support them, but still there is a link in the chain missing: the existence of some kind of benchmarking before attempting any contact with the actual process of technology transfer.

Summary of barriers to use benchmarking by SMEs
No accurate data
Confidentiality
High costs
Informal information
Competitors unknown

Reactions, such as the luck of additional resources to do the benchmarking (the technology transfer will already be expensive), there is no information concentrated regarding success stories in the particular field, no agencies can help SMEs on such matters etc, led to the adaptation of a process, called *the cycle of success*, of Underdown (2002) which involves *networking, benchmarking, mentoring* and *continuous improvement strategies*. Each area can be analyzed in depth, while our interest lies on benchmarking. A brief description will help for the better understanding:

Networking

The cycle starts with networking. Networking is a process of sharing ideas and information with others for the purpose of learning and improvement. Typically, networking is considered to be a process of forming business contacts in a social setting. Networking in the cycle of success goes beyond surface level conversation or sales pitches;

it refers to forming relationships. It involves people engaging in conversations for the purpose of learning about another's business and what they have done to improve themselves.

Special organizations have been set for the purpose of bringing companies together on discussing common problems and ways of improving their entire business. This premise for attending encourages people to discuss enterprise improvement rather than government regulations or international trade. As a result, companies who engage in networking often develop a mutually beneficial relationship that endures for many years.

Networking facilitates enterprise transformation and technology transfer by providing small businesses with an opportunity to learn what to do, how to do it and what to avoid. While many people can provide answers for ``what to do'', few can provide ``how to do it''. Networking is a method for learning ``how to'' information from someone who has actually done it. Networkers learn real life experiences about implementing technology transfer strategies. These conversations lead to the third area of learning: learning what to avoid. Interacting with other companies provides ``lessons learned''. Companies considering transfer can avoid the pitfalls encountered by firms which have had relevant experience

Networking reduces the resources required. Time, money, equipment and human effort are reduced when people learn what to do, how to do it and what to avoid. In addition, with the knowledge gained from networking, the probability of success increases.

Networking is motivational. It starts the cycle of success when people discover new solutions and are convinced to try them. Top managers often resist change unless a crisis has forced them to consider alternatives.

Networking is a mechanism to gather information about alternatives. When managers hear of new solutions to their problems, many want to see them work. Tours of other facilities are often the best way to understand how success was achieved, and usually starts the benchmarking phase of the cycle of success.

Benchmarking

The second stage of the cycle is the actual benchmarking. Many companies do not use a systematic process or ensure that the company to be benchmarked is the best in class. Mainly, small companies benchmark in an ad hoc fashion in the form of tours. Through tours, managers of the struggling organization witness first hand the results of a successful transfer. Managers of both companies hold detailed discussions about the process.

Mentoring

Mentoring is the process of a successful in technology transfer enterprise of providing guidance and assistance to a struggling enterprise to facilitate its transfer process.

The mentoring company offers advice on how to implement the solution and provides hands on assistance when necessary. Thus the relationships that began in the networking stage of the cycle of success are solidified in the mentoring stage.

Mentors provide technical assistance. Throughout the implementation of the new solution, the mentors provide answers to technical questions. Typically technical questions would arise when the struggling company faces a situation that was not addressed during the tours or was different from the one faced by the benchmarkee enterprise.

Mentors provide emotional support and usually can visit the struggling company to motivate employees to support the new solution. They often have more influence over employees than their own managers when it comes to convincing them that the new solution is viable.
Mentors are given instant credibility because they have achieved success using the new solution. They have proven themselves with results.

Continuous improvement

Continuous improvement is a process of constantly searching for better methods of accomplishing a task. It is characterized by incremental and radical improvements to existing processes. Focusing on existing processes differentiates it from other improvement approaches such as reengineering, which disregards existing processes and develops new processes for accomplishing a task (Hammer, 1990).

R&D AND BENCHMARKING IN TECHNOLOGY TRANSFER

One of the most preferred ways of exchanging knowledge between industry and science are personal contacts and informal networks. They particularly allow for the exchange of tacit knowledge and provide a trusting environment for co-operation and discussion. Such networking on an informal, personal level seems to be a common type of Industry Science Relations (ISR) in most of the EU countries. It allows rapid access to new research results and increases appropriateness by controlling access to these networks. In Japan, personal contact between university professors and researchers in enterprises is reported to be the most important method of technology transfer. For example, many professors are involved in stable, long-term oriented personal networks with industry, maintained, amongst other methods, through the recruitment of graduates by the firms involved in the network.

Within these networks, industry demand for specific R&D activities is communicated to universities, and professors often directly distribute new findings to the enterprises with just receiving some indirect remuneration in the form of research equipment and visiting research personnel from industry. Therefore, this type of interaction seems to substitute for a number of other channels and reduces the need for enterprises to enter into formal collaborations.

The benchmarking of technology transfer process as it emerges from the academic side should include:

1. Generation of research results: the success of any technology transfer program depends on the quality of the research output from the institution served.
2. Generation of disclosures: technology transfer starts with disclosures. An effective system to foster and facilitate timely, quality disclosures is critical.
3. Selecting patentable material and filing applications: screening disclosures for technologies that guarantee patent protection and justify the expenditure is a difficult step.

4. Obtaining issued patents: a cooperative team approach between inventors, patent counsel and technology transfer experts is essential to successfully prosecute patent applications that yield strong patents.
5. Marketing and licensing patents: the reputation of the inventor and the institution play a significant role in successful technology transfer. Ultimately, the goal of negotiating is to create a win - win situation that will form a continuing partnership with industry.
6. Realizing financial returns from licenses:
7. Achieving profitability: it is an indicator of how efficient and effective the function is managed. Profitability is of course critical to the sustainability of the function and its capacity to provide returns to inventors and the university.

In university-to-industry technology transfer the immediate donor will normally be the research group that develops the source technology. The ideal donor would be a good communicator, have industrial development and technology transfer experience, and be strongly motivated to make the technology transfer succeed. The reality of the university environment often conflicts strongly with these ideals.

Communications ability is of primary importance because the most important thing being transferred is knowledge.

In the university-to-industry transfer setting, where the recipient is a high-technology company, much of the burden of success rests with the recipient. The ideal recipient would have a basic familiarity with the technology to be transferred; academic, innovation, and technology transfer experience; the goal of acquiring expertise in the technology; sufficient resources to accomplish the transfer; and a strong motivation to make the transfer succeed.

A basic familiarity with the technology will enable the recipient to negotiate with the donor, plan effectively for the transfer, and assess the quality of the technology received.

Technology transfer is, at heart, the transfer of technical knowledge - expertise - from one organization to another. Sufficient resources are as important in technology transfer projects as with any other kind of innovation.

Motivation, once again, is the key ingredient in technology transfer. In the case of university-to-industry transfer, the industrial recipient may often have the most to gain from a successful transfer,

The above technology transfer case and the associated transfer model carry some clear policy implications for commercial organizations considering a transfer of technology from a university research setting. Above all, there must be a fundamental appreciation that technology transfer of this kind is the transfer of knowledge between different cultures, for the purpose of commercial innovation. Although technology transfer inherently involves risk and uncertainty, positive management steps may be taken to predict, minimize, and control that risk and uncertainty. The best first step is an appreciation that technology transfer is an expensive, time consuming social process that requires a high level of organizational commitment to be successful. Its potential effect on a small company is similar to that of a major drive to develop a new product line. Either in success or failure it is likely to change the character of the company in radical and irreversible ways.

Technology transfer is a sequential process, and the recipient organization must carefully manage each stage of the process. Here comes the need of benchmarking which can start with internal benchmarking and end with the benchmarking in technology transfer. During the planning stage any technology transfer opportunity must be carefully evaluated.

Some of the important questions to ask are:

1. What are both organization's technical and managerial capabilities? Weaknesses?
2. What resources can be devoted to the transfer?
3. What is the potential payoff for the organizations? What are the risks?

It is benchmarking's task to match, either internally or externally, maybe via the transfer benchie , the general technical expertise of possible donors. Only by doing this can the recipient reliably appraise the capabilities, technology, and claims of the donor.

A serious step should be to establish a transfer management plan, with realistic milestone specifications and time and resource estimates. It is important that these specifications and estimates reflect the sequential, knowledge-oriented, product-directed nature of the transfer process.

The transfer project, precisely because it is an expensive, difficult, risky undertaking it needs the paradigm and the help of a benchmarkee.

In many cases getting involved in a benchmarking study is the best way to enhance the speed and efficiency of the learning and adaptation stages of the transfer.

Mutual respect between all parties, is necessary.

On the other hand, the academic environment imposes serious limitations to innovation and directed technology transfer. The university is structured to provide general dissemination of knowledge through teaching and student participation in research and through seminars, conferences, and publication of papers. However, when it comes to directed technology transfer, where, as in the text-to-speech case, a specific body of knowledge is to be transferred to a single private firm, the university has its drawbacks.

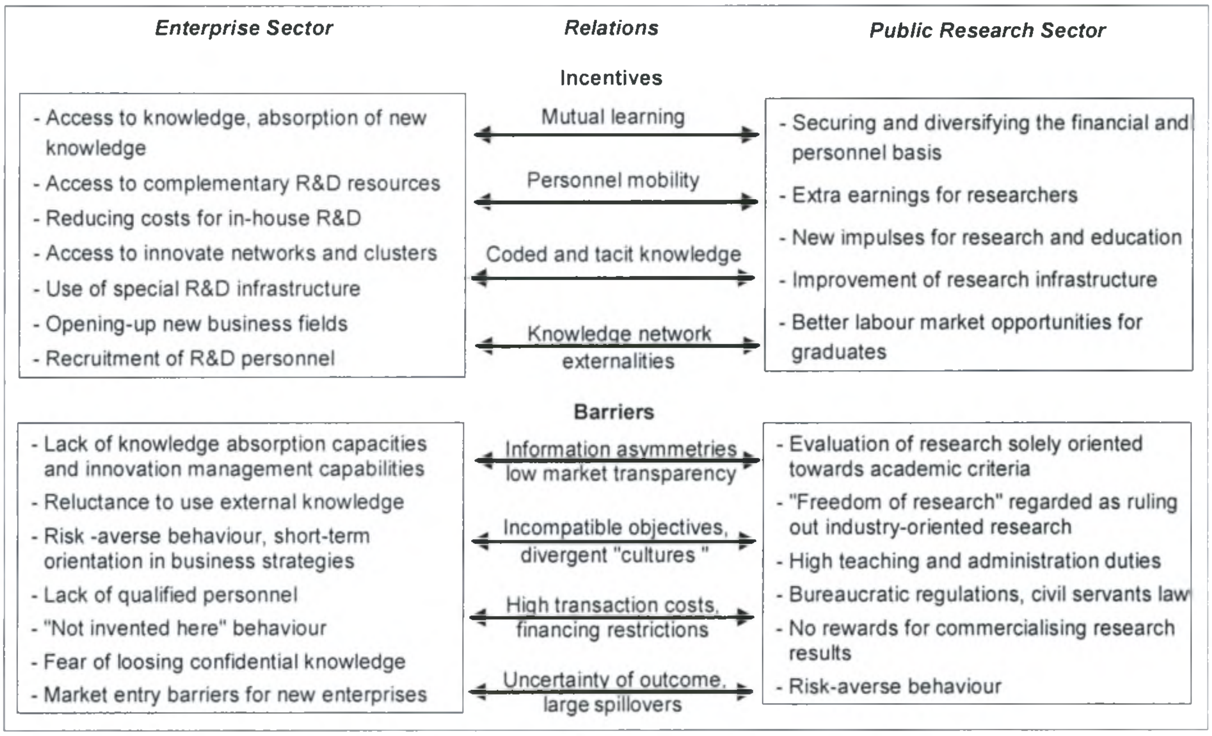
Frequently, the process of technology transfer becomes a "spin-out" of the academic researcher into private enterprise. The motivation may be financial gain, but it may also stem from frustration with attempting to accomplish the technology transfer within the constraints of the academic environment.

As the source of the technology, the university should recognize the need for a benchmarking study, should assist in identifying the benchmarking team and should assist in defining the roles in the process.

Possible barriers to benchmarking efforts in the academic place can be dependent upon:

- certain behavioural features of the market actors (such as risk-averse behaviour, idiosyncratic behaviour, innovation management capabilities);
- market inefficiencies (such as a lack of qualified personnel or in financing sources);
- market failures (information asymmetries, lack of transparency, transaction costs, spillovers, uncertainty etc.); and
- incentive structures which are not favourable (such as evaluation solely oriented towards academic criteria or short-term orientation in enterprise strategies due to short-term oriented financial markets).

Figure 7: Incentives for and Barriers to ISR



(Adapted by the Final Report on ISR, European Commission, Enterprise DG, 2001)

The provision of intermediary structures is an approach for fostering ISR followed by every country. The main purpose is to compensate for several failures in the knowledge market resulting in a low level of interaction between industry and science. Such market failures are related to high transaction costs and significant information asymmetries. By providing support in the terms of technology transfer benchmarking structures that will provide best practice technology transfer projects, through which partners, contract negotiations, and building up of mutual trust, an attempt to overcome these inherent barriers to interaction will be made. The present unsatisfactory picture favour the further occupation with the subject in a broader and more integrating way. Today, there are a huge variety of supportive intermediaries, but none of them is ready to act as a transfer *benchie.* There are no databases with the relative data, no experience and no theoretical basis. Seeking help from the benchmarking theory, or the technology transfer literature alone will not offer the desired results.

Table 6

Types of transfer agents in most of the EU countries, USA and Japan:
Technology transfer offices (TTOs) in HEIs
Independent commercialisation enterprises
Technology and innovation consultants for SMEs
regional consulting networks
Intermediaries at the level of industry associations:
Science and technology parks:
Information provision services, information brokers:

private enterprises offering intermediary services
joint industrial research

(Adapted by the Final Report on ISR, European Commission, Enterprise DG, 2001)

BENCHMARKER'S ATTITUDE FOR AN EFFECTIVE BENCHMARKING

The benchmarker must be seen as understanding its own process well, having a commitment to the spirit of interchange in benchmarking, and having a clear focus on process improvement. Prospective benchmarkers should have documented their own process and be able to provide a question set to the benchmarkee concerning what they hope to learn. The bottom line on the advance preparation criteria is that doing your homework counts.

Delineating the potential value of the proposed benchmarking partnership is another important aspect in gaining access to a prospective host company. This is why benchmarkees rank the "perceived value to our company" criterion second. Demonstrating the seriousness of the effort through up-front homework may serve to convince the host that a project would provide valuable process audit information or be a strong benchmarking promotional experience. Access can also be obtained by highlighting the status of a business relationship as either customer or supplier. In fact, while the existing or potential business relationship is a highly important filter used by many benchmarkees. Thus, there is great opportunity to exploit benchmarkees' interest in maintaining good business relationships in order to gain access for a benchmarking partnership (Langowitz, Rao, 1995).

Good business relationships can be an important objective for undertaking a partnership. In fact, many companies feel hard-pressed to turn down a request from a major business partner and may even go out of their way to coach the prospective benchmarker on appropriate project structure, should advance preparation prove inadequate (hence the iterative nature of the screening steps). A third way to provide value to the benchmarkee is for the benchmarker to offer a reciprocal exchange in an area of the company which is already world class. So, while value can be delivered in varying ways, gaining access can be greatly facilitated by demonstrating endpoint value to the prospective host.

Execution

After agreement is obtained to host a benchmarking project, an important issue for the benchmarker is to use the opportunity for maximum benefit both to themselves and the benchmarkee. The highest concerns of benchmarkees are availability of resources and confidentiality (Hurmelinna et al., 1998). Careful execution is critical in assuring that the means to the benchmarking partnership is as valuable as the ends.

APQC claims that a review of the Benchmarking Code of Conduct is especially important towards dispelling hosts' concerns with regard to confidentiality and appropriate exchange of information. To be as effective as possible, the benchmarker team should include well-prepared managers who are process experts and have been trained in benchmarking practice.

Once the exchange begins, it is imperative for the benchmarker team to keep the host's viewpoint in mind. It is particularly important to remember that the host has selected the project as one on which to dedicate people and resources and that a timeframe and a corresponding agenda have been agreed to, in advance.

On completion of the exchange, follow- up is essential to reaping the rewards of benchmarking. At a minimum a written report should be made documenting the entire exchange, data collected, and major points of learning. This report is essential not only for the benchmarker but for the benchmarkee as well. Also, if reciprocity was an initial quid pro quo for project acceptance, the benchmarker should be sure that the benchmarkee receives reciprocal access when ready. Such forms of follow-up relative to the benchmarkee will be valuable in gaining additional access to the benchmarkee's organization in the future. This is important particularly in large benchmarker organizations in which other functional areas or businesses may later want to gain access to the same benchmarkee.

Obtaining value is a two-way street (Langowitz and Rao, 1995)

While benchmarkers should attempt to provide value to prospective hosts whenever possible, benchmarkees must also be aware of their role in creating a mutually successful benchmarking partnership.

Benchmarkee process behaviour provides insight into the results on objectives achievement. Screening appears to ensure the "satisfactory" to "excellent" attainment of the highly ranked improved relations and reciprocal visit objectives. Prospective benchmarkers with strong business relationships and the ability to provide potential reciprocal benchmarking exchanges are highly valued in the screening process. Even in cases where proposals are weak, if the proposal is from a key customer or supplier, an attempt will be made, as one interviewee put it, to "bend over backwards to make the project work", the screening process can only go so far towards achievement of these objectives. In some cases, screening may not be done as carefully as is necessary. This often occurs in what can be called the overenthusiastic organization. In the over-enthusiastic organization, people are often so excited about what they have accomplished that any request for a benchmark project is seen as flattery and a chance to "show our stuff". The danger for the host in such a case is that, having already been poorly screened, the project will also be poorly structured. If a number of these projects take place, what started out as a chance to gain incremental process knowledge or promote benchmarking can result in an overburdened work group and the internal grapevine impact of a poor experience. In an overenthusiastic organization, it is critical to encourage disciplined screening and structuring of all project requests, regardless of how flattering a project request is.

Even when screening is carefully implemented, however, the actual incremental learning or promotion of benchmarking must be achieved after the project is accepted. This means that the benchmarkee must close the loop on achieving its objectives for learning and promotion of benchmarking.

CONCLUSION

The advantages of the benchmarking method in enhancing the performance of technology transfer between a donor and a recipient is in the benchmarker's ability to compare the performance of critical technology transfer areas between the candidate partners and the Best - Of -the Best (BOB) . The benchmarking gives an insight where the company should focus its efforts, capabilities and actions in order to reach the best conditions for carrying out the transfer. Increasingly, it supports the company in finding under-performing areas and enhancing them by seeking better practices.

It provides managers a well-defined process that leads step by step to the desired conclusion. Still, there are many restrictions in benchmarking technology transfer in transferor's - transferee's relationships. Because each collaboration is unique and the success is based on combining various areas, it is not axiomatic that by improving one area, the entity works better than ever before. That is why benchmarking and benchgrafting are recommended to consider processes instead of individual activities. One should remember, however, that benchmarking partners usually require either a huge sum of financial compensation or a win–win situation.

If a company is able to measure the effectiveness of the technology transfer, the potential is enormous. The achieved improvements by the end of the transfer will only be the top of the iceberg, since the real potential may occur in gaining superior capabilities that have not been involved earlier and making right moves before the competitors have even dreamed about it.

Benchmarking of donor - recipient relationships is taking a risk of loosing time and money, but the potential is huge. If the benchmarking process is implemented properly, the company definitely gets closer to its scope to carry out a transfer according the world-class status.

Benchmarking in a more general sense, is a management technique that seeks to achieve business improvement by helping organizations and individuals learn and develop. To achieve successful business development, a good basis for benchmarking is important, in order to address questions such as: Whom to benchmark against? What processes, functions etc. to benchmark? How to perform the benchmarking?

It is also vital to the benchmarking process, to provide answers to the questions: Where are we now? Where do we want to be? How are we going to get there? The term ``technology transfer benchmarking'' has been used to describe a framework that helps to encourage researchers to find answers to both sets of questions. It is a framework that captures and represents the relevant information for the analysis, planning and comparison tasks involved in benchmarking organizations which wish to make a technology transfer following the world class practices.

This framework places a greater emphasis upon benchmarking as a serious research methodology, to take its place alongside the cognitive and qualitative processes that are an integral part of classification, and vital to the success of benchmarking and organizational development. By integrating technology transfer with the benchmarking process it is hoped that such an approach, in time, may lead to a greater degree of robustness and flexibility in an organization's attempt to embody something new and often radical in the best way and with the maximum of benefits.

Benchmarking technology transfer involves understanding where you are now, deciding where the company needs to be and developing a plan for reaching that goal. This plan must include the dimensions of technology transfer success: seeking, evaluating, using and fostering technology transfer.

Knowing the dimensions of technology transfer success provides companies with a basis for evaluating their own methods of seeking, evaluating, using and fostering new ideas. Understanding the company's processes is extremely important in benchmarking. The knowledge about which methods high-performance companies are using to achieve success in technology transfer and looking at the reasons behind their choices is useful for comparison of current methods, and for deciding which methods to use in the future.

Further empirical research over time will ultimately determine the validity of this new brunch of benchmarking, which also needs further documentation and investigation. New definitions, metrics and structures have to be developed, in order for the new theory to be fully established and exploited.

"Benchmarking is not a panacea for success. It is a tool to learn success."
Rob Reider

CHAPTER IV
BENCHMARKING - TECHNOLOGY TRANSFER & EUROPE

CHAPTER IV

BENCHMARKING - TECHNOLOGY TRANSFER & EUROPE

A. SITUATION AND PROGRAMS IN EU

A1. Greek SMEs, The Region of Thessaly

In general, SMEs are considered important pillars of the innovation system (Harhoff ET al., 1995). Their specific strength is the rapid diffusion and adaptation of existing technologies.

The role of small and medium-sized enterprises SMEs in the Greek economic system, and their contribution to industrial development, are widely recognized. Starting from the 1970s, SMEs have represented a leading force of the national economy, stimulating productive development, employment and exports. Two of these are their flexibility and innovation capabilities, based on the creativity and intuition entrepreneurs, as well as on their ability to combine existing technical knowledge in order to develop new products or, more often, to adapt existing products to the specific needs of particular market niches. On the other hand, several studies have pointed out that the innovation capabilities of Greek SMEs, with particular reference to those firms operating in mature and fragmented sectors, are accompanied by structural weaknesses in technological development:

1. *Poor ability of entrepreneurs to manage technology as a strategic weapon* (deliberate actions to improve the technological base of the firm are seldom taken).Technological innovation is not the final result of a formal process driven by the firm, but takes place in order to satisfy requirements of demanding customers, to react to competitive pressures or to comply with relevant laws. Furthermore, entrepreneurs often show limited propensity to risk and therefore to investment in new technologies;

2. *Limited human resources available for internal implementation or for management of adoption of new external technologies* (Raffa and Zollo 1992, 1998). Additionally, the lack of in-house technical specialists can inhibit SMEs' ability to access external technology and engage in science and technology networks (Rothwell, 1994). Actually, SMEs are not able to express an active demand for new technologies: first, owing to their lack of scientific and technological knowledge, they have difficulties in interacting with producers of capital goods or materials used in the productive process; second, most of them are not acquainted with new product and process technologies developed by R&D departments in large firms or by public institutes of basic research, which could be successfully applied into process or product technological innovation (Gambardella, 1993);

3.*Weak financial standing*. Undercapitalization not only makes SMEs reluctant to invest in R&D but, more often, slows down projects of technological development through acquisition of external technologies (Archibugi et al., 1996). It is very true that limited internal financial resources may be compensated by instruments of industrial policy (contributions of capital, subsidized financing, concession of guarantees and fiscal incentives), but SMEs rarely seize these opportunities owing to the costly and complex bureaucratic procedures involved. All of these features may hinder the process of development and management of technological innovation, which requires long-term vision, willingness to take risks, ability to manage complex processes, and sometimes high financial availability.

4. *Disbelief for the usefulness of benchmarking.* Most of SMEs do not know the existence of benchmarking, regard it as another academic theory, or a technique that cannot be used for the Greek standards. The lack of an already existing database for Greek enterprises seems also to be an obstacle in any adaptation effort. Therefore the URENIO action will help the diffusion and exploitation of this powerful tool to the Greek SME world as well.

How can the difficulties of technological development of SMEs be overcome? Assisted technology transfer (ATT) is a solution to this problem. The importance of technology transfer to SMEs has been stressed over time by governments of many industrialized countries, and several technology transfer centers have been founded (Rothwell and Zegveld, 1982; Bower, 1992). The main issue is: What kind of approach needs to be developed in order to assess technological requirements of SMEs and to implement successful technology transfers?

Since 1997 the Region of Thessaly is actively involved into initiatives promoting innovation and technical development. The Region has been selected to participate in a number of innovative actions of the ERDF (European Regional Development Fund), including RIS+ Thessaly (1997-98), and (1999-2001), Regional Economic Intelligence (Innovation Program, 1998-2000), which led to the formulation and implementation of a regional strategy for innovation and technological development.

Today, Thessaly holds a leading position among the Greek regions in terms of social mobilization, promotion and support for innovation. Still, there are no bridges among research institutions and firms, as well as systematic practices promoting product innovation and development. "New product development" is critical aspect of Thessaly's innovation system, so the strategy has formulated a cohesive approach to ensure that this aim becomes apparent to SMEs supported by sectoral organizational mechanisms and regional policies.

A.2 Today in Thessaly -Programs

INVENT

Besides the recent flourishing of regional innovation initiatives and pilot actions in the region of Thessaly, there are no bridges among research institutions and firms, as well as systematic practices promoting product innovation and development. INVENT (Innovative Ventures in Thessaly) comes to fill the gap and to organize a wide social process for new product development and diffusion, covering all the productive sectors of the Region. It:

- Demonstrates an orientation towards new product development and

- ➢ Encourages the creation of innovative enterprises which are linked with universities and research centers
- ➢ Provides encouragement for spin-off and start - up efforts in the high technology
- ➢ Provides a supporting framework - Regional Innovative Enterpreneurship Support Center (RISC), dedicated to promote innovative actions by the creation of new products in Thessaly.
- ➢ Reinforces the creation, dissemination and integration of knowledge within the productive fabric as a principal source of innovation and regional competitive advantage.

About RISC: It will form a local one -stop -shop innovation service center to SMEs for financial, technical and management support.
The action aims to set up a network by mobilizing regional centers of technology transfer aimed at facilitating direct contacts between the technological council specialists and regional SMEs in order to undertake the "Thessaly innovation policy" The role of RISC is to achieve a wider vision of the regional plan of action for the support of innovation. The objectives of RISC are:

- ➢ To establish a globe of regional innovation policy makers
- ➢ To strengthen interregional cooperation in the fields of innovation promotion
- ➢ To improve the capability of regional actors to develop policies and to set up a framework to support innovation
- ➢ To raise awareness about innovation in SMEs, and
- ➢ To achieve a significant cultural change towards innovation, which is the overall objective of the project.

Among the actions of INVENT, are the following:

- The *creation of learning networks,* for best practices transfer and a regional documentation and measurement system for innovation with dissemination capabilities and a toolbox for on - line innovation.
- *The establishment of documentation center for measuring innovation.* It will select indicators and methods of data processing, collect data and organize them into databases, analyze and benchmark innovation.
- *The creation of Digital Innovation Center, which will concentrate on the development adaptation* and diffusion of tools to Thessaly's SMEs. The aim is the diffusion of technology watch, benchmarking, new product / technology assessment and financing of innovation.

It is worth referring at this point that another action of INVENT is the benchmarking pilot study among Greek enterprises, under the name of URENIO project, run by the Urban and Regional Innovation Research Unit, by the Aristotelian University of Thessaloniki. The action aims in making the benchmarking tool and its usefulness known to the entrepreneurs, while creating a database with valuable benchmarks for several sectors of Greek industry, in order for enterprises to start using it for actively involve in benchmarking.

<u>RIS+</u>

The overall objective of RIS+ is the establishment of a coherent and demands driven strategic framework for innovation. Concerning the EU interventions in regional level, the scope is twofold:

- the effective co-ordination of the relevant EU initiatives and

- The mainstreaming of the actions proposed by the Regional Innovation Strategy within the 3rd Community Support Framework (2000-2006).

The main aims are
- the promotion of an innovation mentality and regional consciousness
- the improvement of the business environment and the development of favorable conditions with respect to innovation
- The strengthening of the innovative competence of businesses.

Among the pilot projects is a framework for seminars and Business Missions of enterprises, with the aim to diffuse information on innovation and technology management to managers and engineers of local firms and research institutes.

RIS+ aims to coordinate and mobilize programs, actions and resources funded under a variety of national and European initiatives with partial, overlapping or complementary objectives. The most prominent initiatives, which the RIS+ seeks to exploit, are:

- the ADAPT, LEADER, Recite II, Information Society and INNOVATION programs
- the Structural Funds in particular the Operational Programs in Thessaly, Research and Technology, Energy and Industry and Services, Environmental Protection, Healthcare and Welfare, Telecommunications and Tourism and Culture,
- The participation of regional agents in European projects.

A.3 Research programs of the European Union

The Single European Act, ratified in 1987, formulated a European research and technological development policy. Its most important aim was to strengthen the international competitiveness of European industry in technology - intensive sectors such as information and communication technologies, the biosciences and materials research.

The policy's main instruments are the Framework Programs of Community Activities in the Field of Research and Technological Development. Practical realization of the framework programs takes place in so - called specific, four - year - last programs, which describe in detail the scientific topics and the procedures for carrying them out.

The growing importance of the EU in science and technology becomes even more apparent if one looks at the substantial efforts that have been made since the late 1980s to strengthen the research and technology base, particularly of the less - developed regions of the EU, with so - called structural (regional, social and agricultural) funds.

Several Governments, among them those of the U.S.A., Canada and the EU countries have put in motion programs to partially fund cooperative research carried out by industry in strategic sectors. The European Strategic Program for Research and Development on information Technologies (ESPRIT) program and the EUREKA project constitute two examples of research consortia.

THE EUREKA INITIATIVE

The EUREKA initiative was launched in 1985 as a reaction to the American Strategic Defense Initiative. It is not a program of the EU, but it has provided a framework for international collaboration among firms and research institutes in the fields of advanced civil technologies. It has a membership of 19 European countries and promotes cross-border alliances to improve European competitiveness. The 19 members partly finance the program. They contribute to maintaining a secretariat in Brussels and they support national project coordinators and staff who may or may not be public servants. Its aim is to

- Strengthen the productivity and competitiveness of European Industry,
- Develop a common infrastructure, and
- Solve problems, especially environmental ones, affecting more than one country.

The programs are market oriented. Two keys in the EUREKA concept are its bottom - up approach for setting an R&D agenda and its flexible structure. This means that in contrast to EU programs, there are no predetermined technological areas. In principle, there are no limitations to the type of projects undertaken. However, nine focal areas have been identified: communication technology, information technology, lasers, energy technology, transportation, robotics, biotechnology, new materials and environment.

There are several large projects under EUREKA, among which JESSI is referred here as an example of EUREKA projects. It started in 1989 and was scheduled to end in 1996. Its goal was to enhance the competitiveness of Europe in the areas of information technology and microelectronics. The main achievement of JESSI is that the major suppliers in microelectronics and information and communications technologies have been brought together, forming a critical mass for large - sized research projects.

THE ESPRIT PROGRAM

ESPRIT is one of the first major European initiatives empowered by article 235 of the Treaty of Rome to promote the competitiveness of European industry. In ESPRIT, Europe's 12 largest information technology forms were invited to draw up programs for European competitiveness in that industry. Nearly 800 firms and 500 research laboratories in universities and research laboratories in universities and research institutes across the European Union participated in the first phase of ESPRIT (1983 - 1987), involving about 250 specific subprojects. The second phase of ESPRIT consciously selected projects and created project clusters for their commercial potential. Pre - competitive research and development constituted about a third of the projects, and application - specific close-to - market projects (three years to reach markets) rose to nearly 50 per cent. This second phase of the program was directed less at anticompetitive behavior and more at meeting international competition. In ESPRIT each project requires the association of at least two firms from two different European Union countries, with or without the association of universities or research organizations as partners. Mytelka says that 50% of the projects were small and medium - sized enterprises, which have gained substantially by participating.

A4. European Organizations of benchmarking support

The Benchmarking Coordination Office, was established in 1997, as part of the European Commission Initiative for the benchmarking of the competitiveness of the European industry. Today the directorate is the Irish Productivity Center. The main aims are:

- The creation of a benchmarking database in the EU, with information on the tool users, representative paradigms and contacts. The database is constructed on three levels: framework conditions, industry sectors and enterprises.
- Technical support to all members of the benchmarking programs, and
- Benchmarking promotion as a tool for the improvement of the European competitiveness and development in Europe.

The database that was created by the European Commission (http://www.benchmarking-in-europe.com) provides a broad list of benchmarking sources in Europe. The following subjects can be provided:

1. benchmarking level (enterprise, sector or framework conditions)
2. industrial sector (electronics, mechanics)
3. Policy sector (labor market, transport structure)
4. Functional sector (finance, human resources, R&D etc)
5. Process experts
6. Geographical aspects

There is also a long list of European benchmarking cases, which is supported by a broad search and filtering service. It offers the results of the STUDYNET action, a program between the General Industry Direction and the Industry Ministries of the country - members of the EU, which deals with competitiveness matters.

The "Benchmarking for success " action, is another effort directed by Forbairt of Ireland.

In this framework the EBN (European Benchmarking Network) has been created, with about 200 members (universities, governments, industry, consultants, quality centers etc). A CD -rom and a book "Benchmarking Facts" have been products of EBN, as well as a national and local benchmarks suggestion.

Benchmarking services are also supplied by the European Foundation for Quality Management (http://www.efqm.org).

In Germany, the Fraunhofer Institute, Berlin established the Information Center of Benchmarking (IZB) in 1994 (http://www-ipk.fhg.de).

The Federation of Entrepreneurial Knowledge Development (FEND) in Spain works on the research, development, and diffusion of high level practices, regarding the knowledge and innovation management (http://www.fenf.es).

The web site *Management Today Best Practice* (www.bestpractice.hatnet.com) supplies information on benchmarking in Europe.

The *Benchmarking Exchange* is a private electronic communication media, user - friendly, which was planned for those, occupied with the benchmarking and the process improvement. The access is accessible only by subscribers. It counts thousands of members from more than 45 countries. It is reported that the member enterprise size varies from 15 to more than 750.000 employees.

Some other useful web sites on benchmarking in Europe are:

United Kingdom

The Benchmarking Center Ltd. http://www.benchmarking.co.uk

United Kingdom Benchmarking Index http://businesslink.co.uk/bench/
Benchmarking Network, UK http://www.quality.co.uk/quality/index/htm
UK Government Information Technology Site http://www.isi.gov.uk

Finland: Finnish Benchmarking Association www.dipoli.hut.fi/org/FBA/project.html

Ireland: Enterprise Ireland -Benchmarking http://www.forbairt.ie/benchmar/links.html

Denmark: Danish Institute of Technology http://www.teknologisk.dk

Italy: Benchmarking Club Italy www.business-italy.it/benchclub/index.html

Austria: Austrian Benchmarking Information Center www.benchmarking-in-austria.at

Portugal: http://tecnet.pt/index.html

Greece: Technology Park http://techpath.gr, http://urenio.org

On an international level:
Financial Benchmarking http://www.finbenchmarkit. Com
International Benchmarking Clearinghouse (IBC) http://www.ibc.apqc.org
International Benchmarking Clearinghouse http://whatworks.org
Hackett Group Finance Benchmarking Database http://www.thig.com

A5. Benchmarking Europe

During the last year a number of Web sites have been created that aim to encourage benchmarking and the development of better practice in government services. The aim of several of the sites is to provide a European perspective on public sector benchmarking.
The Public Sector Benchmarking Service (PSBS) site provides several useful definitions of benchmarking. They observe that most organisations tailor definitions of benchmarking to suit their own strategies and objectives. The two primary examples they provide are:

"Benchmarking is simply about making comparisons with other organisations and then learning the lessons that those comparisons throw up (source: *The European Benchmarking Code of Conduct*)."
" Benchmarking is the continuous process of measuring products, services and practices against the toughest competitors or those companies recognised as industry leaders (best in class)" (source: The Xerox Corporation).

The Benchmarking eEurope site does not do well against these criteria. eEurope Benchmarking is based on a list of 23 key indicators agreed in November 2000. These indicators come from a variety of sources (OECD, surveys, studies).
The European Benchmarking Network (EBN) aims to become a network of contacts in different EU member states. Their primary aim is to help identify benchmarking partners in different member states. It is a clearing house or broker – the role of the EBN will normally be limited to identifying potential partners and putting the requesting organisation and potential partners in touch with each other. Partners decide how to develop their relationship and which approach is most appropriate for them.

The European Commission and the Council of Industry Ministers, supported by the work of the Competitiveness Advisory Groups, the European Round Table of Industrialists and other's identified benchmarking as a key tool in the battle to regain the European competitive position. Research by Ernst & Young found that benchmarking was being used predominantly by large companies, typically employing over 1,000 staff, but not by SMEs.

A5.1. European Commission benchmarking initiatives

Since the mid-1990s, the European Commission has undertaken a number of benchmarking initiatives in response to calls from industry and the member states of the European Union.

Further impetus was given to these initiatives in the Conclusions of the European Council held in Lisbon in March 2000. This proposed the adoption of the open co-ordination method, which relies on the member states themselves to take actions, learning from shared experiences and good practices. The Lisbon Conclusions also proposed the application of benchmarking across a wide range of policy areas.

A5.2. Benchmarking in the Enterprise Directorate-General

In the area of enterprise policy, the objective of benchmarking is to provide an effective tool for improving the competitiveness of companies. It seeks to promote better implementation of measures in key areas of the business environment and in critical functions within the business.

Best practice benchmarking

Implementation of this initiative has involved the implementation of benchmarking at three levels:

1. *framework conditions benchmarking* seeks to strengthen the external environment in which the company operates;
2. *enterprise benchmarking* addresses key functions in the internal environment of the company; and
3. *sectoral benchmarking* addresses elements of both the internal and external environment in the context of the competitive challenges faced by a particular industry.

Implementation of benchmarking at each of the three levels presents significantly different challenges. At the level of framework conditions benchmarking, the challenge is to implement successfully a novel approach. While there is some experience with the application of benchmarking of framework conditions at national level, the Commission initiative is the first which seeks to implement it simultaneously at the level of the European Union and that of a number of member states.

At the level of enterprise benchmarking, the challenge is to promote wide take-up of benchmarking techniques by companies and particularly among SMEs, which have not previously used benchmarking extensively.

At the level of sectoral benchmarking, the aim is to work jointly with industry, which has the sector-specific expertise required to implement projects, in order to ensure that the particular requirements of individual industries are addressed.

Benchmarking score-board

A score-board has been developed in co-operation with the member states to benchmark performance across the EU on key indicators relating to enterprise policy. The score-board consists of approximately 25 indicators measuring performance in relation to policies supporting innovation, entrepreneurship and market access.

Methodology/scope. This score-board is one of several other processes of developing indicators in relation with EU policies going on at the present time. In choosing and interpreting the indicators the present score-board tried to take the point of view of the enterprises; its first objective is to make comparable the context in which they operate. It is a diagnostic tool at the service of enterprise policy to identify issues –'problem areas, best practices, targets – in a concrete and immediate way, through cross-country comparison. The first run of the score-board compared member states in the Community as a whole, *vis-à-vis* its main partners, the USA and Japan. The structure of the score-board is as follows:

The **entrepreneurship theme** is decomposed into three main directions:

1. entrepreneurial dynamism (with indicators from business demography, bankruptcy law and availability of MBAs);
2. regulatory constraints in starting new businesses (with indicators on registration costs and delays and complementary analysis from other sources); and
3. capital markets/financing conditions (with indicators relating to Business Angels and Venture Capital activity, and to new markets).

The **Keeping Dynamic theme** deals with the framework conditions and performance related to innovation, technology and progress towards the knowledge-based economy, under two subheadings:

1. the innovative capacity dimension (with indicators relating to new graduates in science and engineering, R&D efforts, innovative SMEs, patents, high technology exports); and
2. the progress towards the knowledge-based economy, measured with indicators on installed computer power, Internet penetration, cellular phone penetration, the importance of ICT markets and training opportunities.

Finally, **the market access theme** is approached through indicators on imports, public procurement and quality certification as well as the results from a survey of SMEs' perception with respect to major constraints they face in their development plans.

Key conclusions and recommendations. The first run of the score-board leads to the following principal conclusions: at operational level, the need to improve, as a priority, the data related to entrepreneurial activity and to investigate further the relationships between business demography parameters, framework conditions and economic activity. The factors influencing risk taking and attitudes to failure should be further explored as well. In the same area, the comparison of practice with respect to regulatory requirements on start-ups (registration on new companies) made it clear that in some member states there is scope for administrative simplification and streamlining.

The main conclusion from the capital markets part is that risk capital in Europe is now growing fast. Performance varies considerably from one member state to another. In comparison with the USA, European risk capital markets and institutions seem under-developed and far from catching up, in spite of some positive findings. The Business Angels Networks are an example of an institution that has yet to take off. In sum, there is scope for improvement in this area. More focused benchmarking should try to identify best practices with respect to the conditions made to risk capital.

The data from the innovation segments of the score-board (innovative capacity and knowledge-based economy) show with consistency that the USA is generally ahead of the EU (exception: mobile telephony). At the same time, there exist member states that systematically do as well as the USA, if not better: Sweden and Finland. Ireland also has very good results in the high-tech area. These countries over-perform in these areas, even when GDP levels are taken into account. They seem as if they had pioneered into new grounds, while the other countries seem to perform in conformity with their stage of economic development (as proxied by GDP levels).

Identifying best practice in this very complex area remains a priority for the policies having a direct or indirect bearing on it. Finally, among the "input" indicators of the score-board (regulatory environment for start-ups, capital markets development, public R&D), investments in human capital do seem to matter. In a future run of the score-board, human resources indicators will also be examined together rather than integrated in each of the various segments that compose the score-board.

The European Commission proposed benchmarking as an instrument to promote the continuous improvement of Europe's competitive performance in October 1996 in its Communication on "Benchmarking the competitiveness of European industry" (COM (96) 463 of 09.10.1996). In response to this Communication, the Industry Council in November 1996 called on the Commission and the Member States to "initiate a number of pilot projects to address key areas of competitiveness". Since then, a number of pilot projects on benchmarking have been carried out.

In an increasingly 'knowledge-based' economy, the generation and use of scientific knowledge in the innovative efforts of enterprises is seen as one important dimension that determines the performance of a 'National Innovation System'. Hence, science and technology policy in recent years has devoted much attention to fostering Industry-Science-Relations (ISR) and in several countries, policy initiatives in this realm have been launched. A main aim of this study is to identify those framework conditions for ISR, which either facilitate high levels of interaction or act as barriers to ISR, taking into account the following **areas of ISR**:

collaboration in R&D (joint R&D activities, contract research, R&D consulting, co-operation in innovation, informal and personal networks),

personnel mobility (temporary or permanent movement of researchers from industry to science and vice versa),

co-operation in training and education (further professional education, curricula planning, graduate education, PhD programmes),

Commercialisation of R&D results in science through spin-offs (disclosures of inventions, licensing patents, start-ups of new enterprises).

A5.3. Start-ups from Public Science

Universally, research based start-ups from the public science sector have become an increasingly popular form of technology transfer and one of the favoured commercialisation strategies of HEIs. Since the 1980s, and especially in the last few years, the number of start-ups from public science has risen. Academic start-ups are seen as "translators and mediators between academic research and industry", or even more pointedly as indicators of the public sectors ability to develop commercially relevant knowledge, of its entrepreneurial capacity, and of the depth of knowledge transfer between the public and private sector (OECD 2000b). Ideally, academic start-ups represent a form of co-operation embedded in other forms of interaction such as joint R&D, joint publications or researcher mobility.

Academic start-ups tend to be concentrated in certain sectors and technologies - primarily in the life sciences, information and communication technologies, and advanced producer related services such as software, management consulting and technical services. Policies spurring the transfer of public research results through the promotion of spin-offs should address the specific market environments in the respective sectors, i.e. follow a sector specific approach, such as the BioRegio or BioProfile programmes in Germany which give special support to start-up activities in biotechnology.

A good scientist need not be a good entrepreneur. One of the main barriers to start-ups from science is perceived as the lack of entrepreneurial climate in universities and a lack of managerial knowledge in the case of researchers. Start-ups from the science sector have to be promoted, in addition to the access to financial funding, via supportive measures like consulting services. With the establishment of specialised professorships for entrepreneurship and start-ups, the managerial skills of students and the awareness building initiatives, the level of academic spin-offs created can be raised.

If start-ups should play an intermediary role between the public and private sector, contacts between researchers from both sectors are essential. In many countries however, public sector employees are restricted in getting involved in private ventures and this limits the interaction a start-up firm can have with its parent institution. Such restrictions refer to secondary occupations, leave of absence and the right to take ownership in enterprises. Notably, in most countries, full professors have the status of civil servants. In particular, university researchers may acquire tenured positions; i.e. guaranteed lifelong employment at the university might create rather high barriers to becoming an entrepreneur. Since founding an enterprise is related to high risks and the potential gains are by no means sure, the opportunity costs are quite high. Additional supportive measures have to take this into account. Therefore, the main target group should be younger researchers and assistant fellows in public science that should be encouraged and supported in private ventures.
To foster start-ups from public science, the UK and many other countries followed an "infrastructure based approach". A large number of science parks located at or nearby universities or large PSREs have been established, forming incubators for start-ups. Not surprisingly, informal contacts and personal and organisational networks are very

supportive and stimulating mechanisms. Networking contacts are thus critical for spin-offs and relevant information should be locally available.

A5.4. The Role of SMEs in ISR

In most countries, SMEs have only a modest significance for the overall R&D performance of the business enterprise sector. R&D expenditures by SMEs, i.e. enterprises with less than 250 employees, accounts for only about 10 % of total business R&D in the EU countries. Nevertheless, they represent the vast majority of enterprises in absolute numbers. Thus, their behaviour in contacts to and co-operation in science determines the absolute level of ISR. The SMEs level of ISR strongly depends on their absorptive capacities and their involvement in technology-oriented innovation activities, e.g. carrying out R&D on a continuous basis and developing new technologies. The share of innovative SMEs either performing R&D on a continuous basis or showing patent activities is rather low in most countries and rarely exceeds a third of the total number of innovative SMEs. Moreover, between one third and two thirds of all SMEs are non-innovators and do not carry out any R&D or patent-oriented activities at all and consequently have no innovation-related links to public science so far.

From the point of view of industry, it is essential to distinguish large firms from SMEs when discussing incentives and barriers to ISR. Large firms usually do not find it difficult to collaborate with public science institutions. Many of them have had a long experience in co-operation and have learned how to handle their science links. In addition, they often have both the financial and personnel resources (employment of graduated R&D staff) necessary for establishing and maintaining science links. The situation is very different at SMEs, with the possible exception of high-tech SMEs. Most of them have no experience in co-operation with universities.

There are many **barriers** to co-operation, the most important being the lack of in-house R&D competence (i.e. lack of qualified personnel). Information asymmetries are another main barrier, i.e. most SMEs are not able to accurately assess the potential gains of collaboration with science and overemphasise the potential burdens. Other barriers include a lack of information about potential partners in science and a great uncertainty about the outcomes of joint R&D efforts. Policy initiatives attempt to remove those barriers to interaction, either by providing funding for R&D and training of SMEs staff, offering consulting services to improve innovation management capabilities and to raise awareness of science, or by providing information services on potential science partners, often with a regional scope.

The provision of *intermediary structures* is another approach followed by every country to stimulate and support ISR. Amongst others, technology transfer offices (TTOs) in HEIs, technology and innovation consultants for SMEs, technology and science parks, incubators, information provision systems and contact platforms are widespread types of intermediaries. There is non-uniform evidence on their effectiveness and their role in ISR. While there is no doubt that comprehensive intermediary structures foster ISR to some extent, a clear good practice model is missing. According to most experts, TTOs are rather small and are therefore, often below the necessary critical mass to stimulate ISR effectively. In some countries, university assigned intermediary centres specialised in spin-off commercialisation and often having a certain technology focus is regarded as promising approaches (Belgium, Finland, Ireland, and the UK).

A5.5. Critical Success Factors and Good Practices

The ISR report of 2001, identified in each country, at least one example of good practice in framework conditions for ISR, reflecting the diversity of ISR and the shape of national innovation systems in Europe.
In summary, the following critical success factors were identified, which are favourable for the interaction between industry and science and contribute to a high level of ISR.

(i) High level of R&D in the enterprise sector, strong high-tech orientation of the enterprise sector

(ii) High absorptive capacity and strong innovation orientation in the SME sector

(iii) Presence of very large, domestic corporations in high-tech areas representing a huge R&D potential and having both a high need and the necessary capabilities to intensively interact with science

(iv) Cultural attitudes favourable to ISR, i.e. an explicit industry orientation of science is perceived as positive

(v) Coherent technology policy strategy designed to improve many elements and features of the national innovation system at the same time

(vi) Financial promotion for joint R&D by thematic (i.e. "technology-oriented") programmes

(vii) Joint R&D infrastructure for industry and science with a thematic focus developed by a bottom-up approach

(viii) Provision of HEIs seed capital for very early stages of start-ups, including equity investment by HEIs and support networks

(ix) Networks of specialised patent offices commercialising patents from a larger set of public science institutions in order to gain from specialisation and scale economies

(x) Strong involvement of HEIs in the vocational training of researchers, managers and technicians at enterprises

(xi) Mobility programmes and temporary working contracts for young researchers in public science

(xii) Institutional settings in HEIs and PSREs, which establish technology transfer to industry as the mission of an organisation and decentralise, transfer responsibility

Joint research programmes that promote direct collaboration between industry and science are a well-established policy intervention mechanism that has a significant effect upon the level of ISR. Here, good practice particularly refers to thematically focussed programmes that apply a *bottom-up approach of defining joint research themes* (rather than a technology programme approach that defines technology fields of co-operation in advance), have a long-term perspective of co-operation, and rely (at least partially) on an 'infrastructure' approach, i.e. the establishment of institutions and/or facilities that are operated both by enterprises and science institutes which maintain co-operation after funding has ended (e.g. joint research centres, joint companies).

With respect to collaborative programmes, a *competition-based approach* of allocating funding has proven to be effective. Such an approach stimulates the involvement of a large number of applicants but restricts funding to promising 'best practice' cases, which may serve as further orientation points for other actors.

Involvement of SMEs in ISR activities is a major issue in order to broaden the use of scientific knowledge in the enterprise sector. Good practice adopts a two-side approach: First, *absorption capacity in SMEs* with respect to R&D, innovation management capabilities, and the use of external knowledge and advice, should be strengthened and detached from any specific involvement in ISR. Second, SMEs with a sufficient in-house capacity for establishing science links may be stimulated to take up direct research and consult contacts with science. This may be realised through awareness measures (i.e. eliminating information deficits and changing attitudes towards science, e.g. by learning from positive experiences other SMEs have already had) and by direct financial support for the use of scientific expertise in their innovation projects, such as support for joint R&D, training and consulting involving public science researchers, mobility of researchers, and the use of IPRs by SMEs.

In many countries, a successful way of strengthening ISR was to establish *transfer-specialised institutes,* either at universities or within public research laboratories. Key success factors in these institutions include: the keeping together of basic and applied research within one research team; regular auditing of the research strategy in order to cope with changes in economy and society; direct transfer between researchers and industry (i.e. avoiding intermediaries); and individual remuneration for successful transfer activities.

As well as the high level of attention currently paid in most countries by ISR-related policies to certain issues such as IPR, academic start-ups, joint research, personnel exchange, other areas of similar relevance such as co-operation in curricula planning, vocational training, institutional reform, and individual incentive systems gained less attention and should be addressed more intensely by policy.

B. TECHNO-ECONOMIC SECURITY ASPECTS

Ensuring security of the technology and protection of their competitive advantage is becoming an increasingly important consideration for foreign companies who are investing in transferring their technology into subsidiary companies or joint venture operations. The term technoeconomic security relates to the question of how, on a political level as well as on a company level, the business potential of the investment can be maintained. In other words companies transferring technology to newly industrialized countries need to protect their core technology from misappropriation and subsequent imitation when contributing to the country's development and trying to strengthen competitive advantage through establishing foreign operations.

One of the risks of transferring technology is that its absorption and dissemination can, in the longer term, bring about new competitors unless measures are taken to prevent leakage of know-how or the technology supplier can stay ahead of the technological race.

On the other hand, when dealing with benchmarking in technology transfer, the moral and legal issues of benchmarking arise as well.

B.1. The ethical aspects of benchmarking

Samuel C. Certo (1994) gives a general definition of ethics as "our concern for good behaviour; our obligation to consider not only our own personal wellbeing but also that of other human beings." Ethics – where benchmarking is concerned – may be defined as "principles, guidelines, or standards that determine a protocol of interaction between individuals and organizations" (http://www.spinet.org/legeth.html, 2/19/97).

Kent Johnson, Corporate Counsel at Texas Instruments states, "To guard against the erosion of trust, one must focus on avoiding the appearance – not just the reality – of hidden agendas" (Bureau of Business Practice, 1996). Johnson stresses the importance of openness in the benchmarking process.

Many ethical questions may arise in the course of a benchmarking procedure.
Two of the main questions which Johnson deals with directly are:
(1) Can the recipient take credit for developing the idea, approach, etc.?
(2) If the benchmarking partner received information of tremendous value to them, could they take credit for it in their advertising media?
These questions cannot be answered quickly nor can they be answered easily. Both partners in the benchmarking process would need to communicate their expectations and feelings on the above issues.

Some basic guidelines for both partners in a benchmarking relationship to follow are illustrated in the following sentences.

- *Specific and detailed ground rules should be established.* This includes the notion that ideas are not shared to gain competitive advantage, but are instead shared so that both partners can improve or benefit (Allan, 1997).

- *Questions should not be asked* about a company's "sensitive data" nor should pressure be put on a partner to feel that they have to divulge such information to continue the benchmarking process.
- *Data received should be treated as confidential* and should not limit competition or gain business through such a relationship (Pattison, 1994).

B.2. The legal aspects of benchmarking

Due to the general nature of benchmarking, partners should be aware of several legal aspects of this type of relationship. According to Johnson, Corporate Counsel at Texas Instruments, "the degree of legal exposure is different depending on the industry involved, the type of benchmarking transaction you are engaged in, and the business you are in" (Bureau of Business Practice, 1996). The six critical areas of expectation, proprietary information, intellectual property, antitrust and unfair trade practices, evidence, and disparagement and trade libel will be discussed in the following paragraphs.

The critical area of expectation deals with what each of the partners feels should be disclosed and how it should be used. Many times the legal focus is a conflict of interests where one company sees the use of the information as different from the other partner. For example, if the recipient passes along information received to a brother or sister corporation. This may have violated what the benchmarked company originally intended. This concept may also be referred to as the idea of public domain. Companies, therefore, should ask themselves if sharing the information will go against the expectation of the benchmarked company. Additionally, both companies should be aware of and sensitive to the other's expectations.

The second area deals with proprietary information. Proprietary information is defined as "any information created, acquired or controlled by the company that has not been published or released without restriction of a type the company wishes to remain confidential." The Securities and Exchange Commission has developed requirements in dealing with such information. These guidelines include requesting and accepting only the information that you will also share along with obtaining an understanding of each others' controls, restrictions, and definitions of proprietary information (http:// www.spinet.org/legeth.html, 2/19/97).

Intellectual property is another area of legal interest. Intellectual property, like it sounds, refers to property such as scientific works, industrial designs, and computer programs. This is the type of property that may result in patents, trademarks, and copyrights. Some guidelines to remember for this area include an understanding of the nature of intellectual property owned by both partners and consulting legal counsel on restrictions regarding such property (http://www.spinet.org/legeth.html, 2/19/97).

Antitrust and unfair trade practices are probably the main areas of concern for the government. Historically, the law did not believe in engagements that were "purely cooperative." Instead, the law tended to look at these transactions very carefully, scrutinizing them to find ulterior motives. Due to this attitude, all parties involved in the benchmarking process should be aware of antitrust laws and unfair trade practices. Benchmarking in itself is not anti-competitive; however, when dealing with competitors the lines could become blurred. Kent Johnson sets forth three standards to apply. First, the partners should clearly "set the tone" in advance. This refers to an explicit discussion of maintaining rights to compete with each other and not restraining trade. Second, the competitors should avoid the topics of pricing and manufacturing capacity. Finally, less risky means of obtaining information should be used, such as a library, the Internet, and consultants (Bureau of Business Practice, 1996).

Another critical area deals with evidence. Evidence is a relatively simple topic to cover. It deals with information given to one partner company by the other. This information contains areas of success and failure. Johnson states that the purpose is to provide "useful data to the recipient while not shooting yourself in the foot" (Bureau of Business Practice, 1996).

The final area is disparagement and trade libel. Johnson is fairly short and to the point with this topic. For example, he sums it up by saying that the focus should be placed on primarily the good things learned from your benchmarking partner and all information should be straightforward and honest.

Additionally, he mentions that this area is basically common sense for most firms and does not generally pose any problems (Bureau of Business Practice, 1996).

B.3. Perceived limitations and costs of benchmarking

Although benchmarking is very effective overall, it does have limitations. The main problem with benchmarking is the focus on data as opposed to the processes used to result in that data. Benchmarking should be used as a guide, not for statistical precision (Muschter, 1997).

Focusing on the numbers: Greg Hackett's Ohio-based firm is a leader in benchmarking services. He claims the value of benchmarking comes in understanding the process that produces the given data, and in formulating ways to adopt those practices into the organization. Hackett says many finance executives are getting "sucked into the numbers" (http://www.mediapool.com/offtherecord/cfo-ben.html, 2/19/97).

*Lacking clarity on where the data originated:*Another limitation of benchmarking deals with not understanding where the data came from, which can cause errors in making comparisons. For example, an organization may want to compare their headcount in the treasury management process against the benchmarked organization. The benchmarked organization may consider cash management, foreign exchange, and real estate as a part of the treasury. Therefore, the organizations may actually consider the definition of the treasury management process to consists of different departments (http://www.mediapool.com/offtherecord/cfo-ben.html, 2/19/97). According to Pat Jones, Corporate Controller at Intel Corporation in Portland, Oregon, their benchmarking efforts were not a success. Like the above example, they too had the problem of clarity on where the data originated. "To ensure we were doing apples-to-apples comparisons," says Jones, "we had to spend a lot of time reconciling the data. It was incredibly unproductive" (http://www.mediapool.com/offtherecord/cfo-ben.html, 2/19/97).

Losing focus on the customers and employees: Benchmarking can cause some organizations to lose their focus on the customers and employees. Companies that try to produce better numbers quickly can cause employee burnout, errors, and the need for rework. A company may also try to quicken receivables and delay payables to meet a certain numeric goal. This may have large adverse effects on customers as well as suppliers (McNair and Leibfried, 1992).

Resistance by some employees: Ford manager, Hans Kuschnerus, feels that being aware of potential obstacles in implementing benchmarking can help in dealing with them. One obstacle for Ford was resistance on the part of some staffers. With new changes, there will always be some employees reluctant to get involved and cooperate with new policies. He also found that it becomes easy to cut corners to avoid the trouble and cost of benchmarking. Instead of investing the time and effort, organizations will simply visit the company and see what can be learned.

Benchmarking also requires an establishment and utilization of metrics, which are measurements to monitor performance. Performance can be measured in dollars, customer satisfaction, response time, etc. Knowing how performance will be measured is important in the procedure (Bureau of Business Practice, 1996).

Lacking proper implementation: Other problems with benchmarking may occur due to an organization's failure to implement the process properly. One example of a potential pitfall of benchmarking is the lack of actively involving employees during the process. These employees will be the ones ultimately using the information and improving the process (Omachonu and Ross, 1994).

*Ongoing process-not-one-time project:*Some organizations also have difficulty in treating benchmarking as an ongoing process. It should not be viewed as a one-time project. Additionally, some companies feel that if the tactic is not invented by them, it may be inferior. Furthermore, some companies do not look to benchmark because it exposes their weaknesses.

Another common problem with benchmarking is the failure to expand the scope of companies studied. Potential companies to benchmark should include companies in all industries, even those outside of the user company's industry (Omachonu and Ross, 1994).

B.4. Costs of benchmarking

One of the myths about benchmarking is that it is too expensive. It is obvious that benchmarking does come at a price but cost may vary considerably. There are usually expenses that relate to travel as well as indirect costs associated with employee time devoted to team meetings and travel (Feltus, 1997). But, with careful planning, benchmarking costs can be kept to a minimum.

A way to control the costs is to tackle benchmarking one step at a time. Benchmarking is not an extremely difficult and complex process which many people think. A company can benchmark without it being a huge ordeal. A way to reduce the stress to the companies is examining one process at a time. The actual costs can be kept down if the company benchmarks in degrees and defines very narrow areas to explore (Feltus, 1997).

To minimize the costly meeting and travel time, the company must work efficiently and communicate effectively. The first suggestion for the company is to do homework. The company should know what their own specific problems are before employees go to visit other companies. The trip should be clearly defined as to what one wants to accomplish and what to look for in the trip.

Then one must make the information known to the people that one is planning to visit. And since benchmarking is a two-way street, one must understand what the other company wants from you and what you are willing to share with them (Feltus, 1997).

Another misconception that people believe about benchmarking is that there is a cost associated with giving away more information about their total quality processes to other companies than they feel comfortable providing (Feltus, 1997). But, when an employee gives away information, be smart about it and do not give away the heart and soul of the company. As a whole, distributing information and processes will help aid our country (the USA) to become more competitive in the global marketplace.

In a 1995 survey of The Benchmarking Exchange Members, benchmarking was in the top five most popular business processes on which there was current focus. Resources and information are now becoming much more affordable and accessible. In 1992, the average cost of conducting one benchmark study was $50,000. By 1996, the average cost had dropped to $5,000 (http:// www.benchnet.com/bppf.htm, 2/27/97). With the cost of benchmarking falling so rapidly, the use of benchmarking is on the rise.

Overall, benchmarking can easily be done without breaking the company's budget, which is a major misconception of many people. This can be done if one follows the above suggestions and follows them effectively. After all, the knowledge the company gains is well worth the little investment the company makes.

C. IMPACT OF EUROPEAN RESEARCH - COMPARISON TO USA AND JAPAN

Within the framework of the **EU-Benchmarking initiative** "Benchmarking the Competitiveness of European Industry"[1] a benchmarking project on industry-science relations (ISR) was carried out at EU level. It attempts to compare and assess the role of a set of framework conditions on the interaction between higher education institutions (HEIs) and public sector research establishments (PSREs - referred to as 'science') and the business enterprise sector (referred to as 'industry'), and to recommend areas for improvement. The benchmarking exercise covered **eight EU member states** (Austria, Belgium, Finland, Germany, Ireland, Italy, Sweden & the UK). **Two other countries**, the USA and Japan, are also considered as 'third country' comparisons.

In this section, abstracts of this study (*The final ISR report*) are presenting the situation and the role of a set of framework conditions which influence ISR, that is, the relation between HEIs and PSREs on the one hand, and the enterprise sector on the other hand, in each country. Further, it identifies major programmes and policy initiatives and describes 'good practice' examples.

C.1. ISR in Austria

In Austria, the main transfer of knowledge between the enterprise and the university sector still occurs through the mobility of people equipped with scientific knowledge. Asked what the general benefits from universities are, a vast majority of the firms responded that they value highly skilled personnel as the main output from universities and consider the employment of graduates as important access to academic knowledge.
The most frequent type of interaction between the enterprise and the university sector, apart from the employment of graduates, is the joint supervision of Ph.D.s and Masters Theses.

Contract and collaborative research: This type of interaction is most important for PSRE but of lower importance for universities. PSRE have a strong incentive to attract additional resources from industry in order to compensate for decreasing funding from basic (institutional) financing.
If framework conditions, such as public promotion programmes or the legal framework, have an effect upon the extent of contract and collaborative research in Austria, it is mainly that of creating awareness. However, framework conditions such as project financing by the Federal government, the provincial governments and the Commission, for joint R&D activities with industry in thematic or technology-specific programmes or specific legal regulations, do not determine the quantity of contract and collaborative research. It is past experiences in research projects with the enterprise sector, that are crucial for university departments to get involved in interactive relations with the enterprise sector.

Personnel mobility: Personnel mobility between science and industry is rather low in Austria. This may be attributed to the following framework conditions:
Wages for researchers are significantly lower in HEIs and PSREs, mainly due to rigid wage scheme and budget constraints in public science. This prevents mobility from industry to science and stimulates mobility from science to industry only to low extent.

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[1] COM(96) 463 final of 09.10.1996

There are legal regulations which institutionalise differences between science and industry and are therefore assumed to make the mobility between the two sectors more difficult. In particular, that university researchers may acquire tenured positions, i.e. guaranteed lifelong employment at the university, presents a great barrier to mobility.

There are further unfavourable framework conditions too, such as the pension system in public science and the low acknowledgement of non-academic activities for scientific careers.

Training and education: Training and education are seen by the enterprise sector as the main benefits from HEIs. There is however, little involvement of HEIs in further education and vocational training for enterprises. In these areas, specialised institutions outside the HE system offer services to enterprises.

IPR in science: The awareness of HEIs and PSREs concerning the protection of intellectual property through patent application has increased. However, incomes from royalties are not a major means of financing, neither at PSREs nor in HEIs.

Start-ups from science: The annual number of all start-ups by researchers from universities may be estimated at about 25 in total. Almost 60 % of these are in the producer-related service sector. The producer-related service sector includes a wide variety of activities such as economic, technical and legal consultations, and other services. The share of technology-based start-ups is comparably small and the same applies for PSRE. A main barrier to start-ups from science is perceived in the lack of entrepreneurial climate at universities and a lack in managerial knowledge, especially in the case of researchers from natural sciences and engineering.

Networking between industry and science: It may be seen, both from enterprises and from public science institutions, that previous experiences and personal networks between researchers from both sides are important channels for knowledge exchange. These previous experiences do not only refer to informal contacts but also, to a high degree, to previous collaborations. That the common educational background of researchers from industry and science is of great importance may be shown in that graduates often pave the way for co-operation.

Involvement of SMEs in ISR: In Austria, there are several public promotions programmes that specifically aim towards markedly raising the level and quality of R&D activities in SMEs. In SMEs, absorptive capacity necessary for the successful use of scientific knowledge and expertise is often lacking. Hence, there are various types of benefits from HEI that vary significantly with firm size. Small firms appreciate the benefit of highly skilled graduates and of universities directly supporting the development process, less than large firms do. In addition, small firms value the benefit of consulting services by universities less than large organisations do.

Science-based industries: The high-tech sector with strong science links in innovation (computer & software, telecommunication, pharmaceuticals & biotechnology, instruments, and aircraft) has grown a great deal in Austria in recent years. Its share in intramural business R&D expenditure has risen from about 20 % to about 36 %. This has completely changed the specialisation of the Austrian industry, which traditionally had a focus on medium- to high-tech and low-tech sectors, and concentrated on incremental innovations.

A "best practice" example:

K_{ind} - Industrial Competence Centres

The main objective of the programme is to lay the ground for the formation of industrial clusters by providing a durable framework for co-operation, which should lead to the "building of trust and a shared knowledge base". "Awareness activities" and "search for partners" are not explicit activities of the programme. The programme has no active role in organising the network either, although it outlines some minimum formal requirements. Otherwise, the organisation is left to the participants. Neither does the Ministry take an active role as a partner in the centre/network, although some regional governments do.

Focus

K_{ind} supports the establishment of R&D centres jointly run by enterprises and research institutions (universities, government research labs etc), while K_{net} supports the co-operation of geographically dislocated/dispersed research facilities along common themes.

Target groups

All industrial enterprises with there own R&D department and research institutions. SMEs without there own R&D might participate as 'associate' partners at the level of individual projects. The centre/network should have a transfer component that is; technology transfer activities are encouraged. Planned technology transfer activities are a positive selection criterion.

Volume

Three centres are operative at the moment, for which 6,5 million Euro was provided in 1999 (total project costs 20 million Euro). 4 centres are currently (2000) in a preparation phase, with the start of fully-fledged projects expected in 2001.

Duration

1999-2002 (period of initial funding with projects expected to run until 2006). The funding period is limited to 4 years, with the possibility of a 3 years extension.

Institutional setting and organisation

The co-operation can take various forms, ranging from the more loose "association" to the establishment of a formal RJV as a limited company.

Instruments used

Subsidies in the form of grants, up to 60 % of total (eligible) project costs. Enterprises bear a minimum of 40% of the costs. Of the 60 % of public funding, a maximum of 40 % can come from the Programme, the rest can be provided from other public (e.g. regional) sources.

C.2. ISR in Belgium

<u>Contract and collaborative research</u>: Industry's share in financing of R&D in HEIs is remarkably high in Belgium, i.e. interaction by the way of commissioning R&D projects to

universities and carrying out research projects jointly, is an important channel for knowledge and technology transfer. There are several driving forces for this pattern. First, Belgian universities face a low level of basic funding and public funding sources decreased during the 1990s. Thus, there is pressure to look for additional funding for R&D. Second, the scientific disciplines most relevant to industrial R&D, i.e. natural sciences and engineering, show a strong orientation towards research activities, while teaching occupies a lower share of their resources compared to other disciplines. There is some indication that at least some natural science and engineering departments maintain close and regular research contacts with the enterprise sector. Third, despite a generally low level of R&D activities in the business enterprise sector, there is a group of large, R&D intensive enterprises in the advanced technology sector (above all in chemicals but also machinery and metals), which have both the resources and capabilities to interact intensively with public science institutions. There are however, no major financing programmes for joint R&D activities.

Personnel mobility from public science to industry is high in Belgium. This high level is stimulated, firstly, by significant differences in salaries and a high demand by industry for well-qualified personnel. Secondly, fluctuation of higher educated science and technology personnel seems to be generally high in Belgium and thus, demand for replacement at enterprises is significant. Thirdly, public promotion programmes in the field of ISR pay special attention to personnel mobility as an effective channel of technology transfer. Finally, a close interaction between industry and science in the field of training and education, and the corresponding development of personal networks between researchers in both sectors, favours personnel mobility too.

Training and education: There are no quantitative figures on the extent of interaction in training and education but expert assessments suggest quite intense interaction. HEIs (especially polytechnic schools) contribute to vocational training measures for enterprises and there are also promotion measures to increase, amongst others, training interactions between HEIs and SMEs (KIV). Industry is also involved in curricula planning and there are special programmes for promoting PhD students carrying out research relevant to enterprises.

IPR: IPR are used frequently and intensively by PSREs while universities show a weak patenting record until the end of the 1990s. A major reason might be the regulatory framework, which does not provide specific incentives to researchers in HEIs for invention activities. Property rights on inventions belong to the universities (or, until 1998 in Wallonia, to the regional government). There is some financial support for HEIs to cover costs of patent applications and commercialisation but only a few universities have the size, research quality, disciplinary structures and professional commercialisation offices, to use IPR in an effective way. The high patent intensity in the PSREs sector is caused by a few specialised institutes acting in fields of technology where patenting is an important competitive issue.

Start-ups: The level of start-ups from science is high in Belgium, both in HEIs and PSREs. Spin-off activities in the field of new firm formation are supported by infrastructure provision (incubators and consulting services) as well as by direct financial support, especially in the very early stages. The FIRST Spin-off programme is perceived as a good example of an effective promotion programme in this area.

Involvement of SMEs in ISR: There is little evidence for a particularly strong involvement of SMEs in ISR in Belgium. Their share in total business R&D activities is low. There are some policy initiatives in Flanders to stimulate SMEs to use more intensively scientific knowledge in innovation activities, including the employment of scientists (KIV programme).

Science-based industries in ISR: Fast growing new technology sectors such as biotechnology, software, microelectronics and new materials, have a less prominent weight in total business R&D than in other European economies. In 1995, the Flemish government started a new research institute dedicated to the area of biotechnology (VIB) in order to strengthen research in this area and to attract complementary activities by enterprises. VIB has developed well and seems to achieve the high expectations. Furthermore, IMEC, a research institute belonging to the Flemish government and specialised in information technology is a major scientific actor in its field. Nevertheless, it will still take a significant amount of time until science-based industries take a more central role in the Belgian innovation system than they do today.

A "best practice" example:

Leuven R&D

The Technological Transfer Organisation at the Katholieke Universiteit Leuven, called Leuven R&D, can be considered as a good practice in the functioning of an interface service. An internationally well-connected business manager with a track record runs the interface. It has built up considerable experience in the filing and managing of patents, it provides technical incubation to various sorts of research groups involved in applied research projects, it closely collaborates with a university seed capital fund to spin-off an average of 5-7 spin-offs annually, and has created Leuven INC., a non-profit organisation which manages the networking between the different spin-offs in the region. Finally, it manages a science park and an incubator. Start-ups currently in the incubator are expected to grow into the Science Park.

To realise the investment in these spin-offs, the university created, in a collaboration with KBC and FORTIS (two leading banks in Belgium), a university seed capital fund (Gemma Frisius). After a year and half of experience in investing in spin-off firms via the seed stage fund, LRD came to the conclusion that it needed (1) to invest larger amounts of money in each company and (2) to push entrepreneurs to devise more ambitious projects. Initially, they invested between EUR 12,500 and EUR 62,500. Now they target investments in the range of EUR 250,000. They realise that, if the start up does not have enough equity to start with, it will be difficult to adopt a product orientation and automatically, the project will lack ambitions.

The Katholieke University of Leuven is also currently developing two science parks. It wants to encourage its spin-offs to locate in this park in the future. It also wants to attract international companies with complementary expertise to that of the spin-offs and the research labs of the university. In addition, Leuven R&D embarked in a public relations campaign within the university to make the researchers and the professors realise that the university is favourable to spin-offs and to inform them about the resources it can offer them. This includes articles in the campus press, a special course on entrepreneurship and specific presentations. Special attention was given to inform students about the high growth potential of new technology based firms and increase the awareness of IPOs as a form of funding. In Belgium, the dominant model for a small firm is very much the traditional 'SME' (Small and Medium Size Enterprise) characterised by low capitalisation, weak management, and slow growth. One aim with these awareness measures is to change this traditional view and to change the adverse attitude towards fast (but risky) growth among potential spin-off founders.

In 1999, the Leuven spin-offs represented about 150 million Euro in sales and employed over 1,000 people. In the same year, a new organisation was created by Leuven R&D, Leuven inc., whose mission is to promote networking between these different high tech firms and to organise training courses in high tech specific domains. Thus, also the social community has become increasingly active in this small environment.

C.3. ISR in Finland

Contract and collaborative research: Contract research carried out by public science and commissioned by industry, and joint R&D activities by industry and science, are major channels for ISR in Finland. On the side of public science, this type of interaction concentrates on a few types of institutions. In the PSRE sector, VTT is the main performer of such a type of interaction with industry, with a share of R&D financing by industry of about 40 %. In HEIs, it is the two largest technical universities as well as the separate specialised institutes at universities that are most intensively engaged in this type of ISR. The average level of industry funding of R&D in HEIs is rather low however, and may reflect institutional and legal barriers in this type of institution, such as regulation concerning extra earnings. In industry, the bulk of money flowing to science comes from large, R&D intensive enterprises; most often located in high-tech sectors. Collaborative research between industry and science is strongly encouraged by policy initiatives, including Tekes' Technology Programmes and various networking programmes. In recent years, R&D activities and R&D co-operation at SMEs have been strongly and successfully promoted. During the 1990s, co-operation in research between industry and science has increased considerably, largely as a result of a coherent, long-term oriented technology policy strategy to strengthen R&D by providing large public funds and restructuring the Finnish economy towards information technologies.

Personnel mobility: The mobility of researchers from public science to industry is rather high in Finland, with a mobility ratio (mobile researcher per year in % of total researchers in the sector of origin) of 3 to 4 %. The ratio is higher at PSREs than in HEIs and at the latter, some legal regulations in civil servant law do exist which might be perceived as impediments, although they are regarded as having little relevance. Mobility seems to be driven mainly by a large demand in industry to enlarge their R&D activities. Special programmes for promoting mobility from industry to science are scarce. State subsidy for the postgraduate training of employed persons by the Academy of Finland was the only programme of this kind. Mobility from industry to public science is low as a result of significant differences in salaries

Training and education: ISR in the field of training and education is very well developed in Finland. HEIs receive a significant amount of income from training and education activities for adults, including professional training for employees of enterprises (the volume of these activities equals 8 % of total R&D expenditures at HEI). There are several educations and training programmes offered by universities and polytechnics in order to meet the specific and divergent needs of their clients. Education in the field of information technology is a major policy issue and the government in this area introduced a separate programme. Vocational training and further education is carried out at universities in separate, specialised institutes, enabling a sufficient degree of flexibility. Interaction in the field of education also includes programmes for HE graduates working in industry, which aim to up-date their scientific knowledge as well as providing doctoral programmes for industry researchers (such as the graduate schools programme). Further types of interaction concern student training in companies, which is common in universities and compulsory in polytechnics degrees. Furthermore, foresight studies on the companies' skills needs (Osaamisluotain) and other tools are used by industry to influence the discussion of the development of higher education.

IPR in science: Patenting and incomes from licenses play a rather minor role in ISR in Finland. A major exception is VTT, which is the third largest patent applicant in Finland and shows a high patent intensity (25 patents per 1,000 researchers). At universities, there are divergent views on whether the current IPR regulation hampers commercialisation of IP, as the individual researcher is the owner of an IPR. Several universities quite recently started to increase supportive measures for HEI researchers to make more use of IPR and licensing (e.g. consulting, financial support for patent application, innovation centres and incubators). Incomes form royalties in public science institutions are very low, even at VTT.

Start-ups from science: The level of start-up activities by researchers from public science seems to be rather high in Finland, although no exact data is available. Start-ups are promoted via supportive measures such as consulting services and incubators in science and technology parks. Tekes runs a separate programme on this issue, TULI, which provides financial support and aims to exploit the commercial potential of university results via spin-off formation, including the active search for spin-off ideas. Further supportive measures concern incubators and technology parks in public science institutions, and the Centre of Expertise programme.

Networking between industry and science: Building long-term oriented networks between innovative enterprises and public science institutions is a major approach of Finnish technology policy and is being pursued via several programmes and initiatives, such as the Cluster Programmes, Centres of Expertise, Technology Programmes, and National Centres of Excellence. Institutional reform at universities attempts to raise networking by opening university board membership to externals. Networking of enterprises and HEIs is also a major approach in the development of higher education and the design of studies. Finnish science and technology policy put a great emphasis on establishing a co-operative culture in R&D and innovation, and intense co-operation between industry and science is revealed by the CIS2 results. The largest PSRE, VTT, also follows a networking approach to maintain its close industry connection, including having industry representatives on its board.

Involvement of SMEs in ISR: SMEs carry out only a small fraction of business enterprise R&D. Nevertheless, involvement in R&D activities among SMEs has increased significantly over the past few years, largely because of public financial support (mainly via Tekes), which accounts for more than 30 % of R&D financing in small enterprises.

More than half of all public financing for R&D at Finnish enterprises, goes to SMEs. The share of SMEs with continuous R&D activities and with patent activities is one of the highest in the EU. There is a separate programme, Technology Clinics, which aims to improve the absorptive capacities of SMEs and technology transfer from technology providers (public science, large enterprises and research enterprises) to SMEs.

Science-based industries: After the serious economic recession in the early 1990s, the Finnish economy rapidly re-oriented towards high-tech sectors, with information technologies as the leading sector. In 1998, more than 50 % of all business R&D was performed in the high-tech sectors and this share is still increasing. However, the high-tech sector is strongly shaped by one company, Nokia, which alone accounts for about one third of all business R&D in Finland. A major stimulus for the increased high-tech orientation was the launching of the *Additional Research Appropriation Programme* in 1996, which contributed to an increase of GERD (as a percentage of GDP) from 2.3 % in 1995 to 3.1 % in 1999, accompanied by a respective increase in BERD (as a percentage of GDP), from 1.45 % to 2.15 %. In 1999, a programme for strengthening education in information technology started. Technology Programmes, Cluster Programmes and Centres of Excellence and Expertise focus not only on information technology, but support other high-tech areas as well, such as biotechnology and new technologies in energy and environment.

C.4. ISR in Germany

Contract and collaborative research: Both enterprises and public science institutions regard this channel of interaction as the most important one for ISR. About 10 % of R&D expenditure in HEIs are financed by industry while at PSREs, this share is significantly lower (2 %), and also, some public research labs reach shares of 30 % and more. Contract and collaborative research between industry and science in Germany is strongly driven by four forces:

- Firstly, HEIs and PSREs have a strong incentive to attract additional resources from industry in order to compensate for decreasing funding from the General University Funds and basic (institutional) financing.
- Secondly, a high R&D potential and sufficient absorptive capacities at a few dozen very large companies, provides a significant demand for this type of interaction.
- Thirdly, project financing by the Federal government and the Länder governments for joint R&D activities with industry in thematic or technology-specific programmes, is a major stimulus.
- Fourthly, there are several institutions in science which are strongly oriented towards contract/collaborative research with industry, such as the Fraunhofer-Society, Technical Universities, Polytechnic Colleges (with respect to consulting) and specialised PSREs.

In conclusion, framework conditions with respect to legislation and intermediaries seem to have little effect (either positive or negative) for this type of interaction.

Personnel mobility: Personnel mobility from science to industry is high in Germany, with about 5 % of all HEIs researchers and 3 % of all PSREs researchers moving to industry each year. This high level of mobility may be attributed to the following framework conditions:

Wages for researchers are significantly lower in HEIs and PSREs, mainly due to rigid wage scheme and budget constraints in public science. This stimulates mobility from science to industry.

Young researchers in public science (both in HEIs and most PSREs) usually only get temporary working contracts. There are also a large number of researchers working on completed research projects in public science. As further employment within the same institution is restricted or at least not common, young researchers are forced to move to other employers, which are often in industry.

At some types of public science institutions such as Technical Universities, Polytechnic Colleges and the Fraunhofer-Society, the employment of R&D managers from industry as professors or heads of department is common.

There are however, unfavourable framework conditions too, such as the pension system in public science and a lack of acknowledgement of non-academic activities for scientific careers.

Training and education: HEIs are the main provider of highly qualified labour for industry. There is however, little involvement of HEIs in further education and vocational training for enterprises. In these areas, specialised institutions outside the HE system offer services to enterprises. There are no explicit mechanisms to co-ordinate demand and supply for highly qualified labour in Germany. Rather, there is a free labour market with high inter-regional mobility and cyclical unemployment of, and shortages in, graduates of certain disciplines, partly as a result of high fluctuations in the number of new students in industry relevant studies. In highly demanded fields of study, the number of study places is limited but such regulation mainly affects the availability of teaching resources in HEIs rather than the expected demand by industry.

IPR in science: Both HEIs and PSREs increasingly use IPR. The number of patent applications per researcher in natural sciences, engineering and medicine has risen by 40 % (HEIs) and 120 % (PSRE) in the period 1987-1997, and is now at about 20 patent applications per 1.000 R&D personnel, both in HEIs and PSREs. About 7 % of all patent applications at the German Patent Office stem from public science, which is considerably high when taking into account the size and structure of the German business enterprise sector and its specialisation in fields of technology where patenting is a key business strategy. Royalties from patents however, are not a significant source of income for public science in Germany. In HEIs, this fact is associated with the prevailing IPR-regulation, i.e. patents belong to individual professors who are free to decide whether to commercialise a patent or not. Professors are supported by specialised technology transfer bureaux, which are run by individual universities or a regional network of universities. IPR-regulation in HEIs will be changed in the near future however, giving the right of commercialisation to the universities and enlarging the support infrastructure. At PSREs, patents belong to the organisation, and most PSRE institutions run their own licensing bureau. Here, royalties have increased during the second half of the 1990s.

Start-ups from science: The annual number of start-ups by researchers from HEIs may be estimated at about 3 to 4 per 1.000 researchers while at PSREs, this figure is somewhat lower. Start-ups are facilitated by a quite well developed private Venture Capital market, VC programmes by the Federal Government (such as BTU) and specific promotion programmes for university spin-offs by the Federal Government (EXIST) and by five Länder governments. Furthermore, there is public promotion for start-ups in biotechnology via the BioRegio programme (five regions) and its successor, the BioProfile programme (competition is still underway). A main barrier to start-ups from science is perceived as the lack of an entrepreneurial climate at universities and a lack in managerial knowledge, especially in the case of researchers from natural sciences and engineering. With the establishment of specialised professorships for entrepreneurship and start-ups, managerial skills of students and the awareness towards the creation of new firms shall be raised.

Networking between industry and science: Both enterprises and public science institutions report that informal contacts and personal networks between researchers from both sides are important channels for knowledge exchange. Such informal contacts may take very different forms: Alumni meetings in HEIs; meetings in advisory boards and scientific committees; occasional contact at industry fairs, exhibitions, conferences; participation in standardisation committees etc.; regional forums and events; and many more. A main basis for such networking is often a common educational background of researchers from industry and science and personal contacts dating back to the time of study or working experiences in HEIs and PSREs by industry researchers. At industry, it is mostly medium-sized and large companies, which are involved in such networks.

Involvement of SMEs in ISR: In SMEs, absorptive capacities necessary for the successful use of scientific knowledge and expertise, are often lacking. The share of SMEs either performing R&D on a continuous basis or showing patent activity is rather low compared to EU standards. Therefore, several public promotion programmes attempt to remove these barriers to interaction, either by providing funding for R&D or by offering consulting services in order to improve innovation management capabilities. In 1995/97, SMEs (i.e. enterprises with less than 500 employees) accounted for 17 % of all R&D contracts to public science in Germany. This was 4.2 % of their total R&D expenditures, which is slightly above the average share of R&D contracts to public science in total BERD (3.9 %). SMEs main partners for co-operation in science are universities, polytechnic colleges and Fraunhofer-Institutes. In Eastern Germany, there are also good contacts to sector specific; non-profit privately owned research companies.

Science-based industries: Compared to other large, industrialised countries, the high-tech sector which has strong science links in innovation (computer & software, telecommunication, pharmaceuticals & biotechnology, instruments and aircraft sectors), is of a lower significance in the German economy. Its share of total BERD is about 30 %. The German economy is rather specialised on medium- to high-tech sectors such as motor vehicles, chemicals, electrical machines and (non-electrical) machinery, which account for more than 50 % of BERD. In science, there are however, several institutions specialised in research highly relevant to science-based industries. Research in computer & software, microelectronics and biotechnology is carried out at some of the large public research centres, at many Fraunhofer-Institutes, at Max-Planck-Institutes and at specialised research centres. In recent years, spin-offs from these institutions in terms of start-ups of new enterprises, of licensing patents to enterprises and of joint research activities, have increased in number. In the field of biotechnology, Germany is the European leader with respect to patent applications today.

An example of "best practice"

Fraunhofer-Society: A Model of Institutionalised Technology Transfer

The "*Fraunhofer-Society*" (FHG) consists of 48 research institutes, a total staff of about 7,200 (on full-time contracts in 2000) and an annual budget of (2000) 760 million Euro. Founded in 1949, the FHG is organised as a recognised non-profit organisation specialised in applied research in engineering. Amongst its members are well-known companies and private patrons. The basic financing was 220 million Euro in 2000, 90 percent of which was provided by the Federal Government and 10 percent by the Länder (except 3 institutes oriented on military research and financed solely by the Federal Ministry of Defence).

The Fraunhofer-Institutes focus their research efforts in eight fields:

- Materials technology, component behaviour
- Production technology, manufacturing engineering
- Information and communications technology
- Microelectronics, micro-systems technology
- Sensor systems, testing technology
- Process technology
- Energy and building technology, environmental and health research
- Technical and economic studies, information transfer

The success of the Fraunhofer model, as reflected by steadily increasing budgets, is based on a variety of strategic elements, including the decentralised management and substantial autonomy of the institutes, which are pre-requisite for flexible adaptation to the needs of the research market. Another element is the direct linkage between the level of institutional funding to success in contract research, which is a major incentive for market orientation and entrepreneurial behaviour. Indicators for success include their high share of contract research for industry (nearly 40 %), the number of patent applications (1999: 64 per 1,000 R&D personnel), royalties (1999: 5 million Euro, i.e. 0.75 % of the total budget) and spin-offs (40 to 50 start-ups by researchers in 1998 to 2000, i.e. 6 to 7 start-ups per 1,000 R&D personnel).

Furthermore, the success of the Fraunhofer model rests on a balanced mix of the three sources of support: institutional funding (35-40 %), public projects (20-25 %), and contract research for industry (35-40 %). On the one hand, a higher share of institutional funding would imply a decreasing interest of the institutions in industrial contracts, and thus, a diminished orientation toward industrial needs. On the other hand, a considerable decrease in public funding would reduce scientific competence and call the institutes' transfer function into question. The financing structure allows both for oriented (strategic) basic research in new fields of research and for using the results of this research for application oriented R&D which meets industry needs. The institutional linkage to universities is another vital element in maintaining a high standard of scientific competence. Some Fraunhofer-Institutes is managed by researchers who hold a part-time professorship at a nearby university at the same time.

In the German debate on research policy, success with industrial contracts is often seen as the defining feature of the Fraunhofer model, and the close linkage to science is overlooked. Both elements however, are important to guarantee effective technology transfer in the long run. Therefore, managing the balance between scientific and technological competence is a major challenge for the FHG, which is met by regular control of all elements of technology transfer for each institute. In 1998, a systemic evaluation of the FHG took place. The results reinforced the main success factors of the Fraunhofer model: integration of strategic and applied research, decentralisation of transfer responsibilities, strategic planning and audits at the level of institutes. Major recommendations include the increase in flexibility of the wage system (which is today rather rigid due to the application of the BAT-tariff) in order to attract highly qualified researchers, to re-orient the disciplinary structure towards life sciences, material sciences and communication technologies, and to increase networking with other PSREs in Germany (MPG, HGF, WGL).

In 2001, the Research Centre for Information Technologies (GMD), so far one of the 16 large research centres within the HGF-network, will be merged with the Fraunhofer-Society. In 2000, the GMD had about 1,170 employees and an annual budget of about 95 million Euro. As a result of the merger, the FhG will become the leading German PSRE in the growing field of information technology, both carrying out basic research (GMD) and applied research at seven FhG-Institutes.

The Fraunhofer-Society also runs some specialised institutes offering particular transfer services:

- *Fraunhofer Alliances*: Fraunhofer-Institutes pool their expertise in co-operative alliances, appearing jointly on the market to offer their customers a broad range of services. There are currently eight Alliances: Information and Communication Technology, Life Sciences, Microelectronics, Surface Technology and Photonics, Production Technologies, Materials and Components, Polymer Surfaces, and Simulation Technologies (FAST).
- *Application Centres*: They are run by a Fraunhofer-Institute and provide a research infrastructure to university professors who are carrying out contract research for industry. The competence of the Fraunhofer-Institute and the university are combined to offer more customer oriented research services, especially for SMEs in the region with whom university professors often have better contact. Today there are seven such centres.
- *Innovation Centres*: There are two such centres (telecommunication technologies and recyclable polymers) which are constituted as limited enterprises and do not receive any public financing. The purpose of Innovation Centres is to facilitate and speed up the transfer of new developments at Fraunhofer-Institutes to industry. This function is carried out through the manufacture of short-run series for market introduction, pilot and field tests.

Source: Schmoch et al. (2000. 154ff), Evaluierungskommission FhG (1998), Abrahamson et al. (1997, 287ff), www.fhg.de (March 2001)

C.5. ISR in Ireland

Contract and collaborative research: In 1999, 6.5 % of all R&D expenditures by HEIs were financed by industry as contract or collaborative research. In the small PSREs sector, industry financing of R&D is even more important and accounts for 15 % of total R&D expenditure. A major driving force for joint research activities is public financial support to enterprises for R&D activities. A major restricting factor for research collaboration is the small size, strong academic orientation and the absence of world-class research capability in the Irish public science system. Technology-based industries increasingly expect public authorities to put such capabilities in place i.e. to provide the fundamental science from which they will generate the next generation of products. At present, research expenditures in public science institutions amount to 0.4 % of GNP. There is considerable scope to increase this level of investment so that growth in public R&D complements the required increases in business sector investment in R&D. Quite recently, the government proposed the establishment of € 63 million to develop a world-class research capability in the niche areas of information and communications technology and biotechnology.

Personnel mobility, training and education: Personnel mobility from science to industry is reported to be low in Ireland. There are some regulatory barriers in public science but cultural differences and the lack of incentive schemes for researchers in HEIs and PSREs, may be the more important factors. In the area of training and education, there seems to be only little co-operation, and both industry and science representatives feel that interactions should be strengthened in this area. Human capital development is becoming increasingly important in Ireland with the rapid growth of the IT industry. A shortage of graduates has led to an increase in wages for S&T graduates. Increasing differences in salaries for researchers in public science and industry may drive mobility from science to industry, but it may also weaken the position of HEIs in attracting talented young researchers to academic careers. In the long term, one may fear a weakening of the science base, with a negative feedback to industry.

IPR science, start-ups from public science: Today, the use of IPR by public science plays a minor role for disseminating their research results and for producing spin-offs. A major reason may be the current IPR regulation, which does not foresee any special compensation to individual researchers out of incomes from inventions they made. Start-ups by public science researchers are also reported to be low. In this area, some policy initiatives have been established in order to raise awareness of this type of commercialisation of research results, and to reduce barriers to new firm formation by scientists.

Networking between industry and science: There is little evidence of well-established networks of enterprises and public science institutions in Ireland. Maintenance of such networks demands certain resources in enterprises, which are often only available at large companies (such as separate R&D departments, and a high share of researchers). As such, large R&D intensive companies are absent in Ireland, along with industry-science networks. In HEIs, no specific networking activities with enterprises (such as membership of enterprise representatives in advisory boards, alumni, joint research labs, professorships to industry R&D managers, and researcher exchange programmes) are reported.

Involvement of SMEs in ISR: R&D in Ireland is carried out, to a large extent, by SMEs. R&D activities by SMEs have increased significantly over the past few years, promoted by several policy initiatives. Today, the SME sector performs rather well in terms of continuous R&D, patenting and innovation, when compared to EU standards. They present a growing potential for interaction with science. With respect to the HEIs, the TecNet, the Atlantic University Alliance and similar regional networks attempt to foster partnerships between SMEs and HEIs in innovation activities.

Science-based industries: High-tech industries are the main R&D performer in industry, and this sector showed the highest growth rate in R&D investment during the 1990s. However, the bulk of high-tech R&D activities are carried out by foreign-owned enterprises with rather loose ties to the domestic public science sector. The low level of ISR in the field of science-based industries is as a result of comparably low in-house R&D capacities in enterprises (as foreign-owned companies mainly carry out technology and further product development tasks, rather than more fundamental R&D and new product development), and of a weak knowledge base in the high-tech sector in public science, compared to international standards. To foster linkages in this area is a major goal of Irish technology policy. Policies have been put in place to address those areas were public intervention is most needed, and to set up the capabilities at enterprises and HEIs for closer interaction.

C.6. ISR in Italy

In Italy, the debate concerning ISR is strictly linked to the ongoing change of the national research system and is presented in the "Guidelines of the National Research Programme". The discussion lead to the identification of the clear need for a guiding role, specialising in systematic monitoring of national development conditions within the Human, Technology and Organisation areas.

As for universities, in common with almost all other countries, both public and private universities exist in Italy, but they differ greatly in terms of autonomy, funding mechanisms, etc. However, the most important thing to be underlined for public universities is the fact that they are now in the middle of evolution determined by the recent overall reorganisation of the national education and training system. Within this framework, between 1996-1999, a consistent and general innovation process of the Italian University system has been activated.

Where public research centres - CNR and ENEA - are concerned, these two, together with others, belong to the national science research system (including, amongst others, another major body, namely ASI Agenzia Spaziale Italiana - Italian Spatial Agency) and are undergoing a reform process too. On the basis of the Legislative Decree n. 204 of 5 June 1998, *ad hoc* legislative decrees were issued at the end of January 1999 for CNR and ENEA, including provisions to increase their operational and financial autonomy.

This situation greatly affects all ISR related issues. The various reforms are all directed towards strengthening ISR, putting in place new simplified procedures, new important financial and non-financial supporting measures, and more focus on this issue being considered as a central one for enhancing social and economic growth and the modernisation of the country. At the same time however, this very moment is a 'bridging' one, between the old and new situation, and therefore, it is still premature to elaborate data and make assessment on the efficacy of the new tools.

In the past, Italian State support for innovation in firms has mainly been financial, in the form of incentives and facilitation, and to a minor extent, towards network oriented policy. This policy has not always been effective however, due to the overlapping of a number of initiatives, which have been applied without any overall strategic plan. These shortcomings have been compounded by irregularity of the financing.
An important review and rationalisation activity of the complex and stratified legislation supporting the scientific and technological research has been carried out with the Legislative Decree no. 297 of 27th July 1999.

Scientific and technological research support started in 1968 with law n. 1089 and continued with further laws, in particular laws 46/82 and 488/92. The new law no. 297 overcomes the duplication and overlaps which, although difficult to understand, do occur, particularly by those actors less equipped from an organisational point of view, such as SMEs. Law no. 297 can be considered as a true, unified, single reference foreseeing a wide and organic panorama of activities to be financed and providing a clear and simplified identification, both of the beneficiaries and of the possible facilitating tools. For the latter, interventions also aimed at setting up new economic initiatives with a high technological content are now foreseen, both supporting the spin-offs of the research public network and favouring the commitment of venture capital.
Furthermore, an idea, which is not exclusively formal, with the Italian Ministry of Industry, Trade and Small Enterprises is foreseen with the aim of providing final users with a 'one stop shop' presenting their needs and requests, enabling them also to avoid overlaps of activities and dispersion of resources.
Finally, regarding the evaluation of interventions, the Ministry is now obliged to activate overall evaluation procedures - besides the daily monitoring - on the real impact of investments, with the support of the Guidance Committee for Research Appraisal (CIVR) also.

A specific agreement has been signed by ASTER shareholders in order to formalise the main aims and related actions which ASTER will undertake:

1. *Creation and animation of a regional technology transfer network by carrying out the following*

Monitoring research and innovation in the region, and those developed in the region, through the creation and management of research databases which support already existing databases on national and international levels.

Supporting universities and research centres in activities of analysis and project management concerning scientific, technological and industrial issues, for the development and promotion of a culture of innovation.

Diffusion of information concerning research and technology. Co-ordination between the system of regional research and enterprises.

Services of information and technical assistance for the exploitation of research and the protection of industrial property.

Activities supporting the application of new technologies through the creation of valuation sites in enterprises, the constitution of task forces and the realisation of specific projects.

Information, specific services and support concerning the participation in projects, programmes and funding opportunities, technological transfer and innovation, promoted by regional, national, European and international authorities.

Promotion, diffusion and technical assistance regarding opportunities to receive private venture capital or funding in co-operation with others working in the field.

Promotion of projects which concentrate on training human resources for technology transfer and support to the mobility of researchers, in particular, towards enterprises.

Study and experimentation of methods and systems of rating for enterprises which invest on innovation.

2. Promotion of research and technology transfer projects and of contracts of strategic interest for Emilia Romagna Region, support to universities and research bodies working on European and national projects, co-operation on both management procedures and the realisation of technology transfer.

3. Undertaking actions to exploit research results. This also through the creation of enterprises and of autonomous high- tech activities, with particular reference to research spin off and to new technology based firms

C.7. ISR in Sweden

Contract and collaborative research: The level of R&D expenditure in public science institutions financed by industry is below the EU average, although its volume compared to GDP is rather high by international comparison, given the overall high level of R&D expenditure in Sweden. Therefore, ISR performance measured by this indicator should not be regarded as a weak point in the Swedish innovation system. For example, the results of CIS2 show that the co-operation linkages of Swedish business enterprises with HEIs and PSREs are very strong, and that a high percentage of innovative firms co-operate with public science institutions in the course of innovation projects. Moreover, some sectors, especially pharmaceuticals, are heavily involved in financing HEIs and PSREs. In general, the Swedish industry structure is quite favourable for ISR through contract and collaborative research. The Swedish industry is characterised by a strong high-tech sector with a group of multi-nationals which have an international, if not global, focus. These enterprises have tight linkages with Swedish HEIs and PSREs but they are also engaged continuously in R&D abroad. Swedish SMEs are also comparatively strong in R&D activities.

Personnel mobility: Mobility rates of researchers (both from HEIs and PSREs) are comparatively high in Sweden. Due to the structural features of the Swedish industry, the demand for highly skilled personnel is constantly high. The outflow of researchers from HEIs is so high, that some experts hold the opinion that in science, there may be a scarcity of skilled researchers in some fields in the future. The main reason for this migration from HEIs to industry is the difference in earning options. Although the mobility from industry to HEIs is higher in Sweden than the EU average, it is not very significant. Attracting qualified personnel from the business enterprise sector seems to be very difficult for universities.

Training and education: There is only limited information on the extent of co-operation between enterprises and universities concerning training and education. Some measures have been taken to increase the amount of training by experts from enterprises in HEIs and special courses for entrepreneurship have been developed. However, it is too early to make a final assessment of these programmes.

IPR: The Swedish IPR regulation in HEIs, gives the IPR to the individual researcher. There is however, no data available on what extent individual researchers file patents for their inventions. Some experts indicate that the typical university researcher lacks the management capacity to exploit their results efficiently in the market place.

Start-ups: No quantitative information is available on start-ups from public science institutions. However, some programmes have been implemented recently which try to encourage and support the formation of spin-offs. Nevertheless, it is too early to evaluate their effectiveness.

Involvement of SMEs in ISR: The R&D landscape in Sweden is dominated by a group of large multi-nationals. Small firms (> 100 employees) have only a tiny share of R&D (3 %) expenditure. Nevertheless, according to CIS2 data, these small firms have a comparatively high R&D intensity. Thus, their absorptive capacity can be assessed as quite high. During the last few years, special programmes have been implemented to encourage SMEs to use the potentials of HEIs and PSREs.

Networking between industry and science: Although there is no 'real' data available, the high mobility between HEIs/PSREs researchers indicates a high degree of networking between science and industry in Sweden. The success of the Competence Centre Programme shows that networks between science and industry are strong (assuming that these formal networks are built on the basis of former contacts). In addition, some measures concerning networks have been implemented on a regional basis.

Science-based industries: The importance of high-tech industries for R&D in Sweden is high. Most Swedish multi-nationals (for example, in telecommunications, pharmaceuticals, transport and engineering) can be associated with this high-tech base. Their engagement with domestic HEIs/PSREs is quite strong but additionally, they perform a significant part of their R&D activities abroad. The attractiveness of Sweden as a location for foreign based R&D intensive enterprises seems limited as is indicated by the low share of foreign financing of R&D.

An example of "best practice":

Competence Centre Programme

The Swedish Competence Centre Programme is an effort to build bridges between science and industry in Sweden by creating excellent academic research environments in which industrial companies participate actively and persistently in order to derive long-term benefits.

The basic idea underlying the Competence Centre concept is that active involvement from industry in academic research brings about mutual benefits. Active collaboration between research groups and companies in joint R&D projects is seen as the most effective way of achieving good agreement between academic research and industrial needs and an effective transfer of knowledge and technology. The complex needs and problems of industry offer new and exciting challenges to the universities. This translates into a demand for active participation by all the industrial partners in research collaboration and not only a commitment to pay in cash. From 1998 to 2000, the budget for the competence centre programme was about 53 million euros, i.e. around 1 percent of Swedish R&D expenses. NUTEK/VINNOVA, participating universities and enterprises are each contributing one third of that amount. Each centre is closely connected to the activities, long-term priorities and plans of a host university. The university has the responsibility for the centre administration and contributes to their financing by providing a base organisation and other resources.

The programme started in 1995 after an initiative by NUTEK. At present it comprises 28 Competence Centres at 8 universities and about 220 participating industrial companies. The programme is run as a joint venture between NUTEK (now: VINNOVA) and the Swedish National Energy Administration, STEM, which is the governmental financing partner in five energy-related Competence Centres. NUTEK/VINNOVA and STEM intend to contribute to the Centres for up to 10 years.

The Competence Centres are specialised in specific research fields within the following areas: (i) Energy, Transport, and Environmental Technology (8 Centres), (ii) Production and Process Technology (7 Centres), (iii) Biotechnology and Biomedical Technology (5 Centres), and (iv) Information Technology (8 Centres)

From the very beginning, Swedish industry has shown a great interest in the Competence Centres and played an active role in their build-up. Many enterprises, especially the large international groups based in Sweden, are engaged in several centres. About 20 % of the industrial partners are small and medium-sized firms, here defined as companies with less than 250 employees and not belonging to large groups.

A first round of evaluations was carried out in 1997-98 by an international team of experts on this kind of university-industry collaborative effort, focussing on reviewing the introductory efforts to develop Competence Centres.

A second round of evaluations is currently underway. This time, the evaluation teams are constituted of the same experts as in the first evaluation, as well as 2-3 scientific experts in the field of the Centre.

The Centres are reviewed with respect to their development as Competence Centres (their Added Values), their technical and scientific achievements as well as the industrial relevance and benefits.

The first report of the second round of evaluations included statements such as:

"We were impressed by how many times during the visits we were told by the scientific subject experts from their respective technical areas that the intellectual calibre of the work performed to date was world class or first class."

"The involvement of industrial personnel in the Competence Centres Programme, from both large corporations and SMEs (small and medium enterprises), is phenomenal and exemplary. It ranges from project participation all the way to serving on the Boards in strategic roles."

The concept of the Swedish Competence Centre Programme has served as a basis for the development of an initiative of similar kind in Austria, called the K+ Competence Centre Programme.

C.8. ISR in the UK

Contract and collaborative research: Commissioning R&D projects to be undertaken within the context of publicly funded science and collaborating in joint R&D activities is a major type of interaction in the UK system of ISR. Enterprises spend 5 % of their total R&D budget to HEIs and PSREs, and both HEIs and PSREs receive a significant amount of R&D funding from industry. The main motivation in public science for ISR in contract and collaborative research is the access to industrial funding. As basic financing by the government is relatively low, industry money is an important source for strengthening R&D activities in many fields of research. In some research areas and at some institutions, collaboration with industry can also be seen as a strategic institutional policy objective. Furthermore, collaboration with industry provides an outlet for research results. Those incentives to establish contract and collaboration research also have relevance for establishing consultancy links. While research grants and contract income from industry are becoming absolutely and relatively more important over time, major success in obtaining such income is concentrated within relatively few institutions.
On the other hand, there are some barriers impeding IRS in the field of contract and collaborative research. Differences in the research objectives between industry and science could be a problem, as well as that the work needed by industry might be of little interest for academic researchers. The Research Assessment Exercise (RAE) is viewed as a major barrier in this respect - RAE performance determines the allocation of basic funding to departments in HEIs but solely focuses on scientific performance indicators. Strong ISR activities may weaken a department's RAE result, and therefore ISR activities may receive a lower level of priority.

Personnel mobility: Mobility from HEIs to industry is assessed to be high, mainly due to significant salary differences. Furthermore, a large number of policy initiatives attempt to stimulate this type of interaction, such as the Teaching Company Scheme, introduced as early as 1975. The RAE may act as a significant barrier to the greater movement of senior university staff to industry too, because of a lack of an academic publication track record.

Training and education: In the context of teaching and training, ISR are at a high level and still increasing. It should be stressed that industry regards the supply of trained people as its first priority, even from research collaboration. Postgraduate activity is dominated by policy-led initiatives, notably the TCS and CASE. But industry is also becoming more involved in the design and implementation of lower level courses. As this type of teaching must directly respond to industries' needs, course content is the most important factor of the success whereby industry itself counts as an important initiator and 'shaper' of new course work. The second, most important success factor, is the development and maintenance of close links between the HEI and its industrial clients. The most common barrier is the lack of willingness or ability on the part of industry to pay an economic rate for provision. SMEs are facing particular problems. They are often not able to release staff for training even for short periods. Despite the high level of vocational training activities, there is often a lack of priority for this type of activity in HEIs. Education in HEIs often involves student placements at enterprises.

<u>IPR in science</u>: Commercialisation of public science research results by licensing of technology has received central attention in research and innovation policy in the UK. The level of IPR use has increased and may be assessed has high today. Many universities have established holding companies for exploiting a HEI's IPR portfolio. There is an extensive infrastructure in HEIs aimed towards supporting researchers in commercialisation activities. The most common problem associated with the commercialisation of research results is the lack of capital or seed corn development funds. Problems of finance, encompassing marketing and development capabilities are further major barriers, as well as finding the right partner or licensee. In addition, the fear of possible disclosure of results in publications and confidential requirements inhibits the development of ISR in this field.

<u>Start-ups from science</u>: The UK followed an 'infrastructure based approach' to foster spin-off business from public science. Starting in the early 1970s, a large number of science parks located at, or nearby, universities or large PSREs have been established, forming an incubator for start-ups. Many universities have also founded companies to exploit research results arising from a specific stream of research. In 1998, at least 223 such companies existed. No exact figures on the number of enterprises created by former HEI researchers are available but anecdotal evidence suggest that start-up activities from public science is high in the UK.

<u>Networking between industry and science</u>: Networks between industry and science have a long history in the UK. In particular, HEI-industry partnerships have evolved, including enterprises' participation in advisory boards, teaching and training programmes, R&D establishments, and Centres of Excellence. As a result, formal and informal links are widened and deepened between both types of organisations at all levels, and not just centred on a few research staff from both sides.

<u>Involvement of SMEs in ISR</u>: The UK SME sector seems to be less innovative and R&D oriented than in other EU countries. ISR are strongly shaped by large enterprises in high-tech areas such as biotechnology, aerospace and telecommunication. There have been rather few policy initiatives to increase SME involvement in contract and collaborative research so far. New initiatives such as LINK and the Faraday Partnerships address more directly the barriers to ISR at SMEs. In the field of training and education however, SME involvement is high. For example, 66 % of all HEI income from continuing education and training comes from SMEs. Policy measures such as TCS show a share of SMEs in all participating enterprises of 90 %.

<u>Science-based industries</u>: The UK industry shows a high share in high-tech industries, especially in pharmaceuticals and aircraft. These industries intensively use the excellent science base in the UK in the respective fields of research to strengthen their competitiveness. Furthermore, this science base attracts international companies for example, in the agricultural business (Aventis, Monsanto and Agrevo). As a consequence, the share of foreign firms in business enterprise R&D expenditure in the UK is comparably high.

LINK and Foresight: Policy Initiatives to Strengthen Research Collaboration

LINK

The basic objective of the LINK initiative is to improve the competitiveness of UK industry and to improve the welfare of people's lives through the support of programmes of pre-competitive science and technology. More specifically, LINK's mission is to "offer a well-established framework for collaboration between public and private sectors in support of science and technology (S&T) in areas of strategic importance to the national economy. LINK aims to enhance the competitiveness of UK industry, and quality of life, through support for managed programmes of pre-competitive S&T in market or technology sectors, and by encouraging industry to invest in further work leading to commercially successful products, processes, systems and services."

Currently, 56 LINK programmes are sponsored by various government departments and Research Councils in a wide range of technology sectors. Each programme supports a number of collaborative research projects, which each last between two and three years. The government funds up to 50% of eligible costs of a LINK project, with the balance coming from industry. As LINK's programmes focus on a particular technology or market area, the initiative became a good "vehicle" by which the government could implement some of the recommendations coming out of the Foresight initiative (see below). Since March 1995, the government has announced 19 new LINK programmes which are responsive to priorities identified under the Foresight initiative. These programmes will support projects costing up to £ 169 million over the next few years.

The UK Research Councils have all participated in schemes that have sought to encourage industry-academic research links and exploitation activities. They have all been closely associated with the LINK and Foresight initiatives and have established packages which provide adjuncts to such schemes. Thus, the Medical Research Council (MRC) runs an Open-LINK scheme which funds high-quality collaborative projects that meet the LINK criteria, but which do not fit into any particular LINK programme. The Natural Environment Research Council (NERC) operates a pump-priming programme, Connect A, for short research projects, workshops or seminars with industrial relevance. A larger scheme, Connect B, offers grants of up to £200,000 for innovative partnerships with 50% funding from industry. The EPSRC also runs several initiatives in which contributions from industry are required as evidence of commitment and interest.

Knowledge House

More recently in 1996, HESIN set up the Knowledge House to provide an interface connecting the universities and industry in the North East. Its task is to encourage local SMEs to take advantage of the combined resources located within the six North Eastern universities. The Knowledge House functions as a centrally co-ordinated enquiry and response service providing local industry with a single point of contact for advice, guidance and support on a range of technology and management-related issues. RTC North acts as the central co-ordinator of the Knowledge House, with additional managers based at each of the universities. The central aims of the Knowledge House in terms of providing research services to local firms are to:

- provide a rapid and confidential response services;
- offer a free initial search and diagnosis package;
- "source" local assistance wherever possible (i.e. to the nearest available university);
- arrange initial introduction between the firm's staff and the university personnel; and
- monitor the progress of the delivery of the service once specified.

Contact by firms can be made either through the Central Co-ordinator at RTC North or to individual Knowledge house managers which operate at each of the six universities. Where necessary, assistance is provided by defining the exact nature of the enquiry; often an important issue for SMEs who are not used to using external research or technical assistance. This service is provided free of charge by the Knowledge House team. The enquiry is then confidentially circulated throughout the Knowledge House network and sources of assistance and expertise are then identified. In order to achieve a high and even standard of service, once a proposal and a contract is agreed the progress of the project is then closely monitored by the Knowledge House team.

The Knowledge House has been received several accolades in the UK. It also has been commended and promoted in the UK National Inquiry into Higher Education. Its initial enquiry and revenue targets have been exceeded and crucially SME repeat business has been achieved. Second round ERDF funding has also been secured. However, staff associated with the Knowledge House recognise that have the desired "reach" to SMEs substantial public support (subsidy) is required to get "first-time" (i.e. who have never used a university for research or technical services before) small firms to use the scheme.

C.9. ISR in the USA

Research collaboration between industry and science is highly common, and a number of top-level research universities receive major proportions of their R&D budgets form industry. Two types of research collaboration dominate. Firstly, joint R&D within long-term oriented infrastructures such as university-industry research centres, and secondly, research grants to universities, often associated with priority access of the donor to research results. Short-term oriented contract research is less significant. A considerable amount of technology transfer takes place via consulting and technical assistance by faculty members. Many co-operative research projects receive financial support through public promotion programmes and do not involve direct financial contribution by industry to university. As a consequence, the industry's share of total R&D financing at US research universities is relatively low compared to other countries. At PSREs, industry is not involved in direct R&D funding, although there is a significant amount of co-operation and technology transfer. At most federal labs, the CRADAs scheme is applied which does not involve direct financial contribution by enterprises.

Personnel mobility between research universities and industry is high in the USA and reflects some general features of the US labour market and career system. Mobility is supported by few regulatory impediments (researchers at universities are not civil servants, and employment contracts are negotiated individually) and comparably little salary differences between university and industry researchers. Furthermore, NSF programmes such as GOALI give financial support for researcher mobility. In PSREs, i.e. federal laboratories, the situation is different due to the civil servant status of the scientists working there. Mobility is reported to be lower at this type of institution.

Training and education: At US research universities, the combination of education and research has been carried much further than elsewhere. HEIs are heavily engaged in vocational training and further professional education. There is a close interaction between industry and science in graduate education, including lectures by firm employees, placements at enterprises, and joint supervision of master and PhD thesis. Many large enterprises offer fellowships to students and graduates, including an option to employ the student/graduate after completing their study. Furthermore, many enterprises finance professorships at universities. On a local level, industry representatives contribute to curricular planning and decisions on strategic orientation of higher education programmes at universities and colleges.

IPR in science: Both in HEIs and PSREs, IPR belongs to the institution. Inventors receive a certain share of licensing incomes, and the regulation differs between each institution. The level of patent application is the highest among public science institutions in the world, partially due to the strong orientation of US academic research on fields of technology where patenting is highly common (life sciences, engineering, chemistry). Changes in IP regulation (Bayh-Dole Act of 1980) have strongly contributed to the increase in patent activities. In HEIs today, a significant amount of money is earned from royalties (2.3 % of total R&D budget) while PSREs' licensing income is still low. Commercialisation of research results via patenting and licensing is very common at US research universities, and almost every university operates a technology transfer or technology liaison offices responsible for IPR organisation and commercialisation.
The number of start-ups from universities is reported to be high in the USA, although no reliable and complete data is available. Start-ups are supported through infrastructure (incubators) and consulting programmes at the level of individual institutions. Many start-ups rely on licensing university technologies. Many universities provide venture capital to start-ups and operate separate venture capital firms. At PSREs, start-up activities seem to be less pronounced.

Networking between industry and science: Personal contacts and informal networks between industry and science are regarded as the keystone for successful technology transfers, both by industry and university representatives. There are a number of mechanisms to establish and maintain such contacts, ranging from institutional approaches (industry liaison programmes, and technology conferences) to individual approaches (e.g. technology consulting by faculty members).
Involvement of SMEs in ISR: There are several federal and State programmes supporting SMEs in the field of R&D, technology adoption, and innovation. Many programmes include training, management and networking elements. The States offer technology assistant programmes and technology consulting networks, many of which are affiliated with universities or involve university researchers. Nevertheless, the vast majority of SMEs in the USA - as in most other countries - are not involved in ISR.

Science-based industries: ISR in the USA are driven strongly by the rapid development of science-based industries. The USA is the world's leading market in biotechnology, computers, and software. The rapid growth of these industries, and their reliance upon new scientific knowledge, has significantly increased the demand for ISR. At the same time, the universities' opportunities to commercialise new knowledge in the fields mentioned have largely increased with the strong market growth.

Good Practice in Framework Conditions for ISR in the USA

Within the scope and resources of this benchmarking exercise, no analysis of good practice in policy-related framework conditions for ISR in the USA has been carried out. Therefore, a characterisation of good practice examples is not provided. Nevertheless, such examples do exist. According to literature (see Abramson et al. 1997), the following may be mentioned:

- University-Industry Research Centres (UIRCs), including those established through the support of the Industry-University Co-operative Research Centers (IUCRC) Programme, providing a flexible infrastructure for joint R&D with industry.

- The management of technology transfer at large research universities, including specialised Technology Transfer Offices or Industry Liaison Offices that take over the professional management of spin-off commercialisation through patenting and licensing.

- In PSREs, the Co-operative Research and Development Agreements (CRADAs) may be regarded as providing an efficient way of organising joint R&D activities with industry, given the special situation at government-owned and government-operated laboratories.

- The Federally Funded Research and Development Centres (FFRDCs) represent a certain type of long-term public funding of thematically oriented research, both in HEIs and at companies, most often following a specific public objective in technology development, including military research.

- There is a large 'fourth-sector' within the US R&D system, i.e. private, non-academic R&D organisations. Some of them are highly significant both in size and in research output. They demonstrate ways on how to organise high-level basic research and efficient technology transfer outside public institutions.

C.10. ISR in Japan

Contract and collaborative research: There is a rather low level of direct research co-operation between industry and public science in Japan on a formal basis. Concerning commissioned research by industry, several regulations apply that reduce the attractiveness of this channel of interaction. There was a strong increase in contract research in the second half of the 1990s however, but this was partly due to a shift from general industry donations to commissioned research agreements demanded by the government. Formal collaborative research is rare, although several promotion programmes are run by the government, including a university-industry co-operative research centre programme which attempts to stimulate this type of interaction. Given the high-tech orientation of the

Japanese enterprise sector and the likely high demand for scientific knowledge in industrial innovation, the following factors may explain this pattern:

First, regulation at public HEIs and PSREs provide little incentives for formal research co-operation due to inflexibility, bureaucracy and uncertainty on ownership of IPRs. Therefore, enterprises tend to rely more on general donations to a university professor, and define the research carried out by donation funds on an informal basis.

Second, Japanese enterprises have built up large in-house R&D capacities, including basic and strategically oriented research, reducing the demand for acquiring knowledge from public science. However, enterprises rely heavily on interaction with HEIs in order to recruit well-trained personnel for their central R&D laboratories.

Third, there is a significant private enterprise R&D sector, offering technical support, specialised applied research and other R&D services to enterprises. External R&D funding by large enterprises is increasingly allocated to these private R&D companies.

Personnel mobility: There is generally a low level of inter-sectoral labour mobility in Japan, and mobility of researchers between public science and enterprises follows this pattern. In public science, the civil servant status imposes researchers with serious mobility restrictions, e.g. leave of absence, part-time working for other institutions and secondary occupations are almost impossible. However, there seems to be a rather high level of temporary mobility of researchers from industry to science, taking place within informal contacts and personal networks.

Training and education: Co-operation in training mainly takes place on an informal basis, relying on personal relations between university professors and their former students. An interesting type of "indirect vocational training" is temporary visits by industry researchers at universities in order to participate in research projects. Other types of co-operation concern graduate or post-graduate research carried out by technicians and researchers employed in enterprises ("commissioned researchers") and evaluation of research results achieved by industry researchers for PhD.

At Japanese HEIs, there is a longstanding tradition of contributing to industrial innovation through the supply of well-trained graduates, and HEIs therefore, put special emphasis on engineering fields and rather short-term, practically oriented studies.

IPRs in science: The number of patent applications by university researchers is low as a result of a complicated and bureaucratic regulatory framework at national universities and PSREs, and a lack of financial and administrative support (the latter was improved by a new law on technology transfer in 1998). Nevertheless, public science in Japan does contribute to technology development through inventions, but typically without claiming IPRs by the public science institutions. In fields such as biotechnology, up to 40 % of all industry patent applications, lists a Japanese university faculty members as an inventor. Professors are willing to forward inventions to enterprises within personal networks in exchange for general donations. This system is viewed as effective. However, it strongly favours large enterprises, while SMEs have insufficient access to this informal way of distributing university inventions. Therefore, within the new law on technology transfer of 1998, special support to SMEs is provided in order to make use of university-based inventions.

Start-ups from science: There are hardly any start-ups by public science researchers due to the specific incentive and regulatory system. Civil servants are not allowed to hold a management position in a company, i.e. to create a new venture, they must resign from their position at a national university or PSRE. There is no supportive infrastructure for science-based start-ups despite some science parks located close to universities. Financing for technology-based start-ups is rather difficult as there is only a small venture capital market, and even venture capital firms refrain from investing in high-risk projects.

Networking between industry and science: The Japanese ISR-system is characterised by a predominance of this type of interaction. While standard quantitative indicators on ISR in Japan show a low volume (e.g. industry funding, collaborative research, start-ups, use of IPRs, and formal co-operation in vocational training), there seems to be a high volume of new knowledge being transferred through personal contacts and informal interaction. However, it is impossible to quantify the intensity of technology transfer based on informal, personal networks, and industry-science collaboration produces less visible results than in other countries. Assessments by national experts from both industry and science suggest that informal technology transfer is effective, at least from the point of view of large enterprises. However, in some industries where rapid gaining of IPRs is a major competitive factor, a stronger focus on formal interactions and a clear regulation on ownership of IP is demanded (Smith 1999). Furthermore, allocation of science inventions does not follow market mechanisms, i.e. they may not be allocated to those enterprises who may obtain the largest profit out of them.

Involvement of SMEs in ISR: There is no information available on the involvement of SMEs in ISR, but anecdotal evidence suggests that it is mainly the large enterprises that use public science as a partner in innovation. The predominance of the informal system of technology transfer strongly supports such an assessment. SMEs are less attractive to university professors to build up long-term oriented networks as they do not provide a large demand for their graduates, only rarely demand technology consulting, may be unwilling to allow their researchers temporary visits to universities, and have less funds available for donations. At the same time, the complicated regulation on formal research collaboration may represent a serious barrier for SMEs to enter into partnerships with public science. Furthermore, the vast majority of SMEs do not carry out R&D and thus, lack absorptive capacity, and there are only few policy measures to specifically support SMEs in making use of science for their innovation activities. Finally, many technology-oriented SMEs are nested in innovation networks with large enterprises, and technology transfer mainly takes place along supplier chains.

Science-based industries: A significant share of R&D in the Japanese enterprise sector is carried out in industries commonly regarded as science-based industries (especially microelectronics, information and communication technologies, and pharmaceuticals), and high export ratios reflect the international competitiveness of these industries. Their technology performance seems to be less based on the direct transfer of new scientific findings from science to industry than in the science-based industries of other countries. At least two factors may be responsible for this phenomenon. First, Japanese high-tech firms have focussed their innovation efforts on market oriented incremental innovations and adjusted inventions made elsewhere to the specific market needs, including low cost production in order to reduce prices and thus, raise diffusion of new technologies and products. For this strategy, interaction with suppliers and internal R&D on improving production processes and product characteristics are more important than integrating basic science results. Second, Japanese high-tech enterprises have built up large in-house capacities in fundamental research as part of their activities at central R&D laboratories. As these laboratories typically have strong direct ties to development and production activities at production facilities, they allow for a more rapid transfer of new findings into new products and a better consideration of marketing and production demands in new product development, than an external interaction with science would allow. This - highly generalised - behaviour of Japanese high-tech industries has however, weaknesses in some new fields of technology such as biotechnology, where direct transfer of basic research results achieved at universities to commercialisation is a major competitive factor. Here, the lack of formal interactions, in personnel mobility from science to industry, in start-ups from science, and in clear ownership rights of inventions made at universities, are considered ISR based barriers for the development of this industry in Japan (see Kneller 1999). The Japanese government has started several initiatives to gear basic and applied research in HEIs and PSREs more directly towards the need of science-based industries, including programmes such as ERATO, CREST and PRESTO.

- Although all countries analysed show an extensive intermediaries infrastructure, there are only a few examples of them displaying a significant effect upon the level of ISR. Some types of intermediaries, such as tech/innovation centres/"centres of expertise" in Finland and Ireland, SME-oriented transfer networks in Germany, science parks and professional commercialisation units in HEIs in the UK and the USA, and joint industrial research networks in Germany, are good practice examples. Their respective success is related to certain shortcomings in the national knowledge markets, which are specifically addressed by the intermediaries.

CHAPTER V
CASE STUDIES

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CASE STUDIES

Some comments on the use of case studies

Case studies can strengthen the weight of findings, particularly with respect to international generalisation and transfer of know-how across differing cultures and industry production systems.

Most of what has been written about case-study methods comes from other fields of knowledge rather than from the study of management. Thus, definitions in the literature very often reflect only the types of topics to which case studies have been applied in these fields. Psychologists, for instance, think of individuals in the context of treatment, anthropologists of events in societies and political scientists of policies (Platt, 1998).

In the management field, Remenyi *et al.* (1998) defines case study as a detailed investigation of the context and processes that affect a phenomenon within organisations. The most widely accepted definition is given by Yin (1994) who defines case study as ``an empirical inquiry that investigates a contemporary phenomenon within its real-life context and where the boundaries between phenomenon and context are not clearly evident''. This definition is highly pertinent since this research was itself ``testing-out'' research. In this type of research, data collection has to be carried out in ``realworld'' conditions where the kind of control present in a laboratory is not feasible and not even ethically justifiable (Phillips and Pugh, 1994; Yin, 1994; Remenyi *et al.*, 1998).

Perhaps the most critical aspect of a case study approach is the fact that it provides a limited basis for the traditional ``direct scientific generalisation'' (Yin, 1994; Remenyi *et al.*, 1998). However, while case study data cannot be generalised to populations or universes (i.e. statistically generalised) it can be generalised to theoretical propositions (i.e. an analytical generalisation). Thus, the aim of the case studies was not to infer global findings from a sample to a population, but rather to understand and articulate *patterns* and linkages of theoretical importance (see Remenyi *et al.*, 1998).

Case studies reported here refer either to benchmarking efforts or to technology transfer processes. Since benchmarking in technology transfer is a new concept, no case study was found where a benchmarking technique occurred before or during the technology transfer. Searching for partners and comparing critical factors with standard ones were usual in technology transfer cases, but no integrated process was found till now.

A. BENCHMARKING CASE STUDIES

CASE 1. BENCHMARKING AT SHORTS (*adapted by Zairi, 1998*)

Introduction

Shorts initiated a total quality (TQ) programme in response to a significant competitive crisis that arose following their privatisation in 1987. At this time the company suffered losses of around £40 million. Understandably the rationale for embarking on the TQ journey was quite simply survival. Their TQM effort, launched in 1989, focused on:

- saving costs;
- getting employees involved to drive the change process.

Shorts regard this programme as highly successful, and a major contributor to a dramatic turnaround. In the year 1992-1993 profits were around £24-25 million.

Shorts have used various forms of benchmarking for some time, and found **strategic benchmarking** particularly useful following privatisation. The senior management team talked to other companies that had been through a similar process (British Steel was one of those companies) and looked at the different strategies other companies employed following privatisation, and then used the results to identify what should be the direction for the company. The usefulness of external data was therefore recognised at an early stage in the TQ programme.

This new strategic direction **was communicated** throughout the organisation via a vision, **key success factors** and key business processes breakdown for each business unit. **Commitment** to the change programme from the senior management team is quoted as essential in continuing to drive the organisation forward towards its mission.

The initial focus of the TQM programme was internal, where they introduced process based thinking and an emphasis on cross-functional team communication by using simple tools such as process flow charting and process modelling. The clarity these tools gave to the employees in identifying and understanding their processes was particularly influential on the change process. The approach used was to simply say to a team "if you were going to be another company, how would you describe your process?" This process based approach also led to successful development of cross-functional team working where problems were identified, discussed and ultimately solved.

Many problems leading to waste and frustration were identified. One example of this was in the course of a cross-functional meeting it was revealed that only the first two pages of 30-page reports, submitted from one functional group to the other, were actually read. The improvement in internal communications eventually led to a culture that continually questioned the business as usual state.

A **detailed performance measurement system** was also introduced that created great visibility to the quality improvement efforts. These measures, like the processes, were defined from the key success factors and are a reflection of customer wants. Much of the success of the TQ programme has been put down to this introduction of customer focus throughout the company, coupled with the establishment of a philosophy of process based thinking and continuous improvement.

Focus 2000 initiative – the addition of operational benchmarking

The programme "Focus 2000" is Shorts' vision for the future. It aims to continue the successes of the past and produce a dramatic improvement in turnover and profits. In reaching for these goals Shorts have recognised that they must also focus externally, to look for best practice elsewhere and innovatively incorporate transferable elements of best practice into existing processes to significantly improve their performance (Shorts process for Focus 2000 is shown in Figure 1).

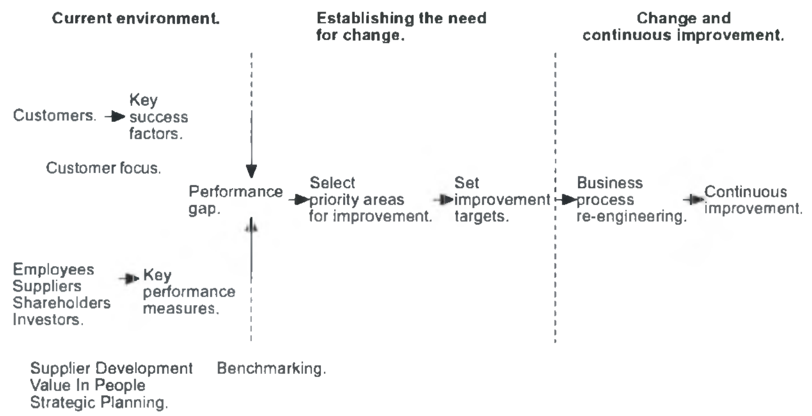

Figure 1.
Shorts' process for Focus 2000

Shorts aim to find companies that are best practice or significantly better inspecific processes. The processes that are selected for benchmarking are those where there is a **significant gap** between the current performance level and what the customer expects, essentially these are the process that are perceived to be holding the business back.

Benchmarking is used both in a reactive way to counter threats and in a proactive way to exploit opportunities. The proactive side is described as more difficult but necessary. Simply the view is that if the business is to grow then proactive benchmarking must be carried out. The rationale for this is quoted as:
Why should we go through all the pain if we can learn from others?

Shorts have used the Xerox methodology for benchmarking, with some slight modifications that place more emphasis on the **planning** and **analysis phases** which are thought to be more relevant to the stage of TQ at Shorts. Shorts define benchmarking as either internal or external, i.e. competitive, generic, or functional, and have applied the Xerox methodology to both. They found internal benchmarking very useful initially as it enabled familiarisation with the benchmarking process throughout the company and encouraged crossfunctional communication. It also enable people to make their benchmarking errors within the company.

The **external benchmarking** that Shorts has carried out has been mainly **competitive and generic.** Much of the benchmarking in manufacturing has been competitive as this is where similar processes are being carried out, and there is a collective realisation that there is more benefit in working together in certain areas. The approach to competitive benchmarking has been based around this understanding of mutual benefit by co-operation.

Shorts have also realised that 95 per cent of best practices are to be found **outside their industry** and they have not become obsessed with competitors. When approaching companies outside their industry Shorts have recognised the importance of taking a professional approach and placed considerable emphasis on the planning stage of a benchmarking project. They have specific objectives, understand that an open co-operative approach is necessary and are prepared to share as much information as they ask for. Simple things like sending in a questionnaire before the visit and ensuring that they are not wasting their benchmarking partner's time have contributed to their success in external benchmarking. The approach Shorts use to identifying best practice and using benchmarking to close the performance gap is shown in Figure 2.

Correct education, throughout the company, is also viewed as essential as frequently people's attitude to benchmarking depends on how they find out about it. To ensure that the correct information is received, a company-wide education programme is vital. The education programme at Shorts describes what benchmarking is, why it needs to be done, how it is done and what the benefits are; this education programme has been open to over 300 employees and is also backed up by articles in the *Changing Times* company newsletter. In this way understanding is developed and the practice of industrial tourism is avoided.
Shorts in 1998 had a number of benchmarking exercises ongoing.
These include:
- Boeing – chemmilling;
- engineering – managing mods;
- manufacturing – non-recurring tools.

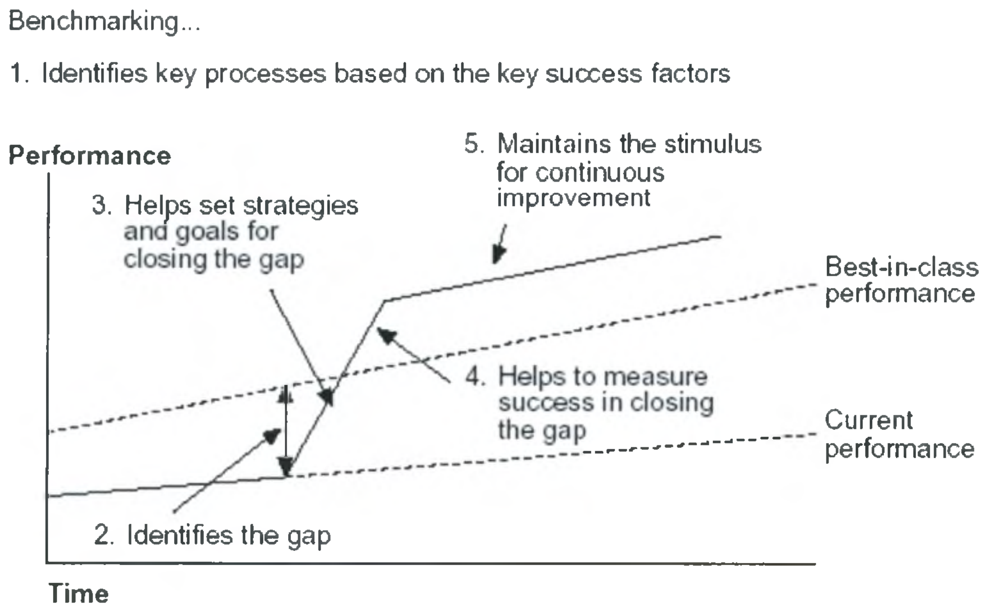

Figure 2. Shorts' approach to benchmarking

An example of benchmarking application

One of the major competitive benchmarking projects carried out at Shorts has been into manufacturing capabilities. The objectives of this study were given as:
(1) assess Shorts relative process competitiveness;
(2) suggest modifications to investment strategy and priorities if appropriate;
(3) ensure priorities are consistent with the commercial aerostructures environment;
(4) assess Shorts current cost position and potential impact of future plans on that position:
• develop process rates assigning true support and overhead rates;
• baseline February/March 1992 data.
(5) provide "best practice" performance metrics for use at a manufacturing cell/process level.

As previously mentioned, Shorts place considerable emphasis on the planning and analysis stages of a benchmarking project to ensure that the benchmarking process, like any other process, is right-first-time. However, once the competitive gap is revealed, be it positive or negative, an established process is used to provide insights to close/widen the gap. This methodology is shown in Figure 3.

One of the outcomes of this analysis was that the biggest factor inhibiting manufacturing processes was cost. Strategies needed to be decided upon that would reduce cost without affecting price or quality. Further analysis led to four primary drivers of cost being identified that typically account for cost differences between competitors. Each key cost driver is examined separately and then all the drivers are summed to describe the overall competitive position.

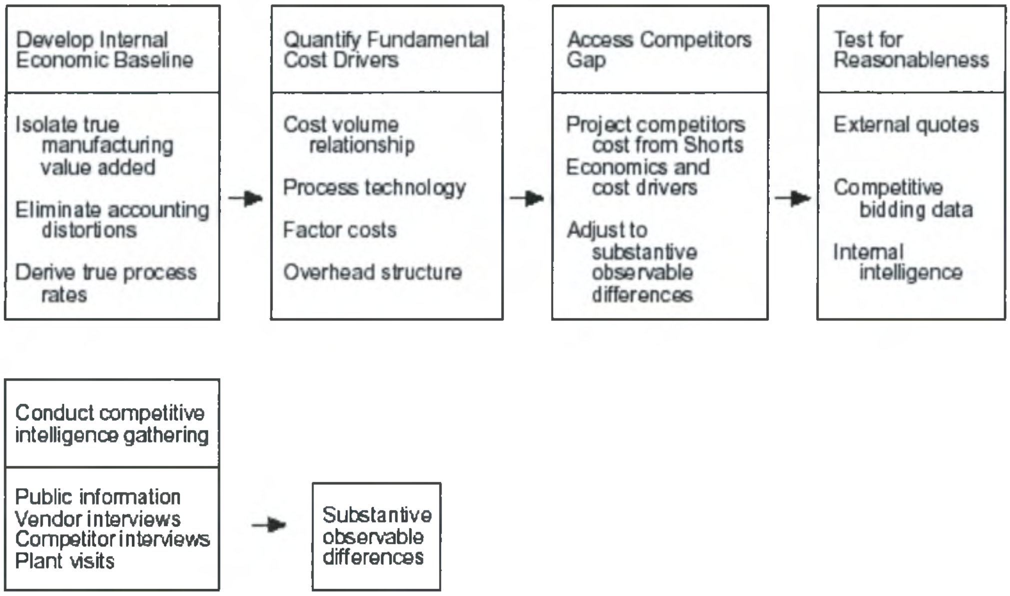

Fig. 3 Short's brothers planning and analysis

The results of this benchmarking study were analysed by first estimating the cost advantage/disadvantage at Shorts, and then lists of best practice performance

metrics were compiled. The culmination of all the planning and analysis was the following summary:
• Shorts equipment modernisation program scope and priorities was largely validated.
• There was an identified need to reduce overheads (divisional/corporate level).
• Key assembly and fabrication processes are currently competitive, chiefly due to lower wage rates in Northern Ireland and focused manufacturing/cell organisation.

The integration phase of the benchmarking process involved the communication of the benchmarking findings in terms of the performance gaps that had been identified between Shorts and best practice, and the gaining of commitment to close these gaps. **Action plans** to close these performance gaps included:

• process improvement plans based on observed best practices;
• best practice performance metrics used as process performance targets (stretch goals);
• corporate services benchmarking project undertaken to investigate reducing overhead costs;
• introduction of internal customer surveys;
• introduction of a customer service award for employees displaying exception commitment to customers;
• introduction of service provider assessment.

Key issues

It has been recognised within Shorts that benchmarking is an effective strategic tool. Indeed inspiration coming from other companies can help develop a vision for the organisation.

There is also a clear recognition that benchmarking is a powerful change agent. As Mr O'Neill of Shorts Brothers argues: The advantage of benchmarking is that it deals with people. The best way to change people is to involve them in projects, encourage them to see how others are doing their jobs. Very often this approach works and individuals come back saying "I don't know why we can't do this", so it is quite a powerful change agent.

• Benchmarking proved to be the best discipline for getting people to focus on the customer. This is so much the case that significant improvements in customer satisfaction have been achieved. The company has managed to reduce overheads to make it in line with its competitors and therefore was able to pass on the benefits to its customers, through price reductions. The knock-on effect appeared to be obvious from then on.

• Benchmarking has helped improve communication and establish the importance of the internal customer. Various departments and business units started to have better rapport and started to use across-functional mode of working.

• Shorts realised that the selection of projects for benchmarking has to be clearly linked to its critical success factors. And since the latter have been developed to impact on customer satisfaction, all benchmarking projects initiated, are therefore geared towards achieving higher impact on customer satisfaction.

Conclusion

Benchmarking has been used as both a strategic tool and an operational improvement tool at Shorts. This indicates the value and versatility of benchmarking in an organisation facing dramatic changes in every aspect of its business. Indeed, the fact that benchmarking can act as a powerful change agent has been recognised. The process of bringing people face-to-face with a superior performing process, and then allowing them to use the power of the team based approach to emulate and improve upon best practice, demonstrates that a change programme can be revitalised by effective benchmarking.

Shorts have found benchmarking to be a very useful tool in their process change and improvement efforts. They now aim to use it more widely, to ensure that this powerful total quality tool is used to improve every aspect of the products and services they provide to their customer.

ON THE SPOT - SOMETHING SHORT!

In the NUMMI venture, the knowledge link is valuable for both alliance partners. Toyota, which had less experience than Honda or Nissan in overseas business management, learned to work with United States trade unions, dealer networks, suppliers and trucking companies, while abiding by local and national regulations. Toyota also learned about managing large United States organizations, whose cultural, social and contractual relationships are considerably different than those of Japanese organizations. Later, all this knowledge became valuable for Toyota in operating its own plant in Greenfield, Kentucky. Likewise, General Motors learned the Toyota way of management (the Quality of Work Life Program) and about Toyota's complex relationships with Japanese suppliers, and so on.

CASE 2. THE EXPERIENCES OF BRITANNIA AIRWAYS

(Adapted by Francis et al., 1999)

2.1. Benchmarking process, evaluation and implementation

One of the first exercises Britannia undertook was to try to get a handle on what really were their engineering and maintenance costs. In order to build up their understanding an internal benchmarking database was established to record all their historic costs from 1990 onwards so that comparison could be made with current performance. This provided a suitable building block for richer benchmarking activity. Once critical costs were identi"ed, and the processes which led to these costs better understood, it was possible to establish a set of key performance measures. This has facilitated Britannia's comparison of performance with that of other airlines.

Published data from sources such as Aircraft Economics provides a starting point for external comparisons once the methods of calculation for each performance metric are understood. Talking with direct competitors was considered too commercially sensitive so Britannia have attempted to benchmark with a number of foreign airlines. In each of these cases:

What we've found is that you've got to go prepared to trade information, in other words it can't be a one way issue. [2] we' re a couple of steps ahead of most other airlines at the moment. So in terms of the learning process I would be prepared to say that most people are learning from us rather than the other way round.

Britannia is keen to stress that they have not done, true benchmarking, which is comparing against "best in class", mainly because they do not know yet who the best in class are. However, it does not necessarily have to be best in class to pick up the good ideas.

It is also believed that for benchmarking to be a truly productive exercise it is necessary to move beyond simply measuring quantitatively and to understand the processes and procedures that lead to the measures. In order to facilitate this it is essential for the organisation to invest enough resources to make the benchmarking activity viable.

What we're not doing properly on benchmarking is getting behind the xgures as much as we should do to understand why the diwerences exist, and the reason we're not doing that is because we're not prepared to put the amount of investment in to do it at this stage.

Britannia uses 18 key performance indicators that, it believes, cover all of the main cost-related properties necessary for benchmarking (within this context). Examples of these include:

Gross Engineering and Maintenance cost: per available passenger seat kilometre; per block hour ; and cost per seat maintained. At the top level this includes understanding what proportion of the total cost of running the airline can be attributed to the Engineering and Maintenance Division. This provides a high level guide to Engineering and Maintenance 's performance, as well as allowing broad comparison with other elements of the business.

There are other macro level indicators, such as revenue per seat and cost per seat, related to engineering and maintenance costs. However, more powerful measures are used which begin to explore the breakdown of costs in more detail. This encompasses comparison of a range of costs, some direct, some indirect, against other factors such as manning and pay levels, di!erent aircraft components, cost of inventory, aircraft age, and passenger kilometres.

The use of key indicators may, at first, appear to foster an over-emphasis on measurement. However, this is not the case. The indicators are used to identify specific problem areas and to bring together the various people associated with that area (engineers, inventory staff and accountants) in order to find the most appropriate solution. This re-addresses the process element of benchmarking, as well as encouraging a positive sense of ownership amongst employees.

A limitation with the key indicators has been that they were initially derived solely from within Britannia. This means that they had not been tested by alternative measures which may exist at other airlines or even at organisations in entirely di!erent sectors. This led Britannia to concentrate more on in-house problem solving which, whilst beneficial in itself, is less likely to lead to any radical or innovative performance improvements gleaned from external contacts within the industry.

2.2. The people involved

For benchmarking to be successful there is a real need for team building and interaction between staff from different professional backgrounds. Furthermore, benchmarking is not seen as an end in itself; rather it is the first step, the trigger, to identify where to take corrective action if things start to go wrong:

Our experience suggests that at the end of the day the numbers comparison is almost superyuous, what is the real issue is the process comparison.

However, there has been a lack of co-ordination in dealing with other companies:

For example, it is possible to benchmark inventory levels for spare parts against competitors and against past experience at Britannia. Benchmarking with partner airlines is a slow and cautious process that requires mutual trust, something that can be enhanced with the formalisation of the relationship at an early stage. Even when a benchmarking partnership is established comparability of key performance measures are only valid if the organisations concerned can be sure that like is being compared with like. This and our research in other organisations has highlighted the benefits of a "benchmarking champion".

ON THE SPOT - SOMETHING SHORT !

British Airways' policy is to strive for total customer satisfaction. Nearly 200.000 interviews are carried out each year with passengers and travel groups. Benchmarking is considered vital, according to the company's policy. Some of the improvements are speedier check - in facilities, express check - in for shuttle services on domestic roots and also to food and drinks served on flights.

CASE 3. PRODUCT DEVELOPMENT BENCHMARKING IN MACHINERY BUILDING *(adapted by Ohinata , 1994)*

Examples of successful and unsuccessful benchmarking are presented here:
Two American machinery building companies conducted a successful benchmarking study with a Japanese firm into methods of product development.
A team of representatives from both American firms, headed by R & D department heads, visited Japan several times in order to learn methods of developing user-friendly products. A user survey at the time indicated that the Japanese company's products were market leaders, and that embodying user needs in terms of product development constituted a distinct competitive advantage. Products from all three companies compete in the global market, but they attract different customer groups; the lack of direct competition facilitated successful benchmarking. Also, the Japanese firm was learning certain processes from one of the American companies and involved in a joint venture in the US with the other.

3.1. Benchmarking in Support Functions

A Japanese industrial firm carried out regular benchmarking studies on international procurement of materials with its German and American counterparts. Although these firms compete in the global market, the limited nature of the benchmarking project ensures the success of the benchmarking activities.

The US plants of an American and a Japanese firm conducted a mutual benchmarking study on job assignment and decision-making procedures. These companies are competitors, but the American firm and the parent company of the Japanese firm are comprehensively allied, their plants are similar in scale and geographically close to each other, and the subjects of the benchmarking project were confined to general management functions.

3.2. Unsuccessful Benchmarking

An American organization approached a Japanese high-tech company on the latter's high-reliability design methods, which the Japanese company was interested in the American firm's product concepts and development methods. This benchmarking project failed because the companies were in direct competition and the proposed benchmarking exercise was too product specific.

A US-based subsidiary of a Japanese firm was interested in the high profitability and customer satisfaction achieved by the after-sales service department of an American market leader. The Japanese company felt that although the two organizations competed on product but not on service. However, the American firm positioned its service department as its most important profit centre; it decided that it had nothing to learn from the Japanese and that the benchmarking project would not offer an equal exchange.

CASE 4. BENCHMARKING AT TNT EXPRESS (*adapted by Zairi, 1998)*

TNT Express takes benchmarking very seriously and because of the nature of its business, has the opportunity to learn from its very wide customer base. For example, one of its major customers is Cow & Gate, the baby food and dietary products manufacturer. TNT Express provides for them a warehousing and distribution process, holding their finished products and through TNT transport, delivering to all of their customers which include supermarkets, chemists, hospitals, community centres all over the country. The running of this dedicated operation has been benchmarked against similar set ups with a lot of learning as a result.

Another example is Rover. TNT Express is an integral partner of Rover's business, in fact they have built a comprehensive car park which is maintained and managed by TNT personnel. TNT receives products which it picks up from Rover suppliers and then sequences them on the assembly line of specific products. TNT Express picks up a lot of learning from Rover who are constantly attempting to instigate new and best practices.

Benchmarking surveys

TNT has made different levels of benchmarks against its confirmed major competitors: Parcelforce, Red Star and Interlink. The comparison reveals that TNT Express is better than Red Star on all criteria, better than Interlink on all criteria and better than Parcelforce on all criteria except price.

The *Business Age Magazine* parcels survey benchmarked TNT Express against 15 competitors in 1993, against four key elements:
(1) booking;
(2) collection;
(3) delivery;
(4) price/value.

Performance league tables

This is the best way that TNT Express encourages internal benchmarking and "best practice". Performance measurement is widely encouraged within all the various depots and people are asked to measure things such as invoice queries, credit notes issued, debtor weeks outstanding on the sales ledger amongst others. Information is submitted by each depot and analysed by top management with feed back on areas for improvement. The information is published in league table format. The criteria feed into various incentive programmes known as "three fives", "five fives" and "going for gold".
The eight key areas involved in internal comparisons between the depots include:
(1) customer trading;
(2) on-time deliveries;
(3) late trunks;
(4) telephone response;
(5) credit notes;
(6) claims;
(7) query resolution;
(8) customer contacts.

The key items are those which represent "The Five Star Criteria" and include: Delivery on time, Failures, Delivered on copy notes and unmatched, Misroutes, Late trunks – (Linehaul vehicles).

The performance league table approach is a powerful internal benchmarking approach within TNT Express, good performance is rewarded and processes producing bad performance are improved through inspiration from best depots. At a local depot level, commitment to improving performance in all the stated areas earns individuals recognition in a wide variety of ways:

- promotional items;
- coasters, drink mats...;
- small team financial rewards;
- national annual administration conference (where winning team is presented with a trophy).

ON THE SPOT - SOMETHING SHORT !

Firms often benchmarked	Typical objects of study
Procter & Gamble	Marketing management
3M	Teamwork, innovation, new product development
Disney	Entertainment, crowd management
Toyota	Just - in - time manufacturing
Motorola	Quality management, continuous improvement
Hewlett Packard	Continuous innovation
Wal - Mart	Logistics, use of information technology
General Electric	Business Process Redesign, leadership development, strategic planning
Banc One	Acquisitions strategy, superior performance, cost control
L.L. Bean	Mail order operations, logistics
McDonalds	Franchising, service consistency

CASE 5. EXAMPLES OF TRADITIONAL BENCHMARKING FROM THE LITERATURE

The published literature abounds with case studies and illustrations of successful benchmarking initiatives that have been executed in a wide variety of operational and organizational contexts. One such example that will now be discussed is the activities of **Xerox**, a pioneer in the early development of benchmarking. In particular, this example demonstrates how Xerox Logistics and Distribution (L&D) first considered and then utilized functional benchmarking to improve the performance of warehousing activities (Tucker *et al.*, 1987).

In the early 1980s Xerox L&D was beset with inefficiencies in the warehousing function. Productivity increases were minimal, at 3-5 percent per year, and profit margins were in jeopardy of eroding. The warehouse picking operation was identified as an area with the greatest potential for improvement and thus targeted as an area for benchmarking. After extensive research and investigation the warehouse operations of L.L. Bean, a non-competitor to the photocopier industry, were identified as suitable for a benchmarking project by L&D. Although L.L. Bean's products differed from those of Xerox, they were similar in terms of physical characteristics, as differences in size, shape, and weight were common (Tucker *et al.*, 1987).

After visiting L.L. Bean's warehouse facilities and studying the practices and methods employed, L&D discovered that superior picking practices were being utilized at Bean, leading to a more efficient picking process. A number of computer based activities that were prominent in Bean's warehousing operations proved to be superior to Xerox's, and Xerox eventually incorporated process and technological modifications that enhanced the efficiency of its picking operations. The result of these changes, based on superior practices learned through benchmarking, allowed Xerox L&D to improve efficiency and productivity (Tucker *et al.*, 1987).

Another successful example of a benchmarking application comes from the automobile industry, in which **Nissan/Infiniti** utilized both functional and competitive benchmarking to develop and establish its customer service standard (Walsh, 1992). This example is insightful not only because a variety of benchmarking partners were solicited, but also because of the highly successful results achieved by Infiniti in executing this endeavor and incorporating the best practices learned from other organizations.

Infiniti's desire to establish a strategically oriented, long-term relationship with its customers served as the motivation for benchmarking against organizations recognized as providing superior customer service. Employee training programs of several organizations were scrutinized among functional benchmarking partners, including Walt Disney Co., McDonald's, Nordstrom and Ritz-Carlton. From these companies Infiniti discovered best human resources practices that relate to empowerment, teamwork, professionalism and providing customer satisfaction. Infiniti also learned lessons from a direct competitor, luxury car manufacturer Mercedes-Benz, regarding after-sales services (Walsh, 1992).

Another company which has exercised the use of benchmarking is **General Motors**. This company compares itself to the best-in-class company. This helps the company realize where they are going wrong and that it is possible to do it better (Finch and Luebbe, 1995). General Motors compares its labor hours per vehicle to that of Ford. General Motors was putting in 30 labor hours per vehicle and Ford only put in 19. This is a dramatic gap that General Motors needed to improve upon. They also benchmarked from Toyota. Toyota was superior to General Motors in four areas. The areas included the following: defects per vehicle, warranty cost per vehicle, order response time, and fasteners per car. These were all areas that General Motors needed to improve on to gain future success.

General Motors also looked at Suzuki. Suzuki was regarded as a leader for having their paint put on properly the first time. The final company that General Motors used was NUMMI. General Motors looked to NUMMI in three different areas, including external JIT parts, internal JIT parts, and fastener part numbers (Finch and Luebbe, 1995). These four companies have contributed to General Motors' benchmarking process.

Another company which has exercised the use of benchmarking is **Andersen Windows.** This manufacturer has been used as a benchmark because of their mass production techniques to assemble items "uniquely tailored" (Martin, 1996). Anderson has been an essential mass producer of windows in the past, but as people's needs changed so did Andersen's processes. Andersen did its best to keep up with the changing market demands. Andersen's so-called "best practices" have placed them at the leading edge of the window market (Martin, 1996). No company is considered to be number one in every area. When a company benchmarks from another company, they will look at different companies for each area that they are struggling in. In fact, many times, the company they benchmark is not even in their industry. Table I shows where many companies go to get the best-in-class company.

TABLE I

Category	**USA's best**
Benchmarking methods :	AT&T, Digital Equipment, Ford, IBM, Motorola, Texas Instruments, Xerox
Billing and collection :	American Express, MCI, Fidelity Investments
Customer satisfaction :	L.L. Bean, Federal Express, GE Plastics, Xerox
Distribution and logistics :	L.L. Bean, Wal-Mart
Employee empowerment :	Corning, Dow, Milliken, Toledo Scale
Equipment maintenance :	Disney
Flexible manufacturing :	Allen-Bradley, Baldor, Motorola, Health-Care Programs, Allied Signal, Coors
Marketing :	Procter & Gamble
Product development :	Beckman Instruments, Calcamp, Cincinnati Milacron, DEC, Hewlett-Packard, 3M, Motorola, NCR
Quality methods :	AT&T, IBM, Motorola, Westinghouse, Xerox
Quick shopfloor changes :	Dana, GM Lansing, Johns Controls
Supplier management :	Bose, Ford, Levi Strauss, 3M, Motorola, Xerox
Worker training :	Disney, General Electric, Ford, Square D

***Source**: Finch and Luebbe (1995)*

B. TECHNOLOGY TRANSFER CASE STUDIES

CASE 1. CASE EVIDENCE FROM THE TRANSFER OF PHILIPS PAGER MANUFACTURE TO INDIA *(adapted by Grant and Gregory, 1997)*

The case reports on a study by one of the authors of the transfer from the UK to India of the manufacture of a telecommunications product (Grant, 1996). The transfer project was observed over a period of 12 months. Data were captured through semi-structured interviews with project management, manufacturing engineers, and shopfloor personnel in the UK and India. Responses were cross-referenced with observation at the home and host sites and documentation where possible.

Philips Telecom Private Mobile Radio (PTPMR) is an autonomous division of the $30bn Philips Electronics Group. PTPMR's manufacturing site in the UK is a mass producer of portable and private mobile radio systems, and wide-area paging devices. Philips had traditionally targeted the European pager market, with a customized, high functionality product. The emerging market for paging equipment in India, which PTPMR wanted to access, was characterized by high import duties, and so a local-for-local manufacturing facility was planned. The manufacturing process was transferred to an Indian company 40 per cent owned by Philips India, to whom PTPMR had previously licensed a portable radio design.

Factors pertaining to adaptation and cloning that arose during the transfer can be structured using the dimensions of appropriateness and transferability, to test the applicability of these constructs.

Issues of appropriateness

The paging product chosen for transfer had been manufactured in the UK for seven years, and was judged to be at the end of its life cycle in the European markets. The product was considered almost ideal for capturing market share in the nascent Indian market, requiring only minimal redesign. The broad range of pager products PTPMR manufactured in the UK was reduced for transfer to India, to simplify planning, scheduling, and control. The cellular structure of the manufacturing process allowed capacity to be easily matched to forecast market demand. Advantage could be taken of India's low-cost labour for the simple manual operations. The manufacturing process raw material requirement, however, was inappropriate for the local supplier base. Local suppliers were not considered to be of adequate quality or sophistication, so kits of components were imported from the UK in completely knocked down (CKD) form. Simple mechanical parts were to be sourced locally later. The region's power supply was notoriously unreliable, but the Indian partner's factory was located in a new industrial zone which provided relatively good infrastructure.

The Indian partner's component placement machines, which had spare capacity, could be utilized for populating the pager PCBs, thus reducing the initial capital outlay of the transfer. However, these machines differed from PTPMR's, requiring conversion and re-optimization of the transferred software.

The host's **existing manufacturing capability and experience** of producing radio products was expected to simplify the transfer. After visiting the host site, however, it became clear that some simplification of the process was necessary to allow the Indian partner to assimilate the process smoothly. The networked computer system used for shopfloor control was replaced by stand-alone stations, and a barcode product identification system replaced with manual code entry. The existing test equipment had evolved some redundancy and was simplified, and a laser product-marking machine, considered too complex to maintain and too expensive, was replaced by a printed label system. A simplified MRP system was prescribed that provided a reduced level of functionality and flexibility. In terms of adaptation to **suit the local climate**, air filtration was prescribed to combat the high levels of airborne dust in that region of India. **Cultural differences were considered to have little impact on the choice of manufacturing process, and the Indian government was keen for this new technology to be transferred to the region.**

Although Indian technicians were brought to the UK prior to the transfer, and PTPMR sent the project manager to assess the host site, **inexperience of performing transfers led to a number of important appropriateness issues not being anticipated**. PTPMR underestimated **the capability gap** between themselves and the Indian partner. For example, PTPMR had wrongly assumed that the partner was familiar with manufacturing practices such as efficiency improvement, TQM, housekeeping, and customer-focus, which were central to the effective operation of the manufacturing process.

Issues of transferability

The pager manufacturing process was amenable to a CKD-type transfer by virtue of being largely an assembly and test process, and it was possible to pilot, and hence test, most of the adaptations to the manufacturing process in the UK, prior to the transfer. The process was adaptable, as capacity could be increased by adding more cells, alternative technologies existed for product marking and process control, and PTPMR possessed sufficient knowledge to make the necessary adaptations. For example, the test equipment was bespoke and could only be adapted by PTPMR's experienced technicians. In terms of knowledge in the process, fault-find and repair know-how had been captured in a cause-andeffect style in the UK. This was used part way into the transfer to hasten the host learning curve, building on the host employees' existing understanding of electronic theory.

In summary, PTPMR focused on the appropriateness of the product and process technology, to the detriment of softer issues, such as the capability and understanding of the host workforce. **Poor communication throughout the transfer, and the absence of a full time PTPMR representative in India,** resulted in patchy implementation of "fixes", and a misleading picture of the project progress. In retrospect, **a more rigorous pre-transfer assessment of process appropriateness for host capabilities would have avoided some of the pitfalls encountered.**
The **fitness** for transfer model was able to capture all of the adaptation factors that arose during the transfer project, suggesting its usefulness simply as a pre-transfer checklist. The appropriateness assessment alone would have shown that the Indian partner did not have the capability to assimilate the methods for mass production of pagers, as it had only been manufacturing the radio products in low volume. A **transferability assessment** would have highlighted the importance of knowledge to adapt equipment and rewrite software, and the need for codified fault-find knowledge. This knowledge was, by chance, available, but was brought to bear late in the transfer and only in response to problems as they arose.

CASE 2. ANALYSING TECHNOLOGY TRANSFER PROJECTS IN DEVELOPING COUNTRIES: TWO CASE STUDIES FROM ALGERIA
(adapted by M. Saad et al, 2002)

Algeria's strategy in the late 1960s/early 1970s was to develop the nation's technological advancement to a high level through building, as rapidly as possible, a strong industrial base. This desire for rapid and heavy industrialisation led in the seventies to a significant thrust of all-embracing projects to purchase complex and costly systems of technology which implied the use of highly integrated mechanisms of technology transfer. These allembracing projects were to be procured through turnkey and ''product-in-hand'' contracts. All project phases were grouped together and the responsibility for activities such as conception, co-ordination and installation were transferred entirely to the technology supplier. The concept and supporting empirical information related to these projects and forms of contracts are extensively discussed in Cooper and Hoffman.

In Algeria in 1970, where about half of the workforce operating in production activities were illiterate and where there were no more than 250 engineers in the whole country none of the factors needed for any kind of technology transfer were available. In order to surmount these constraints and to avert reproducing the same errors, Algerian firms opted for an alternative package, the ''product-in-hand'' project. The focus is now on the long term objective: to guarantee the TT success through increasing the level of local technological capability. This was to be done by including in the project the hiring of foreign experts to train local people. Although a costly form of project procurement, it represented a panacea for avoiding the difficulties generated by turnkey projects. The choice was further motivated by the obvious need to speed up local learning which was expected to enable early, effective and efficient use of imported technology and hence allow new plants to operate to the desired rates of output and to the speci.ed product quality levels early.

This integrated package charged the technology supplier with the delivery of an ''extended'' project, i.e. not only were they to be responsible for design, construction and commissioning of facilities, but for the provisioning of the necessary operating skills, training inputs and the operating organisation's structure. The supplier was now required to adapt the project concept to local conditions and requirements, to train the local workforce, to be in charge of the initial management and finally to offer guarantees related to mechanical aspects, installation and performance. He was also required to provide technical assistance towards integrating local components.

This approach allowed Algerian state-owned organisations to achieve their goals not only regarding technology acquisition but also in connection with assimilation, adaptation and improvement. It was aimed at building the national technological capability by training both workers and management and by providing management and organisational assistance until the plant was running at satisfactory levels and to international standards. This extended project responsibility was designed to make the foreign partner, the technology provider, feel committed to the long term impact of their investment in terms of economical and technical achievement, the same as he would feel for a direct investment. The ''product-in-hand'' projects have been successful in significantly reducing delays to project completion (i.e. attaining a full production capability).

However, what may have been saved in terms of time has been lost in terms of learning to operate, adapt and manage innovation. In summary, the objectives of both the turnkey and ''product-in-hand'' projects are perceived as assisting developing countries to acquire the hardware component of technology. Further ''product-in-hand'' projects are seen as a means of rapidly developing the necessary level of production capability through learning-by-doing following the assumption that knowledge that is dependent upon and associated with production capability is essentially codi.able, simple and easily acquired.

2.1. Case one—the electronics industry

The technology supplier was required to deliver an electronics plant that would produce TV sets, radios, radio cassettes, music centres, car radios, TV aerials as well as a wide range of electronic components such as cathode ray tubes, capacitors, resistors, potentiometers, transistors, diodes, semi-conductors, integrated circuits, metal-plastic pieces and TV cabinets. The whole process of production, starting from the manufacturing of components to the assembly of end products was to be conducted in the one plant. Such an approach meant the use and the assimilation of: raw materials and subgroups to be integrated into this industry; electronic components; design and development of new products and assembly process and testing of end products. The design of the plant incorporated some 20 different workshops, each of which ran with several different technologies.

The plant, operational since 1979, currently has approximately 5000 employees equating to 70% of the organisation's total workforce and its turnover contributes 92% to the firm's turnover. The manufacturing and assembly activities currently require the use of 5000 different machines and tools, 30,000 different parts, about 1000 sub-groups of components and 2000 different suppliers. Most (92%) of the plant's supplies come from overseas. This complexity together with the shortage of in-house skills meant that assimilation would be low. As a consequence, the technology supplier and constructor of the plant was requested to run the ''Department of Materials and Supplies'' for 2 years (1978/1979) as part of the contract.

Adding the hugeness of the electronics plant to this complexity led to a construction schedule spread over 6 years. After lengthy negotiations the contract with the United States partner was signed in 1974 but the whole plant finally became fully operational in 1982. This has meant that the technology and techniques incorporated in the plant were, in the main, those available during the late sixties and early seventies. This has led to an inevitable, fairly rapid and signi.cant degree of obsolescence of the majority of the transferred technologies, not to mention the products. This obsolescence has occurred not only at the level of finished products but also at the level of electronic components. There was obsolescence in component design too: some electrical components had entirely disappeared from the international market and mechanically, the original product design incorporated the use of several cases with disconnectors which implied the production of large and heavy printed circuits, a distinctly out of date technology.

The variety of products, activities and suppliers has made the management and coordination between the di.erent departments and workshops extremely arduous for the inexperienced Algerian workforce. As a consequence, it has been difficult to manufacture products on schedule whilst meeting both satisfactory quality and cost criteria. The complex interactions between the different departments and workshops have made it impossible to optimise use of production capacity; the maximum achieved has been 60% . Today, the dependence on external/foreign assistance for management and skilled operations is still significant. Difficulties such as breakdowns, delays in the delivery of spare parts, repairs that have to be dealt with by foreign experts located abroad lead to long delays in production schedules and explain the chronic gaps between the designed and actual utilisation of capacity and volumes of output.

2.2. Case two—the farm machinery industry

Similarly, Algeria's farm machinery industry was essentially set up during the 1970s and 1980s through turnkey and ''product-in-hand'' projects. First came the construction of an engine and tractor plant (3446 employees) and a farm machinery plant (1600 employees).

Both plants were large and designed to manufacture a wide range of products. Initially the purpose of the engine and tractors plant was to produce 10 different end products as well as the parts required for these end products. Similarly, the farm machinery plant was designed to manufacture 33 different products in four product ranges: farm machinery, sowing machinery, fertilisation machinery and treatment machinery, as well as a wide range of parts to be integrated into the .nished products. As a result, this particular plant is operating with some 300 machine tools and producing 10,000–12,000 components. A combine harvester requires 7000 different components. In Algeria 2000 are manufactured in this plant. In contrast the German producer (and owner of the license) uses plants that produce no more than 30% of the total number of components; the rest are provided by a large group of external sub-contractors.

Two observations are made. On one hand, a large variety of technologies of high complexity were introduced into these two plants, however, the level of skill and experience of the workforce was simply not adequate.
On the other hand, the organisations had to cope with a large and diversified number of suppliers from abroad which has inevitably led to constant stoppages of production, frequent bottlenecks and an under-utilisation of capacity, a maximum of 35%. After 15 years of experience, the utilisation of production capacity is still less than 50% and there is a persistent gap between the forecast and actual rates of production.
Also, the more integrated and complex the plants are in terms of size and technologies, the more difficult it is to run them efficiently. In addition both industries remain entirely dependent on suppliers from overseas.

2.3. Overview

These organisations have now run for more than two decades without being able to even approach international management standards. The turnkey project has not provided the production capability predicted, rather, it has been a passive consumption of imported technology. With the ''product-in-hand'' projects, where provision for training and assistance has been included, a degree of progress along a learning curve is visible. However, this learning curve has been limited to the execution of production tasks. The non-involvement of local managers in decision making to do with the purchase and installation of processes has not enabled them to assimilate detailed information nor to understand how and why methods work. As a consequence, parameters such as output and utilisation of capacity are not up to the level of the initial design, the cost of production is still signi.cantly high as is the ratio of overheads to production costs. As local managers are not involved in the pre-implementation phases of the process of TT, local skills are not developed. Too much attention is still given to the a cquisition of the hardware or the embodied component of technology. Training of local experts has happened in the ''product-in-hand'' project but this has been limited to the minimum level of skills necessary to operate the imported technology.

Three major criticisms can be levelled at this strategy of TT, which is based on complex and highly integrated packages.

1. The approach so far adopted by Algeria does not involve local managers at the implementation phase, de.ned by Voss as the ''user process which encompasses the action from the purchase and the installation through to the successful use of technology''. As a consequence, local skills to do with installation are not developed. Kumar et al. comment and strongly recommend that if managers in developing countries want to be more involved in their country's development, they must possess a greater understanding of how to acquire and implement technology.

2. Technology transfer arrangements have suffered from a weakness that too much attention is given to the hardware and too little to the software aspects of disseminating improved technologies.

3. Training has been carried out, but only in a narrowly focused way developing only the minimum level of skills necessary to operate the imported technology.

The failure of these TT projects demonstrate that a number of social, cultural, organisational and economic features can make it di.cult or impossible to replicate the o.-the-shelf technology previously developed and used in developed countries. It also highlights the need to adopt a holistic and integrated approach in studying international technology transfer. A comprehensive study of technology transfer needs to be associated with an 'open system' approach which includes not only the technical aspects of the transfer but also the related environmental factors and the consolidation phase of the process of technology transfer

CASE 3: JOINT VENTURES*(adapted by Lasseve, 2003)*

CASE 3.1. A FRENCH-THAI JOINT-VENTURE

The French-Thai Chcmitex Co (FTCC) is a joint-venture company established in 1972 between the French Zeta Group* and Mr Yipsoon" a local entrepreneur. The purpose of the company is to produce and sell synthetic fibres for the textile industry. The investment amounts to U.S.A60m in fixed assets plus an additional U.S.L20m in working capital requirement. The Zeta Group is a large chemical group, diversified in eight sectors and active in 40 countries, with only selling activities in South East Asia. ln the early 197Os, the textile division was plagued with recession in Europe, due to ncreasing competition from developing countries.

The official policy of the group was not to invest internationally in this sector but rather to license technologies. In 1971, a French bank established in Bangkok presented a market survey showing tremendous sales opportunities and introduced Mr Yipsoon to the group as a prospectivejoint-venture partner and also as the main customer for the output of the projected plant. Mr Yipsoon, a local entrepreneur of Chinese origin controlled about 50 per cent of the spinning and weaving industry in Thailand through a dozen of wholly owned subsidiaries or joint-venture companies. In Thailand only one company, controlled by a Japanese Group was producing synthetic fibre and Mr Yipsoon wanted to find another source of supply. The management style of Mr Yipsoon was very personalistic and members of his family were at the head of his various companies.

The joint-venture company FFCC started its operations in 1976 after more than 18 months delays in construction of the plants due to conflictual relationships between the partners. The operations of the company started at a time of world recession and increase in cost of raw materials. During the first 3 years, the company operated at loss. Relationships between partners degenerated into an open conflict which attracted the attention of the local press. A leading Thai bank was obliged to arbitrate and finally after four profitable years the Zeta group sold its capital to the local partner. In their comments about this experience Zeta executives mentioned that one of the major mistakes they made was to have embarked in a joint-venture with a local industrialist who was also the major customer of the joint-venture and also not to have spent enough time to investigate Mr Yipsoon's track record and reputation.

CASE 3.2.: GAMMA PHARMA A GERMAN-INDONESIAN JOINT ENTURE

Gamma Pharma" is an Indonesian registered company; 70 per cent of the capital is held by the Lambda group of Germany and 30 per cent by P.T. TIGA", a family owned local pharmaceutical producer and distributor.
The Lambda Group is a second generation family firm based in Europe specializing in herbs and related products. It invested in Indonesia as a response to Government pressure rather than in pursuit of a conscious strategy. Elsewhere in S.E. Asia (Thailand, the Philippines) it manufactures by subcontracting.

Lambda having traded in the area and for a number of years imported herbs from Indonesia, was pushed into local manufacture by the government's new regulations. This brought the firm to see Indonesia as its production base for regional exports. For the rest of the world the company aims to export out of Europe. The company was prompted by government regulations to hand over 30 per cent of its shares. It did, to its distributor P.T. TIGA. P.T. TIGA is a family owned local company, which started in the mid-1960s as distributor of imported drugs and soon developed a small laboratory which became a manufacturing company in the early 1970s. It took advantage of the requirements of the Indonesian government to have manufacturing of drugs done locally in order to develop a strategy of joint venture and licensing agreements with laboratories having a good name and technology m their respective fields.

P.T. TIGA started a joint venture with Lambda. The operation started in 1972 and commercially developed well until 1975; the relationship deteriorated after an international crisis and P.T. TIGA led the foreign partner to try to cancel this distribution agreement. P.T. TIGA overexpanded and was unable to pay for his shares which Lambda had to finance at a heavy cost to its operations. Worse, he could no longer pay for his supplies and had to be replaced as a distributor, but not as a shareholder. As a Lambda's executive puts it: 'We took the easy way, now we pay for it'.

Those two cases indicate that most of the problems originate from a lack of deep prior understanding of the intentions of the local partner, its capabilities and its management style. In the case of the French Zeta group a careful analysis would have indicated that the local partner strategy was to benefit from a second source of raw material and his own vested Selecting interest was not really compatible with the joint venture company profit objectives, not to mention the huge difference in management style and practices between the partners.

In the second case, the German Lambda group tried to solve an administrative problem by bringing in a distributor as a shareholder without realizing that the strategy of the local company was to increase as fast as possible its product portfolio without really focusing **on** any of them.

In both cases as in many others studied by the author (Lasscrre, 1983) a lack of rigorous partnership planning is at the origin of disillusions and conflicts.

CASE 4. UNIVERSITY-TO-INDUSTRY ADVANCED TECHNOLOGY TRANSFER *(adapted by Goldhor and Lund, 1983)*

4.1. Introduction

In early 1976, Dr. James C. Bliss, President of Telesensory Systems, Inc., had completed arrangements to acquire from M.I.T. the necessary technology to develop a text-to-speech reading machine that would be an aid to the blind. By the end of October, 1980, a prototype reading machine was complete and by early 1981, five years after the start of the project, six machines were made available to the Veterans Administration.

The reading machine is a device that translates printed English text into spoken words or sentences. As the user scans a line of printed text with a camera-like device the machine reads the text and speaks to the user in phrases and sentences, all in real time. Such a machine could be an enormous boon to those who are sightless or for various other reasons cannot read, adding one more dimension of freedom to the visually handicapped.

Three parties had an interest in the outcome of the endeavour: the donor of the technology, the Natural Language Processing Group of M.I.T.; the recipient of the technology, Telesensory Systems, Inc. of Palo Alto, California; and the funding agency, in this case the government as represented by the National Science Foundation. There was, indeed, a fourth partly - the community of blind people - which had a large stake in what transpired. It was for their benefit that the project was undertaken, but, as is frequently the case, these ultimate customers were represented only indirectly by the entrepreneurial firm that saw this group as a market for its innovative products.

The problem of creating a generally useful reading machine was an enormous technical challenge. Simple machines that could speak a limited vocabulary of words were possible and were being introduced, but a machine that would both read and speak with a virtually unlimited vocabulary required a more fundamental approach to speech synthesis. This task had been undertaken by a research group at M.I.T. under Professor Jonathan Allen, and by 1975 a sophisticated, working system was demonstrated. At that point Telesensory Systems sought to acquire and exploit that technology. This case study examines the efforts to accomplish the transfer of the technology.

4.2. Analysis

TSI is an aggressive small company with a strong self-image of technical sophistication and creativity. In 1975 they were growing rapidly, had a successful primary product, and had just completed a second product development effort that involved synthetic speech and microprocessor technologies. The announcement of the Kurzweil Reading Machine, and the implications of Kurzweil's encroachment on TSI's product area, funding sources, and customer base, represented a challenge TSI could not ignore. TSI's response was to develop a reading machine of their own - a better machine: less expensive, with greater utility and producing higher quality speech. The response was largely dictated by their self-image, their corporate experience, and the experience of Bliss and Savoie with reading machine simulations.

A significant aspect of TSI's corporate experience was finding federal and other non-commercial support for the development and distribution of high-technology products. The apparent availability of federal financial support for the development of a reading machine was an important argument in favor of attempting the project.

A reading machine product was a "natural" for TSI: potential sponsors could easily understand the product and see the need for it, and potential customers reacted with enthusiasm. It seemed an exciting product for an exciting company with exciting technological credentials. The decision to develop a very sophisticated product over a relatively short amount of time, in the face of TSI's small size and its other commitments, provided strong reasons for acquiring the text-to-speech technology from an outside source.

M.I.T.'s Natural Language Processing Group was an obvious source for that technology: personal contacts already existed between Professor Allen and Bliss, NLPG had a first-rate reputation, and the NLPG technology seemed ripe for commercial application.

From NLPG's point of view, TSI's interest in their programs came at a time when the practical applications of their research was a key issue with the M.I.T. group's sponsors. In a sense, TSI's need was to find a technology to implement their product, while M.I.T. needed to find a product to demonstrate their technology. To both parties the match between these needs seemed nearly perfect, and neither party felt the need to explore in detail how the transfer would occur, how much adaptation would be required, or how the licensing issues would be settled.

Both parties' enthusiasm for the venture, and NSF's supporting grant in the spring of 1976, started the project off on a high note. The subsequent difficulties in getting the text-to-speech software running at TSI did not reach a critical stage until the spring of 1977, when the inability of TSI to produce a tape recording of speech synthesized in their lab brought home sharply to TSI's management the uncertain status of the transfer attempt, and TSI's strong dependence on M.I.T. TSI's response to that crisis was to reaffirm the company's commitment to employing the highest quality speech available. The decision was made to hire additional engineers, and use members of the donor group as consultants. Goldhor's work in the summer of 1977 included leading seminars on computational linguistics and speech synthesis: the first time an organized attempt was made to transfer text-to-speech ***knowledge*** (as opposed to software) to the TSI engineering department.

By the end of 1977 an M.I.T.-like system was running, but not in real-time, on a large computer, and a very simple non-M.I.T.-based system was running in real time on a microcomputer and VOTRAX synthesizer. The M.I.T.-like system allowed TSI to demonstrate their prospective speech quality, while the simple system allowed them to demonstrate the real-time response of the reading machine. But if TSI was becoming more comfortable with the abstract concepts of text-to-speech. it still had not fully dealt with the implications of the size and complexity of M.I.T.'s implementation of those concepts.

The next crisis came in the spring of 1978, when a combination of impressive showings by Kurzweil, a lack of progress in developing a real-time version of the MIT software, and an increasing reluctance on the part of NLPG to get involved in development issues forced TSI once again to choose between abandoning the transfer effort and increasing their level of effort. This crisis revolved around the organizational capacity of TSI to develop a product as complex as a reading machine.

Once more. TSI's response was to reaffirm their commitment to both the technology and the product, and seek to solve their problems by increased staffing. The fact that TSI had just received another grant from NSF to continue adapting the M.I.T. technology must have been a factor in their decision to continue.

The first TSI-developed, real-time, M.I.T.-based text-to-speech system was demonstrated in January of 1979. This was still a very rudimentary system, and required two laboratory minicomputers to run. Nevertheless it was a psychologically important event because it demonstrated that TSI had substantially internalized the M.I.T. text-to-speech technology and adapted it to their own uses. Relatively steady, if still slow, progress continued throughout 1979 and 1980.

The Speech Division was established in mid-1980, and by the end of 1980 a prototype reading machine, including a working high-quality text-to-speech system, had been completed. At the end of this time it was clear that the technology transfer effort had succeeded. Whether or not the originally conceived product - a reading machine for the blind - would be successfully and profitably marketed remained an open question. TSI still needed to find a way to produce this complex product reliably and cheaply. Further, because of changing federal priorities and funding levels, TSI once more had to assess the size of the market for reading machines.

The technology transfer effort - or more precisely the expertise TSI developed in its effort to make that transfer succeed - has engendered a variety of product and service possibilities in the speech systems field. Ultimately, these may turn out to be much more important to the company than the original product.

4.3. Summary of crises

The authors identified a number of "crisis" points in the case history. By "crisis" we mean a point in time when a significant problem has become evident to a participant, who makes a clearly identifiable response. The crises they have identified are:

For TSI: Announcement of the Kurzweil Reading Machine (1975).
For NLPG: Need to demonstrate the utility of the group's research results (1975-76).
For TSI: Failure to transfer the M.I.T. software successfully (March 1977).
For NLPG: Pressure from TSI to devote NLPG resources to application-oriented problems in adapting the M.I.T. software (late 1977, early 1978).
For TSI: Unsatisfactory progress on the reading machine development, including unsatisfactory progress in adapting the M.I.T. software for reading machine application (1978).
For TSI: Unresolved questions about the market for the reading machine product; continuing lack of a marketable text-to-speech system (1980).

It is worth pointing out that TSI responded in a consistent manner to each crisis: in each case it reaffirmed the importance of the reading machine product and speech synthesis technology to the future of the company, increased the development resources it was allocating to the project (except in 1980) and continued to search for outside sources of funding.

4.4. Role of participants

In this instance of technology transfer the recipient organization, TSI, clearly played the largest role. The project's duration, crises, and ultimate success were strongly influenced by the character of the recipient. TSI's lack of experience with complex software systems and with this particular kind of long-distance technology transfer led them into a project that was much more difficult than they imagined. Their strong self-image as an innovative high-technology leader in their field resulted in an unshakeable commitment to both the reading machine product and the MIT. technology. It seems clear that Bliss, the company's president, was an important champion of the project throughout.

TSI's familiarity with federal and other non-profit of funding for their products and development projects meant that they were only loosely coupled to hard market considerations in their decision-making. This opened up a number of opportunities for them, but also perhaps locked them into continuing along a course that would ultimately prove unprofitable or only marginally profitable.

TSI was growing rapidly during the period covered by this study, and many of the problems with the text-to-speech project can be traced to that rapid growth. The rowth was particularly rapid in the engineering department, so that not only was that department much larger in absolute size at the end of the period than at the beginning, but it was larger in relationship to the rest of the company. The same can be said of the engineering budget, which by the end of 1980 had grown to over 20 percent of the company's revenues.

The character of the donor group - NLPG - also affected the transfer effort. From within an academic setting the group seemed have a strong engineering flavor - their output was working programs, rather than just journal articles. Nevertheless, this emphasis on demonstrable algorithms did not extend to an interest in developing applications for speech synthesis. Professor Allen saw this distinction quite clearly, and acted strongly and consistently to maintain the research focus of the group. Apparently TSI did not understand this distinction when the transfer effort began. Finally, it is clear that NLPG seriously underestimated the difficulty of converting their software into a practical real-time system. The situation, then, was of two quite disparate groups, each trying to estimate their own and the other group's capabilities in a venture that neither had tried before, and with no way of evaluating the reliability of their own estimates, let alone the other group's estimate. With the best intentions, both groups overestimated their own - and their partner's - capabilities.

The National Science Foundation played a very restricted role in brokering and monitoring the transfer effort and subsequent development. Its participation was limited to trying to estimate in advance whether the project could succeed. Their organizational structure, procedures, and capabilities gave them little opportunity to affect the project once it was under way.

The M.I.T. Patent Office was seriously hampered by (1) its unfamiliarity with the technology being exported; (2) its inexperience in licensing M.I.T.-developed software for commercial use; (3) the fact that TSI was radically changing the original programs; (4) the uncertainty as to the ultimate commercial value of the property; (5) the complex, inconsistent, and rapidly changing laws governing copyrights and licensing of federally funded research; and (6) its own small size and rapid turnover of staff. The delay in settling the licensing issue was a source of friction to both M.I.T. and TSI, but it is doubtful that either party was really injured by that delay, just as it is unclear which party, if either, the final settlement favored.

ON THE SPOT - SOMETHING SHORT!

Incubators, industrial parks and "technopolises". The Japanese were the first with Tsukuba City, followed by the French with Sophia Antipolis.

CASE 5: THE SCIENTIFIC–TECHNOLOGICAL PARK OF LIGURIA

The Scientific–Technological Park of Liguria (STPL)1 was founded in 1997, with the primary role of promoting innovation in Ligurian SMEs and assisting them in the process. The first step of this action was a survey carried out — with the collaboration of the Ligurian World Trade Center — on the local technology developed by research centers and university departments in the region. The aim was to identify the regional situation of **technology available for transfer to local SMEs.** This phase led to the compilation of an index of 350 technologies, which were included in the Catalogue of Technology. (The Catalogue, which briefly describes each technology, was used as a fundamental tool during the program).

STPL then cooperated with consulting companies, professional firms and the University Departments of Economics and Social Sciences to study and manage the process of transfer to SMEs operating in 11 sectors in the region of Liguria, located in area in the districts of Genoa, Savona and La Spezia. STPL entrusted our team with the task of identifying firms, belonging to the sectors of plant engineering and industrial automation, with the right prerequisites. We considered plant engineering SMEs — all those which design and/or produce, and/or install machinery or components in a plant, or which totally build the plant (Genco and Maraschini, 1997).

Our work was organized in three phases:
1. *analysis of technological needs*;
2. *proposal of new technologies to be transferred*; and
3. *start-up of the implementation process.*

The *analytical phase* includes analysis of the demand for technology. The work team analyzed and evaluated the potential beneficiaries of the transfer process through direct interviews with the entrepreneurs, in order to:
1. assess the "static" competitive position of each company, identify its strengths and weaknesses, and its technological level in terms of assets and know-how (*analysis and self analysis*: *the status quo*);
2. help the mid-term "dynamic" ambitions of each company to emerge (*diagnosis and self diagnosis*: *ambitions and/or needs*); and
3. assess the gaps between existing resources and capabilities and those necessary to implement strategic ambitions, with special focus on the technological gap (*identification of needs*: *the gap between ambitions/needs and status quo*).

In the *proposal phase*, the work team identified and suggested the technology which could be the subject of the transfer. It then searched for the donor offering that technology, and for possible technological partners with whom the project could be developed.

Finally, the *conclusive phase* started when the SMEs were put in touch with the partners dentified. If an agreement on the use of the technology (or on joint development, if the technology required adapting) was reached, the work team took care of preliminary tasks related to the actual transfer process (i.e., market surveys and business plans, identification of sources of financing).

The proposed projects

	Technology	Donor	Recipient
Pure plant			
Financed	Modular standardization of small/medium plants for energy cogeneration	Ansaldo Energia (research center, division of large firm)	Crosa & C., S.p.A (installation, mounting and maintenance)
			Cornin s.c.r.l. (construction, installation, mounting)
			Multiservice s.r.l. (plant control)
Not financed	High-temperature dust filtration system	Ansaldo Ricerche (research center, division of large firm)	Omev s.r.l. (installation, mounting and machinery for cokeries)
			Cornin s.c.r.l. (construction installation, mounting)
Not financed	Rising platform, floating dock type, made with fiberglass elements	BC Engineering (research center, division of large firm)	Sambin s.n.c. (main contractor, installation, mounting and maintenance)
		Navalimpianti (small firm)	Tecnofluid s.r.l. (engineering and construction of fuid dynamic system)
Components and automation system			
Financed	CAD system for personalization of vibrating feeders	University of the West of England, Bristol, UK	Gasco s.r.l (vibrating feeders)
			Wado s.r.l. (engineering and development of components)
Not financed	Advanced field bus for naval applications	Dibe University of Genoa	Simco s.r.l. (engineering and construction of electronic system)
		Navalimpianti (small firm)	FAE (engineering and construction of electronic system)

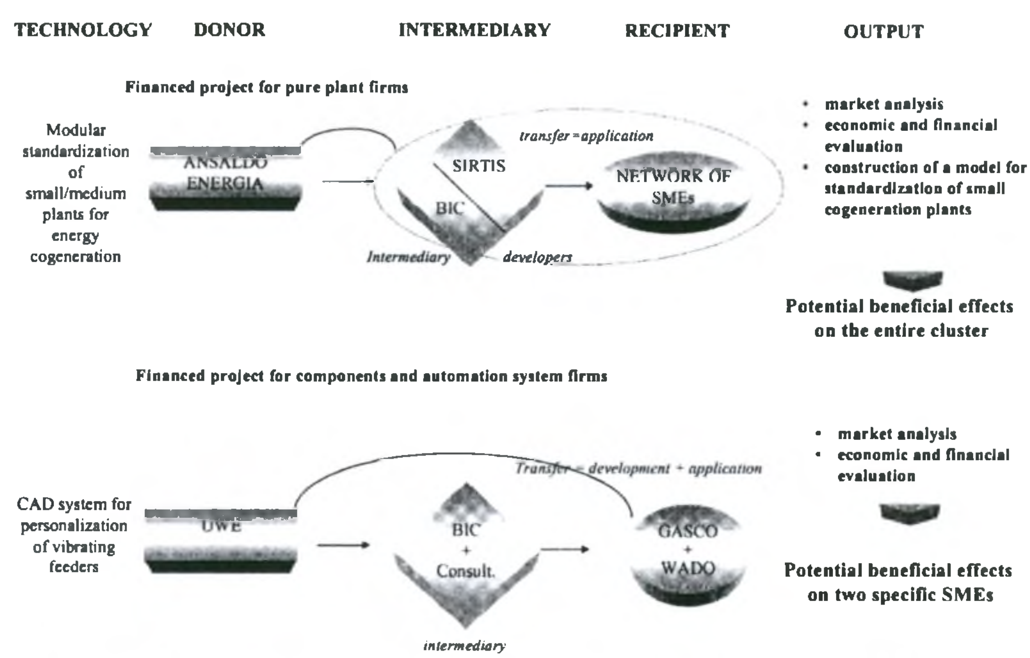

Fig. 2. Projects promoted by the STPL Committee of Evaluation: essential features.

In the illustrated examples above, the technological knowhow had been originally developed by Ansaldo Energia. The intermediary was Sirtis — a spin-off of Ansaldo — in collaboration with Business Innovation Center. Close relations between the donor and the intermediary facilitated communication processes. Although the technology was not intrinsically new, its application was innovative. In general this may facilitate the process of technology transfer, because both costs and risks associated with development can be better controlled The application in fact required different capabilities related to designing, development, engineering and production of the new product, as well as commercial capabilities, which were not available in a single firm. For this reason the best possible solution would have been to set up a network of SMEs, with Sirtis — the inter- mediary — acting as a coordinator of the activities developed within the network.

During the first phase of the implementation both firms appeared to be enthusiastic, and pooled their resources and activities. On the other hand, there were serious problems of communication between donor and recipients that the intermediaries were only partially able to overcome. We must also add that perhaps the project was disproportionately ambitious, if compared with the true capabilities of the beneficiaries: full implementation would have required an additional investment amounting to 1.2 billion Lire over a period of two years (i.e., 20% of the annual average income of the primary recipient firm). When EU funds ended, the project was interrupted.

CYCLE OF SUCCESS -A METHOD OF OFFERING HELP TO SMES WHEN BENCHMARKING IN TECHNOLOGY TRANSFER

CASE : CYCLE OF SUCCESS *(adopted by Underdown, 2002)*
(Chapter III)

Over the past six years, the SBDCEE has been a source of help for several small companies. The SBDCEE is funded in part by the Small Business Administration and the State of Texas to support small manufacturers to achieve competitive advantage by assisting them to transform all operations of their enterprise. Engineers from the SBDCEE assist small manufacturers on a weekly basis over a one- to two-year period.

Another mechanism by which the SBDCEE assists small companies is the Breakfast Workshop Series (BWS). The BWS is an interactive seminar series that presents topics concerning enterprise transformation. The workshops are designed to promote awareness of enterprise transformation topics among small companies and to provide an opportunity for small manufacturers to network with other companies experiencing common challenges. Concepts and topics that support enterprise transformation are presented utilizing lectures, films, books, articles, guest speakers, skits, and success stories. The BWS began in 1992 with 24 topics presented weekly over a period of nine months. Today, the BWS offers 32 topics every week in the same time frame.

Industry cases

The initial occurrence of the cycle of success was in the Spring of 1993. At this time, informal networking was ongoing among regular attendees of the BWS. To facilitate networking further, a tour at a local company was arranged. This company, which is referred to as ``Catalyst'' to symbolize its role in the networking, refurbishes aircraft engines for the major airlines. Catalyst is part of a large global conglomerate. In the fall of 1992, Catalyst transformed its entire enterprise from a state of crisis to a position of competitive advantage. The SBDCEE sponsored a tour of Catalyst in the hope of motivating small companies to transform their enterprise. The intent was to expose them to an enterprise of excellence.

During the tour, managers of small companies came across the same concepts discussed at BWS, but from a more applied standpoint. Second, they saw an implementation sequence of the concepts presented in the BWS. Not only did they know what to do, but how to do it. They had an opportunity to ask questions about the implementation and learn the pitfalls and things to avoid. The tour marked the second stage of the cycle of success: benchmarking.

Case 1.: a small machine shop

Two companies came away from this tour inspired to take action. These companies are referred as ``Sheetmetal'' and ``Rubber'' to indicate their primary products. Sheetmetal was constantly behind schedule. Late deliveries, large amounts of overtime and six-day work weeks were the norm. After visiting Catalyst, Sheetmetal's president was ready to make drastic changes. During the next few weeks

Sheetmetal worked on the implementation of a pilot manufacturing cell with a pull system of inventory control.

Sheetmetal managers and employees took several follow-up tours at Catalyst during this period to understand the details of implementing manufacturing cells. The managers at Catalyst assisted Sheetmetal in developing production schedules and alternative cell designs. Sheetmetal went on to convert its entire facility into cells, including office areas. This ongoing assistance from Catalyst marked the first occurrence of the third stage of the cycle of success: mentoring.
Results were dramatic. Over a period of only two weeks, Sheetmetal's pilot Cycle of success cell had achieved a 200 per cent improvement in throughput. As other cells came on line, the numbers became staggering: work in progress reduced by 65 per cent, first run yield improved by 77 per cent, turnaround time reduced by 86.5 per cent and cost of goods sold reduced by 42 per cent (Underdown et al., 1995).

Managers of Sheetmetal soon realized that to achieve their full potential, they must consider all enterprise processes for improvement. Over the next six months, Sheetmetal employees designed and implemented manufacturing cells throughout the plant. Once the manufacturing cells were operational, they formed cells in the office areas. Improvements were made in bidding, accounts payable and receivable, and other front office processes. Redesigning these processes increased capacity by 60 per cent and reduced order generation time by 75 per cent. Clearly, Sheetmetal had achieved radical change.

Since the completion of a cellular transformation in the Spring of 1994, Sheetmetal has continued to make improvements, thus marking the fourth stage of the Cycle of Success, continuous improvement. Sheetmetal formed teams of the people in each cell. These cell teams hold monthly meetings to discuss improvements. Cell configurations and operating procedures are continually changed as operators discover better ways to process orders. As part of the continuous improvement effort, Sheetmetal continued to send its employees to the BWS in 1995 and 1996 in an effort to give them more exposure to transformation concepts.

Case 2: a small rubber molder

While Sheetmetal was implementing cells, Rubber was observing with close attention. The managers of these two companies formed a friendship while attending the BWS. Managers of Rubber stayed in frequent contact with their counterparts at Sheetmetal. Weekly phone conversations were common. Managers discussed current progress and alternatives that Sheetmetal was considering. As significant progress was made, Rubber managers would tour the Sheetmetal facility. These conversations and tours marked the networking and benchmarking stages of the cycle of success for Rubber.

Managers at Rubber were not ready to implement radical change immediately following the tour of Catalyst. They were still skeptical. They wanted time to research the concepts themselves. This approach mirrored their management style of cautious and methodical progress. Once the managers of Rubber realized that Sheetmetal's results were continually improving, they entered the mentoring stage of the cycle of success and took action. Managers of Rubber held several meetings with Sheetmetal and Catalyst managers over the next few months to facilitate the implementation of cells. Managers of Rubber formed a ``steering team'' and developed a vision of what they wanted to become and a plan to get there. Upon completing the plan, they developed a communication plan to inform employees that a major change was coming and that they would have an integral part in making it a reality. The steering team formed teams to design and implement cellular manufacturing in the same manner as Sheetmetal and Catalyst. Over the next few months, teams met regularly to design cells and plan the move.

Rubber changed the entire company into manufacturing cells in one move. The steering team felt that changing the entire company was the best strategy after witnessing the experiences of Sheetmetal and Catalyst. The lessons learned from these two companies propelled Rubber past many of the pitfalls that sidetrack a company during the transformation process. Thus the benefits of networking and mentoring with the SBDCEE and two local companies began to pay dividends.

Rubber's transformation yielded radical results. Team productivity increased 37 per cent, while sales rose 7 per cent and profits improved by 80 per cent. Cellular manufacturing and reduced lot sizes contributed to significant inventory reductions: overall 14 per cent, work-in-process 88 per cent, raw material 24 per cent and finished goods 7 per cent. Customer satisfaction also made great strides. Customer returns were reduced by 29 per cent and customers are now using the company to benchmark other suppliers. With gross sales increasing from $5,229 to $6,810 in 1994, this organization is well on its way to developing a competitive advantage (Underdown and Deese, 1995).

Case 3: a large drill bit manufacturer

The third occurrence of the cycle of success started in 1994. This company, called "Drill" to represent its primary product line, is a part of a large global conglomerate. It started attending the BWS at the recommendation of a business acquaintance. Total quality management, cellular manufacturing, and teams were all familiar terms to the top managers at Drill. The issue was how to integrate these concepts into a company that was already the industry leader. In order to gain more insight as to what other companies were doing as well as the views of academia, they started attending the BWS in the spring of 1994, thus starting the cycle of success: **networking.**

Drill produces drill bits for blasthole drilling as well as raised boring and related drilling for the mining industry. Though it held over 35 per cent of its market, it was in need of change. Customers' requirements were changing quicker than Drill could react. It had the need to respond rapidly to the ever-changing business environment in order to serve better its customer's needs and maintain market share.

One of the significant benefits of the BWS is the opportunity to network with other local companies facing similar challenges. Managers of Drill found that other companies attending the BWS had experienced similar constraints and had implemented cellular manufacturing as a solution. Several companies in the BWS had benchmarked with Pratt & Whitney, an aircraft engine manufacturer in Connecticut. The managers at Pratt & Whitney were the same ones who had turned Catalyst around in 1993. Drill visited them, since they were considering large-scale changes. Pratt & Whitney's managers were very receptive to the idea of helping Drill just as they had been in 1993 with Sheetmetal and Rubber. Drill made the necessary contacts at Pratt & Whitney to benchmark its operations in cellular manufacturing.

In November of 1994, Drill managers toured Pratt & Whitney's facility, which marked the second stage of the cycle of success: **benchmarking.**

In December of 1994, a cross-functional team was formed of Drill's shop employees, managers and engineers to design and implement a pilot cell. During this period, the managers of Drill maintained contact with managers at Pratt & Whitney to answer questions. This proved to be an important sounding board as managers of Drill encountered resistance to change among employees. Since Pratt &Whitney conducts business in the Dallas/FortWorth area, its managers used those trips as opportunities to visit Drill and check its progress. Thus, the third stage of the cycle of success emerged: **mentoring.**

These trips quickly became cheerleading sessions since Drill was experiencing resistance to operating in manufacturing cells. Managers from Pratt & Whitney spoke to groups of employees about their experiences with manufacturing cells, the pull system of inventory control and teams. After working out the details of the cell designs, Drill employees moved all the equipment over a weekend. The plan was to miss no production, which worked effectively.

The pilot cell was so successful that Drill decided to restructure the entire shop into a cellular configuration. The actual move was performed in phases due to the need for additional equipment necessary to have three fully functional, self-sufficient cells. During the first six months of 1995, in preparation of the shop reorganization, Drill trained employees to be functional members of a self-directed team. Every employee became a team member and learned to support each other as well as other teams. The training was conducted with its sister division in Houston to improve communication and teamwork in order to enhance sharing of best practices. Thus, **the networking stage of the cycle of success was in use again**. This time, the networking was within the company rather between companies. These training sessions helped to create a more seamless organization.

The results were very positive. Owing to inefficiencies, headcount grew 30 per cent from 1993 to 1995. After implementing the cellular process and continuous improvement efforts, headcount was reduced to near the 1993 level. The decrease was achieved by eliminating non-value added activities and attrition. As a result of implementing cells, Drill did not proceed with a planned expansion. Instead of adding 15,000 square feet to its facility, it cleared out 12,000 square feet for a new production line. The implementation of cells dramatically impacted the plant's performance. Compared to 1993, Drill reduced cycle time by 80 per cent on average. The average set-up time has been reduced by 70 per cent and work-in-process decreased by 78 per cent.

The result of all these strategies is the ability to respond quicker to customers' changing requirements. All employees are now customer focused. Efforts such as these demonstrate the power of the fourth stage of the cycle of success: continuous improvement.

Summary of lessons learned

Upon reviewing these cases, several common ``lessons learned'' emerge. First, networking is essential to sparking the cycle of success and most benchmarking activities. The companies profiled in this paper had a common place to gather on a regular basis, which provided regular opportunities for communication and benchmarking.

The second lesson is the influential power that benchmarking can have on facilitating a transformation to agility. During the benchmarking phases of the cycle of success, company managers witnessed a company that had successfully transformed. They saw that transformation was possible, and in a very short period of time. They saw what a transformed company ``looked like'' and how it operated. They had an opportunity to ask questions about the implementation and learn the pitfalls and things to avoid.

The third lesson learned is the importance of mentoring and collaboration throughout implementation of a transformation. Note how Catalyst and Pratt & Whitney helped Sheetmetal and Drill through the details of implementing cells including scheduling, budgeting and trouble shooting. In addition, note how Sheetmetal assisted Rubber avoid the mistakes it made during its efforts to transform.

CHAPTER VI
CONCLUSIONS - RECOMMENDATIONS

CHAPTER VI

CONCLUSIONS - RECOMMENDATIONS

At the beginning of this new millennium industry faces an acceleration of the globalization of economies. Enterprises will have to cope with a fundamental transformation of structures, the organization and nature of international trade, capital flows, information networks and technology. Enterprises operate in many markets and competition is intensifying. Declining costs in information technology, communications and transport drives globalization. The effect has been a move towards greater facilitation of entry by firms into new markets and diversified cross-border trade and investment. Globalization increases competition and, if well managed, has the potential to improve global resource allocation and overall efficiency.

In a global, rapidly changing economy, enterprises and industry have to go away from detailed local activities and encourage and promote worldwide best practices. Globalization requires benchmarking in order to achieve a competitive position. Competitiveness is a prerequisite for economic growth and employment.
In this regard, benchmarking has a key role to play. Benchmarking aims at identifying best practices world-wide and has a role in fostering continuous improvement among all economic actors, including the public service.

Benchmarking stimulates companies to define breakthrough targets that are challenging but credible because other companies have reached them. Benchmarking offers concrete answers through the identification of best practices that drive best performances. Best practices need to be fully understood in order to identify the elements that facilitate or impede the adoption of best practices.

Benchmarking is a tool or a means to initiate and direct *continuous improvement* processes. It has been developed for enterprises in order to improve performance and productivity in global competition. For public authorities it serves to improve effectiveness and the quality of services.

Benchmarking is a systematic process of *comparison against the "best in the world"* aiming at exceeding that level. A benchmark (based on *key performance indicators*) serves as an orientation mark for improvement processes and the *analysis of "best practice"* serves to understand how the benchmark has been achieved in order to direct actions targeted to upgrade ones own performance. In this sense benchmarking could also be understood as an organized way to have a *collective learning process* for improvement towards higher quality of output and services.

Several steps are undertaken from definition to implementation such as:
> Identification of a target issue to be improved
> Development of one or some specific performance indicators (benchmarks) for that particular issue

> Comparison of own performance against the best world-wide
> Analysis of best practice and improvement potential
> Implementation of actions to improve
> Continuous monitoring

In the initial phase, benchmarking was seen as a management technique to be used only by specialists and to be applied only when large breakthrough improvements were needed, often in a crisis situation. Benchmarking has since become an important tool in the management process. It represents ongoing, structured comparisons with the goal of promoting continuous improvement from organizational solutions adopted by each company in managing its business processes.

Benchmarking is not a policy but ***a method and a tool*** that can support the objectives mentioned above. Independently of the area to be benchmarked, the methodology may consist of the different elements and procedural steps that constitute the ensemble of an improvement process1 as detailed below:

a) High level commitment
- identification and decision process for the target issue;

b) Analytic support structure
- key performance indicators;
- analysis of world-wide best practice;
- comparison of own practice against best practice;

c) Improvement and learning mechanisms
- identification of improvement potential;
- implementation of changes;

d) Monitoring mechanism
- reporting of progress made.

In a nutshell, benchmarking is a strategy that aims towards improvement, greater effectiveness and a higher quality of services rendered, and towards initiating change. Benchmarking aims to increase productivity and promotes value for money, quality and better services. In order to do so, high level commitment from the top management or highest level of policy makers is necessary to overcome resistance and to support the activities.

Benchmarking consists of different elements and procedural steps. It has to be supported by research that establishes quantitative indicators and qualitative analysis of best practice. Benchmarks indicate the performance level as well as the target to be achieved. Best practice demonstrates how this target has been achieved. The display of best practice will inspire, and can serve as a learning opportunity for actors to improve and to approach - or even overcome - the benchmark.
Benchmarking can be regarded as:

➢ *A normative* concept: It provides an orientation towards leading edge practice.

- *Analytic*: It develops key indicators and helps to understand why and how the best practice has been achieved.

  - *Action related*: It aims towards improvement and change.
  - *A continuous learning* concept: It raises awareness about performance gaps, suggest ways to fill them and stimulates a continuous improvement process.

Today, Benchmarking is moving on. It needs to be extended to new fields and become more specific about certain areas that are sensitive and vital for the new rules of the market game. Furthermore, Benchmarking Culture must support the use of innovative and challenging targets, primarily in the strategic field of changes in order to promote competitiveness and excellence in performance.

This thesis addresses the question of involving benchmarking in technology transfer and how benchmarking can promote and ameliorate the transfer of technology . In the emerging economic and social environment, where knowledge, its use and exploitation will be the key to competitiveness, the interaction of knowledge generators and users will be critical for success. In particular,

- Knowledge is increasingly important for competitiveness.
- Inter and intra industry shifts towards services generate a new demand for technology transfer.
- An increase in the efficiency of existing technology transfer schemes is necessary.

In most economies, technology policy has sought to bring the worlds of scientific and commercially oriented research closer together. Referring to transfer from R&D institutes, innovation and technological development depend increasingly on the ability to use new knowledge produced elsewhere and combining it with the stock of knowledge available in a particular enterprise. For this purpose, absorptive capacities, transfer capacities and the ability to learn by interaction are crucial success factors in innovation (see Cohen and Levinthal 1989, 1990, Foray and Lundvall 1996). New and commercially useful knowledge is the result of interaction and learning processes among various actors in innovation systems, i.e. producers, users, suppliers, public authorities, and scientific institutions (see Lundvall 1988, 2000). Universities and other public research institutes, as major producers of knowledge, are increasingly expected to contribute to this process.

For SMEs to be innovative in the emerging vista of market, they will increasingly participate in networks, clusters and other collaborative fora. The initiative for much of this must come from SMEs themselves. However, public policy can contribute by ensuring that actors such as publicly owned research institutes and centres become active partners in such networks.

To succeed in technology transfer it is necessary to be ***technically competent*** but also to strike the right communication note to suit the individual or sector to which the technology is being transferred. Therefore ‘technical know-how’ coupled with the ‘ability to communicate’ in a non-technical way, e.g. in the language of a craft worker in an SME rather than that of an academic, are the benchmarks.

The ***'personal' relationship*** of confidence and trust between the craft worker and the consultant in the technology transfer institute is crucial to the success of the process. Thus a benchmark would be 'building a relationship over time' as part of an integrated concept for delivering technology transfer services. If a good relationship, fostered and developed over several perhaps brief contacts is built up, it allows a greater amount of technology transfer services to be offered or required by companies.

Networking, - specially when referring to SMEs - is an important way of transferring innovation and technology and increasing the multiplier effect. This networking ability would also be a benchmark for spreading of innovation and for technology transfer.

Technology transfer institutes fill the gap between Universities and Research Institutes, which are at the cutting edge of innovation and new technologies and SMEs. This so-called ***'bridging effect'*** is important. Technological change is ever faster as well as increased competition. Technology transfer institutes should be clustered to increase this bridging effect.

Innovation happens at two ends: at the science and knowledge creation front and at the adaptation of technology to concrete products and their further development. The knowledge creation at the science and technology front is a crucial factor of competitiveness via the mastery of high technology at the one hand. On the other hand, the important role of tacit knowledge transfer by firms in the process of innovation must be emphasized, as well as its demand for technology transfer. Also, the use of Internet and electronic commerce gains increasing importance.

Accordingly, benchmarking and consequent best practices may be applied for:
- Productivity of research institutions
- Service ability and quality of technology transfer institutes and their dissemination capacity
- Mobility of personnel between technology institutes and industry
- Bridging effects of industrial clusters or organized public organized technology transfer
- Use of Internet and electronic commerce
- University – industry relationships and knowledge acquisition

The benchmarking pilot project "Financing of Innovation"2000, made clear that one of the reasons for the success of the US innovation support system had been consistent investment in research and development (R&D) policies over periods as long as twenty or thirty years.

The success of the national innovation system is expressed in:
- The number of patents filed by industry, universities and public research centers.
- The number of university spin-offs, start-ups, and campus companies.
- The high-tech content of countries exports would be a further indicator.

The transfer of "high tech" knowledge will in future likely come from the top universities where the cutting edge of new technologies is to be found. SMEs, particularly, absorb knowledge from their customers, competitors via the bridging institutions from public and private R&D and through technology transfer fairs, word of mouth, exhibitions etc. The support for SMEs through government policies also needs to take the form of equipping the universities and technology transfer bodies with the latest in 'high tech' industrial equipment.

On the other hand, technology transfer can be between countries, which is probably responsible for one of the most important trends in world economic development over the last century, namely. the convergence of productivity levels of the world's most industrialized countries. It is an unmistakable fact of economic development in the industrialized world that the countries with low productivity levels tend to have higher productivity growth rates, whereas the countries with high productivity levels tend to have lower productivity growth rates.

The process of technology acquisition by developing countries is one of learning and improving their technological capability. This is a complex, long-term, process with various levels of technological competence such as the ability to use the technology, adapt it, stretch it, and eventually to become more independent by developing, designing and selling it. It very much relies on the effort of technology acquirers.

An LDC firm may acquire foreign technology to serve two strategic purposes: to improve direct economic returns and to strengthen its technological competence. Therefore, the effectiveness of International Technology Transfer projects should be measured from these two aspects.

A recipient firm may expect two major economic outcomes from the transfer of foreign technology: to expand production capacity and to improve production efficiency.

A particular reference concerns SMEs, which need a completely different approach than large firms regarding both benchmarking and technology transfer. In accordance with the important role they play in economy, there is a lot of literature dealing with frameworks and special conditions. Technology transfer and innovation for SMEs is crucial for increased competitiveness -in Europe that is stated in many reports of the European Commission. Knowledge transfer and technology transfer to SMEs must be improved. Benchmarking has a contribution to make in improving policy making in these areas of activity particular because the topic of Innovation and Technology transfer for SMEs is broad and complex. There is a wide range of policy actions employed in fostering innovation.

Special frameworks and programs have offered great help in the area of Internet use and electronic commerce. These issues include sourcing goods, expertise and knowledge retrieval - the Internet offers new possibilities for SMEs. There is scope for the use of e-mail and Internet to increase the virtual clustering and networking of SMEs, which are not geographically close to each other. It is to be noted that the range of skills requirements in SMEs is much broader than in a larger firm. Training support policies should provide for this wide range of skill needs.

For SMEs the organization of a technology transfer project often requires the intervention of a third party and, in many countries, public agencies fund or support this bridging function. Successful examples of how this interaction is achieved may be found in Germany.

Good practice is always specific to the market and institutional environment and addresses market failures and barriers stemming from this environment. Learning from good practice means firstly, learning to carefully identify these market failures and barriers and secondly, selecting a proper mechanism to tackle them. As a consequence, good practice on technology transfer should be related to *specific fields of technology* and the way in which knowledge production, knowledge exchange, and innovation takes place in these fields, and to the specific barriers that exist in them.

Given the complexity of the transfer process and regarding benchmarking as vital, already existing institutions — i.e., science parks, business innovation centers, public agencies — should act as an interface between potential donors/recipients and candidate benchmarking partners in order to effective analyze, plan and implement the process itself. These institutions, acting as intermediaries have been called *transfer benchies,* at least for the needs of this thesis and should be able to:

1. Make firms aware of their technological needs and of the existence and potential benefits of new technologies (Gertler, 1996);
2. Monitor the local, national and international technology markets, with the aim of identifying solutions to the technological needs. This task is critical specially for the SMEs, given that SMEs have limited resources available for independent gathering of information (Rothwell, 1994)
3. Monitor the local, national and international technology markets, with the aim of identifying case studies and best practices of technology transfer
4. Guide the communication process between donors/ recipients and paradigm organizations, to facilitate information exchanges, knowledge generation and data collection
5. Facilitate the benchmarking process, providing advice, methods and tools; and
6. Coach firms to minimize difficulties when implementing the adopted technologies.

In the planning phase, the *transfer benchies* can serve as matchmakers, not only matching the capabilities of the source technology with the requirements of the envisioned target technology, but also educating the donor / recipient as to the nature of technology transfer, and helping them develop a formal or informal "contract" with the benchmarkee that spells out the needs and commitments of both sides. In the next phases they can provide technical expertise, and can act as translators between the two cultures, provide process consulting, help smooth out legal problems, find financial support from government and private agencies, and provide general encouragement when, as will inevitably happen, the technology transfer hits some rough spots.

Through benchmarking, the technology transfer process can take place in a satisfactory time schedule, avoiding delays and unpleasant happenings and with important cost savings. Furthermore, costs can be justified in terms of benefits gained. Decision-making is improved and the organization accelerates its pace to innovation, or new product development.

Technology transfer benchmarking provides strategic information and knowledge regarding technology types, channels and mechanisms, potential partners and locations, as well as best practice in every step of the process.

On the other hand, it helps to avoid difficulties and pitfalls, regarding the choice of wrong partnerships and ways of transferring the desired technology, faults that cost additional money and time. The benchmarking methodology, as presented in Chapter III, using the critical success factors regarding partners, choices (e.g. channels) and implementation, discussed in Chapter II, can lead to the choice of the Best - of -the Best, and make any project a success, working on the safe side. The international literature has offered us plenty of examples and case studies of failures in technology transfer, because planning was inadequate and without benchmarks, that could prepare the road to success. Yet, benchmarking was till now an underestimated tool, left to be used only in process improvements.

Technology Transfer Benchmarking can copy with questions about the best ways to allocate resources, the appropriateness of technology to be transferred and the instruments to integrate foreign technology into local technological development. Laws and protection meters, governmental barriers and institutional pitfalls, transfer agencies' misunderstandings can be avoided, when implementing the best in class. Being properly informed and well prepared the technology buyer can strengthen its bargaining power, make excellent negotiations, secure implementation and expect creativity and prosperity.

By integrating technology transfer with the benchmarking process it is hoped that such an approach, in time, may lead to a greater degree of robustness and flexibility in an organization's attempt to embody a new technology, either on the purpose of innovating through an R&D institution, or just to become more competitive.

Benchmarking technology transfer involves understanding where you are now, deciding where the company needs to be and developing a plan for reaching that goal. This plan must include the dimensions of technology transfer success: seeking, evaluating, using and fostering technology transfer.

Of course this new branch of benchmarking has its dark side too. Searching for the best practice in the area of technology transfer needs expertise and monitoring of global transfer processes. This effort costs time and money and there is nothing to assure the benchmarker that eventually will reach the suitable benchmarkee. The ground reason is the existence of interaction between the transferor and the transferee, which, given all other factors excellent and according the B-O-B, cannot guarantee the successful communication and cooperation. This disadvantage calls for further research on key factors and parameters, as well as a better establishment of the methodology steps, to make the benchmarking process more effective and efficient.

When benchmarking technology transfer, there is always the danger to fall into the trap of copying a project that was a success, especially when the actual transfer scopes are similar. One must bear in mind that transferring technology is an interaction among three parts: the donor, the recipient and the technology., so there is a great deal of analysis and thinking has to be one, in order to curve the best way to success.

Another disadvantage is the lack of relative data and databases, which expands the time and the density of the effort required and makes it almost impossible for SMEs. A need for policy frameworks and the creation of relative data is obvious, in order for the method to become a useful and not too expensive tool. Still, there is some doubt about the effectiveness of a database for transfer benchmarking. The risk with databases is that the focus is solely on indices, which in the case of technology transfer is not enough to drive the process in an efficient way. One cannot extract from a database the strategic concepts and the intentions for future exploitation of an acquired technology.

All benchmarking regarding framework conditions should be carried out on a global level to be meaningful. The strong points of different systems under comparison should be captured. For this purpose high quality appropriate key performance indicators should be developed in order to identify best practice countries or cases. Also, best practices on how an outstanding transfer benchmark has been achieved should be made clear in order that implementation of changes and the learning process of practice transfer can be tackled. Because of the complexity and multidimensionality of the transfer process, only if benchmarks are developed and best practice is displayed can the usefulness of a practical oriented approach become apparent.

Benchmarking transfer projects should include the concerned actors in the field from project definition to the interpretation of data. Identification of benchmarks sometimes involves looking at processes as well as measuring indicators, it is there f o re important to maintain an appropriate balance between quantitative and qualitative measurements .

Benchmarking, Technology Transfer and European Union

Technology transfer benchmarking must be looked upon as a tool for improved transfer processes, within a wider scope of customer focused improvement activities.

For a number of years Benchmarking has been an efficient way of improving productivity and competitiveness. However, the High Level Group on Benchmarking (which was established by Commissioner Bangemann to advise the Commission on how to use benchmarking as a tool) concludes that Europe in general lags behind the US in terms of awareness and use of benchmarking in various sectors. However this is not the only sector that USA beats Europe. Technology transfer and company's growth are still behind among the Member States of EU. Although there is a serious lack of statistics in Europe on what proportion of companies are actually growing and on corporate growth rates, most indicators show that both rates a re much higher in the USA. There is perhaps a need for more basic statistics that would allow us to define a number of parameters of importance for the growth of companies, which can then be examined in greater depth at different stages. For the competitiveness of Europe, benchmarking must be applied not only by private enterprises but also by the public sector in order to focus and improve the value-added work. In the US we see benchmarking being promoted in the public sector through initiatives such as "Reinventing the Government". Initiatives with similar aims must be taken in Europe. Special measures to improve the conditions for SMEs are mentioned in several of the pilot projects..

Especially in the case of technology transfer benchmarking, a dynamic competitiveness initiative must be put in place and intensive and informal discussions and presentations must rise awareness. Resources must be committed to this new branch, which is essential if the Commission is to be effective in facilitating and coordinating the start of such processes. The High Level Group, in its final report on benchmarking has identified that technology transfer to SMEs is among the areas critical to competitiveness where it believes that benchmarking could fruitfully be applied. (The other critical ones being:
- human resources and work organization in the information society;
- taxation and public spending (beyond the pure statistics);
- innovation; and
- environmental performance and sustainable development for SMEs.

Simply copying any single factor or supporting policy may be ineffective in producing desired performance. What is important for the application of technology transfer benchmarking is the identification of the critical process steps in each of these factors. Benchmarking requires a consistent set of definitions covering the components of the myriad of factors involved and a common understanding of the scope and range of policy supports.

Therefore, a framework conditions benchmarking project, has to focus on the inputs to the selected process and the outputs from it, to stimulate the development of the process itself. But it must also focus on the effectiveness of the contextual policies The philosophy and practical steps of such a benchmarking activity are roughly similar in the different domains of application. However, enterprises can quickly activate measures to address competitive slippage identified through benchmarking. Indeed, new ways of organizing work and firms are aimed at designing organizations that not only respond to but initiate improvements in key areas benchmarked.

The key strategy at this stage therefore is for theorists to integrate the new branch by developing suitable definitions, techniques and methods with a concurrent preparation of the ground for implementation. This can be achieved by using benchmarking methodologies and models to:
· highlight the relative gaps and the impact on firms
· determine best practice and performance leaders world-wide
· identify the key framework areas impacting on economic and competitive performance
· offer platforms of collaboration to Member States to reflect the transfer and implementation of best practice

The role of European public policy in the promotion of technology transfer and innovation should cultivate suitable environments and cultures in which these two concepts will thrive and remove structural and administrative obstacles that slow or hamper world class performance. However, the Second Community Innovation

Survey (CIS) reveals that the agencies charged with transferring technology to SMEs (i.e. so called bridging institutions) are often not effective.

The problem of innovation and technology transfer is not confined to one Member State; it is relevant to Europe as a whole. Therefore, the strengthening of European networks of technology transfer points applying best practices would be an important outcome of a benchmarking project.

Referring to transfer benchies, they must be close to the customer to break through the barrier between the benchmarking sides as well as the transferor / transferee relationship. Simple organization structure, physical location close to target SMEs, interested in all of SMEs problems holistic service-not cherry picking, long term relationship perspective, and simple payment system for services rendered are some of the characteristics of efficient agents. What's more, there is a need for specialists and not for generalists. So, benchmarking agents must expertise in technology transfer projects and visa versa, transfer agencies in effective benchmarking.

A good example is the organization of "industrial districts" / clusters in Italy, which seems to offer an alternative successful approach to the implementation of this new branch of benchmarking.

A negative example is Greek SMEs, most of which do not know the existence of benchmarking, regard it as another academic theory, or a technique that cannot be used for the Greek standards. That means that there is much more work to be don here, in order to reach European standards at first, educating entrepreneurs in benchmarking and technology transfer separately and then extending to technology transfer benchmarking. Therefore the URENIO action helps this effort and can be used as the connecting link to the diffusion of the new concept.

Greater awareness in a more general aspect, must be established in the ongoing debate on Europe's priorities. At the same time, if Europe is to meet its competitiveness challenge effectively, mechanisms and instruments to support implementation of technology transfer benchmarking policies are essential and must be given particular attention.

Finally, **case studies** on benchmarking and on technology transfer have highlighted the dynamics and the need of the new branch:

- benchmarking has the potential to be more specific and specialized, needs to expand and capture more sensitive areas; while
- technology transfer projects are known for too many problems and obstacles, a conclusion more stressed by the fact that usually there are only the success stories that are published and become known.

Needs and potentials drive undoubtedly to the establishment of technology transfer benchmarking theory, in order for such processes to become success and increase the competitiveness of the firms adopting it.

The dawning of the new millennium has found an increased globalization of economies where organizations are competing more and more in greater numbers of diversified markets, both domestically and internationally. While globalization enhances efficiency by increased competition and more favorable global resource allocation, firms are reliant on their possibilities for entry into new markets. Benchmarking in technology transfer is a new powerful weapon to concur the race to be the best in every organization's activity. The new branch of technology transfer benchmarking needs specialists and not generalists, leading organizations and pilot projects to show its strength and potential.

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APPENDIXES

APPENDIX A

APPENDIX A

BENCHMARKING METHODS, TECHNIQUES AND TOOLS

The main objective of the incentive regulation method is to promote efficiency improvement by rewarding good performance relative to some pre-defined benchmark. As the rewards are based on performance, two key issues are the choice of appropriate benchmarks and techniques used to measure the performance. Regulators have adopted a variety of benchmarking methods and techniques in incentive regulation. According to one classification, actual performance can be measured against benchmarks that are 'linked' (endogenous) or 'un-linked' (exogenous) to the performance or behaviour of individual firms (DTe, 1999). A different classification can be based on whether the benchmarks are derived from the 'best (frontier)' practice or some 'representative (average)' measure of performance.

From a regulatory policy point of view, a major difference between frontier and average benchmarking is that the former has a stronger focus on performance variations between firms. Frontier methods can therefore be used for setting firm-specific efficiency requirements. This approach can be suitable at the initial stages of regulatory reform when a priority objective is to reduce the performance gap among the utilities. Average benchmarking methods may be used to mimic competition among firms with relatively similar costs or when there is lack of sufficient data and comparators for the application of frontier methods.

Frontier benchmarking methods (adapted by Jamasb and Pollitt, 2001)

The frontier-based benchmarking methods identify or estimate the efficient performance frontier from best practice in an industry or a sample of firms. The efficient frontier is the benchmark against which the relative performance of firms is measured. The main frontier benchmarking methods are Data Envelopment Analysis (DEA), Corrected Ordinary Least Square (COLS), and Stochastic Frontier Analysis (SFA). DEA is based on linear programming while COLS and SFA are statistical techniques.

In DEA the efficiency of the firms is computed rather than estimated. DEA identifies the best-practice frontier of the firms, and measures the relative efficiency scores of the less efficient firms in relation to the frontier. An advantage of DEA is that it does not require specification of a production or cost function. DEA allows calculation of allocative and technical efficiencies. The latter can be decomposed into scale, congestion, and pure technical efficiencies (Fa¨re et al., 1985). DEA can be used with Malmquist indices which measure productivity change between two points in time (Coelli et al., 1998). DEA can also examine the effect of specific factors, often referred to as environmental variables, that are beyond the control of the utilities (Yaisawarng and Klein, 1994).

DEA results can be sensitive to model inputs and outputs. A weakness of DEA is that the method utilises a limited amount of available information, namely frontier firms, to derive the efficiency scores. The results are therefore sensitive to measurement errors in the frontier. Further, the number of efficient firms on the frontier tend to increase with the number of inputs and output variables.

In SFA and COLS the efficiency scores are estimated rather than computed. Both techniques require specification of a production or cost function. The UK water and electricity regulators apply COLS to the operating costs of water and electricity distribution utilities. Similar to DEA, the COLS technique assumes all deviations from the efficient frontier are due to inefficiency. Efficiency scores with COLS are, therefore, rather sensitive to the position of the frontier firms.

On the other hand, SFA recognises the possibility of stochastic errors in the measurement of inefficiencies. At the same time, if there are no measurement errors in the sample, the error assumption would result in some inefficiency being regarded as noise. Consequently, due to the error factor, the estimated efficiency scores with SFA are likely to be higher than those measured by COLS.

Efficiency scores can be sensitive to model specification and choice of input, output, and environmental variables. This raises questions as to the robustness and accuracy of calculated *X*-factors based on unstable rankings.

There are also partial approaches to frontier-oriented benchmarking, such as the method used in the study of the electricity distribution utilities Victoria (UMS, 1999). These methods generally assume separability of different cost categories and comparability of firms with different scales. The Norwegian Water and Energy Administration (NVE) uses a Value Chain Model (VCM). The VCM model is used for one-to-one benchmarking benchmarking of the state owned transmission company Statkraft against the Swedish transmission company Svenska Kraftna¨t. The model makes provision for adjustment of data for operational and environmental factors.

Mean and average benchmarking

In contrast to frontier methods, benchmarking in incentive regulation can be in relation to some measure of mean or average performance. One such regressionbased statistical method is the Ordinary Least Square (OLS) method that is closely related to the COLS method discussed in above. OLS estimates an average production function or a cost function of a sample of firms. The actual performance of firms can then be compared to the estimated performance by plugging their input, output, and environmental data into the estimated function.

A simple mean or average of the costs of a group of firms can also serve as the benchmark. In this approach, all the firms in the group may be subject to the same price cap. A version of this approach is used by the National Energy Commission (CNE) in Chile to calculate the value added for the distribution services. The value added for a group of comparable firms is derived from a designed efficient model or reference firm (Rudnick and Donoso, 2000; Rudnick and Raineri, 1997). In Spain, the regulator uses model firms for different geographical areas in order to allocate a portion of the total system revenues among distribution utilities.

Also, in the US performance-based regulation (PBR) may make use of a sliding scale method where there is a dead-band around a target rate of return. In sliding scale method the actual return can vary within the deadband while profits and losses associated with returns outside the band are shared between the utility and customers.
The target return can represent a fair rate of return based on the return earned by comparable industries or firms operating in similar environments. The sliding scale method can therefore be viewed as a form of average benchmarking in which the regulated utility is competing against average performance in the industry or economy .

Another method based on average performance is to use Total Factor Productivity (TFP) as the benchmark. This method, for example, can use the Tornqvist index as a measure of historical productivity growth of the sector or entire economy in setting the efficiency factor X in price cap regulation (ESAA, 1994). The method is relatively easy to implement. However, less efficient firms may find it easier than efficient firms to outperform the TFP and earn large profits.

Finally, targeted incentive schemes can use average or frontier performance benchmarks to address specific aspects of the operation of the firms. These benchmarks may be based on the past or expected performance of the firm or industry.

International benchmarking

The frontier-oriented benchmarking methods require relatively large samples of firms. Therefore, countries with a small number of distribution and transmission utilities can benefit from international comparisons. International benchmarking is perhaps more useful for comparison of transmission utilities as there is more often a lack of domestic comparators. Also, international comparisons are generally advantageous in the case of non-US firms, as these are likely to be behind the frontier. Although a few regulators use international benchmarking methods, and more are likely to follow suit, some theoretical and practical aspects of them are still open to debate.

International benchmarking raises particular difficulties. The most notable issue is that of comparability and quality of data, which may only be improved in time and requires co-operation among the regulators. In addition, when comparing monetary units the correct handling of currency exchange rates is of particular importance. Relative differences in input prices (e.g. wage rates, taxes, and rates of return on capital) beyond the control of the firm may have to be taken into consideration. A problem with frontier methods is that it is not clear whether the frontier provides a valid comparator even in the absence of data errors and shocks. For instance, in DEA models that assume constant returns to scale, a firm may be compared to a part of the frontier defined by firms of radically different scale. To reduce these problems some regulators, such as in the UK, only use national samples for benchmarking. Therefore, in international benchmarking quality of data is of greater importance than in national comparisons. For example, the data used needs to sufficiently represent different types (e.g. urban vs. rural) and sizes of utilities, and to take account of differences in standards and definitions.

In addition, input and output variables for international benchmarking models should reflect possible differences across countries.
The calculation of the likely future rate of movement of the frontier is problematic. Measures of past productivity growth usually include both frontier shift effects and movements towards the frontier. However, the problem is minimised if firms are compared to world best practice as the range of variation in estimates of world best practice frontier shifts (given international benchmarking) is small (1–2% p.a.).

Once efficiency scores are calculated the crucial assumption in deciding the *X*-factors is the rate at which efficiency gaps can be closed. Therefore, national regulators will need to make allowance both for this and for in-country heterogeneity. In international comparisons, firms in some countries will be able to close the gap faster than others.

Balanced scorecard

The balanced scorecard methodology emerged from the study "Measuring Performance in the Organisation of the Future" conducted in the early 1990s and sponsored by the Nolan Norton Institute (the research arm of KPMG). The study was motivated by the belief that existing performance measurements, which tended to rely heavily on financial accounting measures, were rapidly reaching a point of obsolescence. From a year-long study Kaplan and Norton (1992) developed a framework for integration and performance measurement which included incorporated strategic, operational and financial measures. According to Kaplan and Norton (1992):
Managers should not have to choose between financial and operational measures. No single measure can provide a clear performance target or focus attention on the critical areas of business.
Managers want a balanced presentation of both financial and operational measures (Kaplan and Norton, 1992).

The balance scorecard provides answers to four basic questions:
(1) How do we see us? (customer perspective);
(2) What must we excel at? (internal perspective);
(3) Can we continue to improve and create value? (innovative and learning perspective);
(4) How do we look to shareholders? (financial perspective).

From the financial perspective the scorecard helps in systematic scrutiny of key hard financial criteria, which the company must achieve to maintain its standing in the corporate world. The customer perspective aids the process of translating strategic statements to specific measures that really matter to the customer, such as quality and

delivery time. The internal perspectives focus attention on critical internal operations that are needed to satisfy customer requirement and help in identifying and building the necessary competencies for competitive success.
The innovation perspective emphasises the need to look further into the future, thereby helping to break away from a short-term focus.
The scorecard works via a process in which managers for each of the above perspectives set goals, and specific measures for each are stipulated in order to achieve each goal. In this manner high level goals are cascaded downwards into the organisation through a process of tight specification while utilising a consensus approach. The scorecard in this way helps to translate and implement strategy. The strategic linkages enable the scorecard measure to be tied together in a series of cause and effect relationships. The scorecard thus can be used not only to clarify and communicate strategy, but also to manage strategy. The advantages of the scorecard are that in a single report it presents many of the seemingly disparate elements of a company's agenda. It also helps prevent sub-optimisation by forcing managers to consider all operational measures at the same time.

Gap analysis

Implicit within the benchmarking paradigm is the notion of gap analysis, namely the difference between the organisation and a best practice company, or the specific stated aim. Comparisons made within benchmarking are often about understanding the gap. Indeed, many of the tools of benchmarking produce as an outcome a gap analysis. For example, self-assessment, such as that described by the EQA model, leads to the production of trend data of where the company is, where it is moving towards, and whether it is moving in a direction towards attaining its overall stated goals.

Making comparisons against the best or stated aims allows companies to assess the nature of the leap that they have to make in order to catch or surpass work class competitors. Analysis of gaps from base (current performance level) to benchmark (current performance level of the best companies) helps companies to prioritise resource allocation (Balm, 1996). Often the type of gap analysis that is conducted is unidimensional. This form of analysis has the advantage in that it facilitates easy monitoring of trends over time. However, this form of gap analysis often misses out the complex trade-offs that exist within business. In order to do an effective gap analysis, which captures the true level of complexity, it is necessary to simultaneously consider multiple gaps.

A complementary framework to the unidimensional gap analysis technique is the spider-web diagram. The spider-web diagram can show at a glance multiple targets and gaps, and thus captures trade-offs that occur between goals and their achievement in terms of resource allocation. The spider-web diagrams can be used at multiple hierarchical levels to pictorially display the gaps. For instance a gap analysis could done for multiple stakeholders whose interests are measured along different dimensions.

It is obvious from the discussion presented in this section that there is a close inter-linkage between gap analysis and the concept of the balanced scorecard. The data resulting from a Balanced card approach can be fed into a gap analysis spider map. This

type of spider-web gap analysis can be further supplemented by techniques such as force field analysis, which can be used to highlight barriers resulting in the identified gaps. The force field analysis can then be used to initiate the development of plans to overcome the gaps. This creates feedback into the high level strategic planning process of the balanced scorecard, and thereby serves to close the loop of self
improvement.

The importance-control grid

The importance-control grid depicts the degree of alignment between importance and control: the greater the distance of a factor from the diagonal, the larger the degree of imbalance.

By plotting the scores on a grid, the following distinct areas may be identified:

- *core issues*, which managers see as the most important and over which they can exercise the most control; these issues require the greatest management time, effort and planning
- *complex issues*, which are perceived as being important but over which managers can exercise limited control
- *simple issues*, which are of lesser importance and which are easily controlled by management
- *peripheral issues*, which are generally of limited importance and over which little control can be exercised.

The grid provides a useful methodology for identifying such problems, and can be extended to suggest action for improving technology adoption. The terms core, complex, simple and peripheral are labels for easy reference to the quadrants (Hipkin, Buratti, 1994).

What is DEA?

Data envelopment analysis (DEA) is a linear-programming-based methodology that can evaluate multiple inputs and multiple outputs to calculate a ratio (performance measure) of total weighted output to total weighted input; this ratio (generated from actual field data) is the relative efficiency of a decisionmaking unit (Charnes *et al.,* 1978, 1981). A decision-making unit (DMU) can be any economic agent with limited resources, aspiring to attain specified performance goals with as few input expenditures as possible.

DEA has been applied to such assorted activities as:

- airline operations (Chan and Sueyoshi, 1991; Schefczyk, 1993);
- banking (Giokas, 1991; Oral *et al.,* 1992; Al-Faraj *et al.,* 1993; Barr *et al.,* 1993; Sherman and Ladino, 1995);
- brewing (Day *et al.,* 1995);
- the defense-industrial base (Bowlin, 1995);
- education (Beasley, 1995);
- electricity generation (Charnes *et al.,* 1989; Miliotis, 1992);
- health care (Banker *et al.,* 1986; Borden, 1988);
- manufacturing (Ray and Kim, 1995; Shafer and Bradford, 1995);

- non-profit organizations (Charnes *et al.,* 1981; Pina and Torres, 1992);
- pay equity in professional baseball (Howard and Miller, 1993);
- retail organizations (Athanassopoulos, 1995);
- transportation and logistics (Clarke and Gourdin, 1991; Chu and Fielding, 1992); and
- vehicle maintenance (Clarke, 1992).

DEA, is a very useful tool because:
- it deals with individual cases;
- it can produce a single measure for each company;
- it can handle multiple-input and multiple-output situations;
- it places no restriction on the functional form of the input-output relationship;
- it does not require any predetermined weights (or costs) for different types of outputs (or inputs);
- it focuses on revealed best-practice frontiers rather than on central tendency properties of empirical data; and
- it can provide an indication of the levels of improvement needed before an inefficient company could be considered efficient (Charnes *et al.,* 1994; Lewin and Morey, 1981).

Because of these advantages, DEA approach has found widespread applications in both the public and the private sectors (Charnes *et al.,* 1994; Lewin and Morey, 1981). There are two basic DEA orientation models: input reduction, and output augmentation. The former, also known as input-oriented model emphasizes how to use minimum input resources to achieve a given level of output. The latter, known as output-oriented model, focuses on using a given level of input to achieve the maximum possible output.

A primary advantage of DEA is that the procedure calculates a combined index of overall performance using multipliers (weights) that maximize each DMU's efficiency score, relative to other DMUs (firms) in the comparison set. This means that the multipliers can vary from firm to firm, which allows the comparison to account for structural differences among organizations. Structural differences are system-wide features of a firm's production and institutional processes where overall firm performance is influenced by nonlinear interactions among the network's components (Forker, 1997). Structural differences may be due to different organizational goals, varying decision-making competencies among managements, better and worse communication with workers, different levels of employee morale/ motivation/cooperation, diverse degrees of intelligence and learning among a firm's workers, and/or any of a number of other intangible traits that directly influence company processes (Forker, 1997). These aggregate-level differences affect the efficiency with which company-wide programs (such as total quality management) are implemented, and can confound performance evaluation procedures.

DEA, TQM, and benchmarking

Total quality management (TQM) has been recognized as the most effective input for world-class manufacturing and has become an ``order-qualifier'' for prosperity in the marketplace (Stundza, 1990). TQM is defined as ``an integrated system of principles and procedures whose goal is to improve the quality of an organization's goods and services'' (Forker *et al.,* 1997). It is closely associated with benchmarking as a tool for process improvement.

Small and medium-sized firms have been slow to adopt TQM (Ghobadian and Gallear, 1996). Smaller companies frequently lack the resources to develop inhouse TQM programs and to devote the labor hours required for successful implementation. Other firms, by directing TQM implementation efforts toward quality practices with limited impacts on performance rather than those more suited to their organizational structure, waste resources, even though they may attain the goal of zero defects.

DEA provides a method of identifying those suppliers who are achieving fewer defects (the output goal) with fewer input expenditures (e.g. effort, time, money) than their peer suppliers (i.e. others in the same data set). These ``best practice'' suppliers are those on the ``efficient frontier'' where no other supplier can produce a smaller number of defects except by using more of at least one of the inputs (e.g. TQM practices). DEA produces an efficiency score for each supplier, relative to the other suppliers in the database, that demonstrates who the ``best practice'' suppliers are and by how much the less efficient suppliers fall short. This information can be used by purchasing departments to identify which suppliers would benefit most from supplier development and to what degree improvement is possible. The ``best practice'' suppliers and their associated multipliers can be compared against the ``inefficient'' suppliers to formulate corrective strategies (Forker, Mendez, 1999).

Analytic Hierarchy Process Technique

The application of the AHP is based on the following four principles :
1. *Decomposition* – A complex decision problem is decomposed into a hierarchy with each level consisting of a few manageable elements; each element is then further decomposed and so on.
2. *Prioritization* – Involves pairwise comparisons of various elements residing at the same level with respect to an element from the upper level of the hierarchy.
3. *Synthesis* – The priorities are pulled together through the principle of hierarchic composition to provide the overall assessment of the available alternatives.
4. *Sensitivity analysis* – The stability of the outcome is determined by testing the best choice against 'what-if ' type of change in the priorities of the criteria.

The AHP provides a measure called the consistency ratio (CR) to check the onsistency of judgment. Inconsistency is likely to occur when decision-makers make careless errors or exaggerated judgment during the process of pairwise comparisons. A consistency ratio of 0.1 is considered as the acceptable upper limit. If the consistency ratio is greater than 0.1 then the decision-makers have to re-evaluate their judgments in pairwise comparison matrix until the ratio is .nally less than 0.1.

Since service quality cannot be improved without measuring it, is necessary first to establish proper performance standards in relation to customer needs and perceptions.

In order to determine such a benchmark the technique of AHP (Analytic Hierarchical Process) technique, can be usefully utilised. Saaty first introduced the technique in 1980. AHP can be used to synthesise "customer" judgements into an overall performance measure of each organisation. AHP helps not only in identifying major competitors of a company but also can be used to assess the performance of the organisation on each attribute relative to its principal competitors. Moreover in contrast to instruments such as SERVQUAL, AHP permits investigation of the sensitivity of the performance criteria to any changes that may occur in customer judgements. Additionally AHP enhances the managers' ability to make trade-offs between various quantitative (e.g. size, price, service, time) as well as qualitative attributes (e.g. employee courtesy, general cleanliness, atmosphere) (Saaty, 1980).

For the purposes of benchmarking a simple four step methodology may be deployed, developed by Wind and Saaty, (1980) and Zahedi, later (1989).
(1) Break down criteria under consideration into manageable number (5-8) of sub-criteria and attributes. Next structure these criteria and attributes in hierarchical form.
(2) Make a series of pairwise comparison among the sub-criteria according to overall aim being examined.
(3) Estimate relative weights of criteria, sub-criteria and attributes based on customer survey. Determine overall priority scores and ranks of competitors along each criterion dimension.
(4) Aggregate priority scores and synthesise them for measurement of overall performance.

AHP is a decision-aiding tool for dealing with complex, unstructured and multiple-attribute decisions. Since its initial development, AHP has been applied in a wide variety of decision areas, including those related to manufacturing/production systems. A review, as well as suggestions for new applications, is given by Partovi *et al.*

There are three basic steps in using AHP: the description of a complex decision problem as a hierarchy, the prioritization procedure; and calculations of results.
The first step in the application of AHP is disintegrating the unstructured decision into components and then arranging them in a hierarchical order. In a typical hierarchy, the top level reflects the overall objective of the decision problem. The elements affecting the decision are called criteria and they are represented at the intermediate levels. Criteria can be subjective or objective depending on the means in evaluating the contribution of the elements below them in the hierarchy. Furthermore, criteria are mutually exclusive and their priority or importance does not depend on the elements below them in the hierarchy. The lowest level comprises the decision options or alternatives. The number of criteria or alternatives should be reasonably small to allow consistent pairwise comparisons. The hierarchy does not have to be complete, that is, an element at the intermediate level is not required to function as a criterion for all elements in the lowest level. Thus a hierarchy can be divided into subhierarchies sharing only a common topmost element.

Once the hierarchy has been constructed, the decision maker begins the prioritization procedure to determine the relative importance of the elements in each level. Elements in each level are compared pairwise with respect to their importance to an element in the next higher level and, starting at the top of the hierarchy and working down, a number of square matrices called preference matrices are created in the process of comparing elements at a given level. The decision maker can express his preference between every two elements verbally as equally important (or preferred, or likely), moderately more important, strongly more important, very strongly more important, or extremely more important. These descriptive preferences would then be translated into numerical ratings 1,3,5,7, and 9, respectively, with 2,4,6, and 8 as intermediate values for compromises between two successive qualitative judgements. The nominal scale used in AHP enables the decision maker to incorporate experience and knowledge in an intuitive and natural way. This scale is insensitive to small changes in a decision maker's preferences, thereby minimizing the effect of uncertainty in evaluations.

After forming the preference matrices, the process moves to the third step of deriving relative weights for the various elements. The relative weights of the elements of each level with respect to an element in the next higher level are computed as the components of the normalized eigenvector associated with the largest eigenvalue of their comparison matrix. The composite weights of the decision alternatives are then determined by aggregating the weights throughout the hierarchy. This is done by following a path from the top of the hierarchy to each alternative at the lowest level and multiplying the weights along each segment of the path. The outcome of this aggregation is a normalized vector of the overall weights of the options. The reader interested in the mathematical aspects of this procedure is referred to Saaty.

In practice however, the use of the AHP to model and analyse production decisions can be made much easier using personal computer software, such as Expert Choice. This software is very user-friendly and can greatly facilitate the use of AHP in the workplace.

One important advantage of using AHP is that it can measure the degree to which the pairwise comparisons are consistent. This measure, called the consistency ratio (CR), allows managers to detect inadvertent misjudgements in comparisons. Not only does this reduce careless errors, but it can reveal to the manager his or her own unsuspected bias or exaggeration concerning one or more of the comparisons. A consistency ratio of 0.10 (which is the acceptable upper limit for CR) means that, loosely speaking, there is a 10 per cent chance that the elements were compared in a purely random way. If the CR is larger than 0.10, it is recommended that the decision maker should re-evaluate the comparisons, since some of the judgements are contradictory. Expert Choice provides the CR for each preference matrix and the overall CR of the decision hierarchy.

Narasimhan outlines the following benefits of using AHP: it formalizes and makes systematic what is largely a subjective decision process and thereby facilitates "accurate" judgements; as a by-product of the method, management receives information

about the evaluation criteria's implicit weights; and the use of computers makes it possible to conduct sensitivity analysis of the results.
Another advantage of using AHP is that it results in better communication, leading to clearer understanding and consensus among the members of decisionmaking groups, and hence a greater commitment to the chosen alternative.

Graphical techniques for benchmarking partner selection
(adapted by Razmi, Zairi and Jarrar, 2000)

The main benefits of using the proposed graphical techniques is that they allow decision makers to compare the potential benchmarking partners based on individual attributes and finally, provide a comprehensive profile of all the partners' characteristics in an understandable manner. Therefore, practitioners can rapidly understand and absorb the large volume of information.

The following four types of graphical techniques have been developed for use in benchmarking partner selection, and are based on multi-attribute decision-making tools (MacCrimmon, 1968; Canada and Sullivan, 1989).

Alternatives to alternatives scorecard

A scorecard is a matrix in which alternatives (the alternatives can be considered potential partners/candidates) are shown in the first row and attributes are shown in the first column, and the outcomes of each alternative are described by number between 0.00 to 10.0 with respect to each attribute. Then for ease of interpretation of the scorecard, the best alternative for each attribute is highlighted by symbol and/or colour. If the user would like to determine their own organisation's rank amongst those best practices, arbitrarily, they can place the described number for their own organisation in the last row. In this manner, in one glance the best practice performer can be highlighted based on any chosen attribute. Furthermore, the weaknesses and strengths of the organisation can be revealed.

The main disadvantage of this technique is that it does not take the attributes' weight into account. Furthermore, by increasing the number of alternatives and attributes, the complication of the decision increases. Therefore, the use of this technique is to narrow the candidates list in the initial step rather than to obtain the final candidate list.

Shaded circles to portray scorecard-type result

This is a technique similar to the previous one, but offers a more visual presentation of the result. instead of writing the outcomes of each alternative in the matrix in number format and highlighting the best in each row, those outcomes will be presented here by shaded circles. In this case the alternative with more shaded areas is considered the best.

This method offers a more understandable interpretation as it is visually based. Again, this technique also assumes all attributes have the same weight, which is not true in a practical situation, and can be considered as a disadvantage.

Ranking the alternatives

In this technique, candidates are compared in pairs against each different attribute or decision criterion. For each attribute, the organisation must decide which of the two candidates being compared is more advanced. The preferred alternative gets allocated one full score, and in case of a tie, half point is given to each alternative. When all alternatives (candidates) have been compared based on all individual attributes, the results are summarised by a chart . The candidate with the higher rank will be selected as the partner of choice. Although this technique facilitates decision making, it does not include any priority rating for the attributes (i.e. all attributes carry the same weight in this study), and this therefore can be seen as a disadvantage. Moreover, there is no systematic method to control the consistency of the comparison, and it might become subjective during certain instances. Therefore, the use of this technique is recommended only when the number of candidates to be compared is limited. Otherwise, consistency and control can become very difficult.

Polar graphs

The polar graph is designed in a way that the ideal or ``best'' possible outcome of alternatives is assigned to the border of the circle. The rays drawn from the centre of the circle correspond to an evaluation rating on a scale of 0.0 to 10.0 for different attributes (each ray representing an attribute). By connecting each alternative's outcomes to each other, different polygons are created to represent the specific candidate organisation. The candidate that provides a web covering the larger domain is considered to be the best choice.

This powerful visual presentation and the ease of decision making based on it, are considered to be the main advantages of this technique. Moreover, the technique facilitates the understanding of weaknesses and strengthens of each candidate. However, it is not an effective technique when the number of alternatives is more than three or four. Therefore, it is not suitable for use in the initial steps of partner selection when many potential candidates are taken into account. In addition, the polar graph is very practical and effective when an organisation wants to detect the gap between its performance and that of a specific world class manufacturer. However, it still shares the common disadvantage of all other techniques whereby all attributes have the same weight.

Data analysis methods

Three data analysis methods as suggested by Büyüközkan (1996) and Maire and Büyüközkan (1996) are presented below:

- lexical analysis, and two multivariate analysis (factor analysis) methods
- principal components analysis (PCA),
- common factor analysis (CFA).

Lexical analysis. Opinion inquiries often have three steps: designing of a questionnaire, carrying out the questionnaire and data collecting, and data compilation and analyses. The questionnaire, generally in the form of a list, is made up of different types of questions: closed end questions (with one, multiple, organized and scale answers), or, open end questions (numerical and textual). Answers to open end questions take the form of text which makes them more difficult to classify than answers to closed end questions.

Factor analysis. Factor analysis is one of the specific techniques included in multivariate analysis. Factor analysis, including variations such as principal components and common factor analyses, is a statistical approach that can be used to analyze interrelationships among a large number of variables and to explain these variables in terms of their common underlying dimensions (factors). The statistical approach involves finding a way of condensing the information contained in a number of original variables into a smaller set of dimensions (factors) with a minimum loss of information (Bouroche and Saporta, 1980; Hair *et al.,* 1987; Lagarde, 1983).

Benchmarking Maturity Matrix

Successful organizational benchmarking is an evolutional process that begins with a management culture committed to improvement and change. With a focus on results, management and project members must also understand processes, tools, and the role of a focal point (an individual champion or team of champions). Results are important to demonstrate the value of the benchmarking initiative. They usually can be tied to financial measures and related work groups or areas impacted by the benchmarking findings. A process runs the initiative, and knowledge-sharing tools enable the process and hasten knowledge transfer.

The Benchmarking Maturity Matrix is a newly developed model that emonstrates the maturity of 11 key elements developed from five core focus areas: management culture, focal point, processes, tools, and results. Accompanying the model is a simple form that assesses the current state and desired future state (usually defined as two years from now). Element by element, an organization can determine where it exists within the matrix by assessing whether it is:

not utilizing benchmarking,
becoming aware of benchmarking,
building support structures for benchmarking,
getting business results, or
maximizing benchmarking impact.

Formatting the Matrix

The 11 key elements within the matrix are framed around five core focus areas: management culture, focal point, process, knowledge-sharing approach, and results.

The 11 elements are:
Knowledge management/sharing,
Benchmarking,
Focal point,
Benchmarking process,
Improvement enablers,
Capture storage,
Sharing dissemination,
Incentives,
Analysis,
Documentation, and
Financial impact.

For example, Key 1 in the management culture--level knowledge management/sharing--asks the applicant to define his/her organization's orientation toward learning. The applicant selects from the following descriptions of maturity:

Level 1: Internal financial focus, with short-term focus that reacts to problems
Level 2: Sees need for external focus to learn
Level 3: Sets goals for knowledge sharing
Level 4: Learning is a corporate value
Level 5: Knowledge sharing is a corporate value

The descriptions reflect the level of maturity and differ for each key element. The other 10 questions are:

Key 1: Which of the following descriptions best defines your organization's orientation toward learning?
Key 2: Which of the following descriptions best defines your organization's orientation towards improving?
Key 3: How are benchmarking activities and/or inquiries handled within your organization?
Key 4: Which of the following best describes the benchmarking process in your organization?
Key 5: Which of the following best describes the improvement enablers in place in your organization?
Key 6: Which of the following best describes your organization's approach for capturing and storing best practice information?

Key 7: Which of the following best describes your organization's approach for sharing and disseminating best practice information?
Key 8: Which of the following best describes your organization's approach for encouraging the sharing of best practices information?
Key 9: Which of the following best describes the level of analysis done by your organization to identify actionable best practices?
Key 10: How are business impacts that result from benchmarking projects documented within your organization?
Key 11: How would you describe the financial impact resulting from benchmarking projects?

When calculating a score, organizations can decide if participants should be forced into the proposed scoring model of whole numbers or be allowed partial-number scores. Larger organizations may choose to use a segmented scope for assessment by specific projects or at department levels. Ideally, all groups can share their results so that the organization as a whole can aggregate its data to assess the maturity of the enterprisewide benchmarking initiative.

Benefiting From the Matrix

According to Dillon, the tool is important for internal assessment as a diagnostic tool and for comparisons to other companies or internal groups. Essentially, the matrix drives improvement by providing direction. By highlighting performance gaps, it enables organizations to identify strengths and opportunities as well as prioritize improvement efforts. Many organizations have a finite amount of resources to dedicate to such efforts, so it is critical to focus on elements with the greatest opportunity. The assessment exercise allows project teams to recognize the strongest elements and expose an area that is not doing well.

The matrix also standardizes interaction within an organization by improving communication and creating points of reference and processes. "We believe that internally you could use this as a group exercise to calibrate discussions around what is benchmarking, effective use, and how to positively impact actual results," said Dillon. "And just on its own merits, the wording of each level is perhaps an indicator of things to consider as you design your actual improvement plan."

Accessing the Matrix

APQC has recently launched the Benchmarking Maturity Matrix Tool on its Web site at: http://www.apqc.org/best/bmkmatrix/DispSurvey.cfm. Using this tool, organizations can quickly and easily assess their benchmarking initiative at no charge. Participants also have the option to compare their progress to other companies in the database (those whose responses to the assessment tool have been entered) and create maturity tracking charts to take back to their organization. A counter reveals what the average is based on, and data is updated with each completed survey.

APPENDIX B

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DEFINITIONS

Throughout the study, a number of concepts and notions are used which - according to our opinion need to be clarified:

- ***"Science"*** refers to publicly financed higher education institutions (HEIs: universities, polytechnics and colleges) and public sector research establishments (PSREs: public research laboratories, governmental research institutes, academies of sciences and other publicly financed research organisations).
- ***"Industry"*** refers to the business enterprise sector and covers both the manufacturing and service sector.
- ***"Industry-Science Relations"*** **(ISR)** refers to different types of interaction between the industry and science sectors which are directed at the exchange of knowledge and technology. This includes direct and indirect transfer channels such as personnel mobility, graduate mobility, joint research projects, contract research and consulting, licensing, prototypes, spin-offs (start-ups by researchers from science), training for industry researchers, informal contacts (including the use of publications), personal networks, training of students at firms etc.
- ***"Framework conditions for ISR"*** covers all those factors, which affect the behaviour of actors and institutions in industry and science, which are involved in knowledge and technology exchange activities. For analytical reasons we distinguish between two broad types of framework conditions: the *"knowledge production structures"* covers some general features of a national innovation system such as size, industry structure, R&D orientation, sector specialisation, market characteristics, and cultural and social attitudes. *"Policy-related framework conditions"* refer to those factors which are strongly shaped by policy decisions or may directly be designed by policymakers such as legislation, public promotion programmes and initiatives, the institutional setting in public science and the publicly established or supported infrastructure of intermediaries in the field of ISR.
- The term "***institutions***" is used to denote different types of organisations in public science characterised by different institutional settings such as mission, organisational structure, financing, stakeholders etc.
- "***Spin-off***" is a new company that is formed (1) by individuals who were former employees of a parent organization, and (2) with a core technology that is transferred from a parent organization (Rogers and Steffensen, 1999). Spin-offs thus represent the transfer of a technological innovation to a new entrepreneurial company. University spin-offs transfer technology from their parent organization but later they transfer that technology to their customers. University spin-offs should be more active in

technology transfer than corporate spin-offs in order to overcome the early disadvantages of university entrepreneurs for company development. Nevertheless, Smilor (1987) found indications that business parent organizations could assist better than universities in providing benefits to a spin-off company. Besides the transfer and support of more different kinds of knowledge, a business parent organization can support the spin-off firm with physical assets. For example, production machinery is more likely to be found in a private corporation than in a university. Similarly, developed products, marketing channels, customer and supplier contacts and so forth, are more common within a business organisation than in academia. A university spin-off may initially face more difficulties than a corporate spin-off (Perez & Perez, 2002).

- ***"F.D.I."*** : Foreign Direct Investment. According to commonly accepted definitions, any investment worth more than 10% of the total equity of the host organisation counts as direct investment. While FDI normally carries hard technology transfer, while indeed hard technology is often part of the *raison d'être* of FDI, it is possible to envisage FDI without hard technology transfer, and indeed not difficult to find examples of it. Soft technology transfer, by contrast, is a sine qua non of foreign direct investment. To put the point even more strongly, even if an investing company did not want its management technology to be transferred, it would not be able to stop it (Dyker, 2000).

- ***"Licensing"***: Transfer of intangibles or property rights, in order to get the technology to the market faster.

- **"Franchising"** : Licensing of an entire business system as well as offer of property rights. Safe and quick way to own a business under an established trade name. Franchising is most popular in consumer service products and less with more strategic products whose manufacture requires significant capital investment and high level of managerial and technical skills

- ***"Sub-contracting"*****:** Types of agreement ranging from the purchase of components to the complete production of specific products Acquisition of know-how and technical assistance in areas such as plant layout, equipment selection and operation planning, training on quality management systems. Strong dependence upon the foreign partner. It can help develop indigenous capabilities in some major industries such as electronics and automobiles where subcontracting is important. However, transfer of technology can be limited to specific areas of subcontracting agreements. The success of transfer of technology is dependent upon the subcontracting relationship

- ***"turnkey contract":*** the whole implementation process is entrusted to a single foreign supplier who accepts the responsibility to implement the project of technology transfer up to the point where he hands the keys over to the client.

- ***"product in hand":*** contract the responsibility of the supplier is not limited to the equipment installation but also includes the initial management and operation of the equipment and training of the operators (Love and Walker, 1986).

- *"joint - venture"*: agreement in which two independent legal partners establish a third independent legal firm for the pursuit of common interests. Normally the equity arrangement between firms determines their respective roles and the influence of the partners; the flow of knowledge and capabilities is basically unidirectional, while the access to markets is multi - directional. In the newer form of joint ventures, where equity is not associated with control, the partners' relationship is more informal and the social relationship more important.

- ***"cross - licensing":*** Market power rises from sharing knowledge and obtaining strong production as well as marketing positions through shared patent rights. It has been dominated by large corporations, although more and more medium - sized firms in the developed world are now engaging in cross - licensing.

APPENDIX C

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BENCHMARKING, MODELS AND THE APQC

About APQC

The American Productivity & Quality Center (APQC) is a business-oriented non-profit source for performance improvement and decision support —information and knowledge, networking, research, training, and advisory services. Organizations of all sizes and industries—business, government, education, and health care—partner with APQC to discover global best practices and grow into learning organizations.

The code of contact by the APQC

The key elements of this code are as follows:

- keep it legal;
- be willing to give what you get;
- respect confidentiality;
- keep information internal;
- use benchmarking contacts only;
- do not refer without permission;
- be prepared from the start;
- understand expectations;
- act in accord with expectations;
- be honest;
- follow through with commitments.

Together with the expectations, this code formed the basis for the contract between the researchers and the firms. This contract was "psychological", as motives, goals and the locus of control, as well as business arrangements were agreed.

Guidelines of the APQC for benchmarking contacts

Be prepared to respond to at least the following categories of questions:

1. Name and description of requesting company
2. Name and description of the process/technology to be benchmarked
3. Goals and purpose of this particular benchmarking project
4. Reason the target company has been selected for this particular project
5. Current status of the requester's benchmarking project
6. Current status of the requester's internal analysis (e.g. collection of data per the data collection plan)
7. Key performance measures associated with this benchmarking program
8. Desired date frame and/or the project schedule.
9. Suggested formats of information exchange (questionnaire, phone interview, site visits, sharing of process documentation etc).
10. Limits or restrictions on information exchange; suggested terms for confidentiality
11. What are the benefits / outcomes to the targeted company for participating?

Xerox Model

Xerox's success is the first in the history of benchmarking. It has become a real model since, being in a critical situation in 1972, Xerox has achieved what is called today a top-benchmarking partner status. In 1979, Xerox started benchmarking and by 1989, had won the Malcolm Baldrige National Quality Award (Boxwell, 1994). The Xerox benchmarking methodology was a ten-step process (Camp, 1989).

Step I: identify what is to be benchmarked. Xerox's benchmarking process first started in the photocopier manufacturing unit as part of an effort to assess its manufacturing costs. Benchmarking was in effect invented in the late 1970s, when a shocked Xerox decided to analyze the performance of its Japanese associate to discover how Eastern rivals could sell excellent photocopiers for less than it cost the parent to make them.

Step II: identify comparative companies. Xerox first studied one of its Japanese affiliates, Fuji-Xerox, and later on Canon, Minolta and Toyota to determine whether the relative costs of their Japanese counterparts were as low as their relative prices (Finnigan, 1996).

Step III: determine data collection method and collect data. The studies confirmed that US prices were higher than the Japanese ones. Japanese costs became the target for Xerox. However, the benchmarking process was only starting. Managers from the main plant visited Xerox's Japanese affiliates and saw what they were doing at the factory floor. Xerox then started collecting the information.

Step IV: determine current performance gap. The information collected at the previous step is then used to determine the gap that might exist between Xerox's performance and the best in class.

Step V: project future performance levels. From the gap analysis, projected future performance levels are determine and how these levels are going to be achieved and maintained is determined.

Step VI: communicate benchmark findings and gain acceptance. All Xerox employees receive at least the basic 28-hour leadership through quality training Benchmarking and many were trained in advanced quality techniques. Over the last four years, Xerox has invested four million man-hours and $125 million in its training program. Once a new benchmark has been established and incorporated for in future strategy, it is communicated to the rest of the organization so that others may also use it in their standard operating procedures.

Step VII: establish functional goals. Xerox identified that purchased materials accounting for 70 percent of its product unit manufacturing costs, small strides could translate into significant quantifiable benefits. The company cut its supplier base from more than 5,000 in the early 1980s to 420 today. Defective components have been reduced from about 10,000 parts per million in 1980 to 225 today. Six of seven parts inspectors have been reassigned to other jobs, and 95 percent of supplied parts need not be inspected at all. Component lead-time is down from 39 weeks in 1980 to eight weeks last year. And the cost of purchased parts has been slashed by 45 percent. These goals were not necessarily all set at once but with the continuous process put in place for lowering costs they came more easily and without disruption.

Step VIII: develop action plans. Concrete action plans need to be developed and Xerox developed these plans, resulting in the reduction in lead times and the quality improvement of the copiers.

Step IX: implement specific actions and monitor results. Benchmarking has to be a coordinated plan. Specific action plans have to be drawn up and the results monitored to ensure that the required results are being achieved.

Step X: recalibrate benchmarks. After having benchmarked Japanese industries, Xerox didn't stop there, it started looking at L.L Bean, the American Hospital Supply and Caterpillar. The results speak for themselves as Xerox is the only company in the world to have won all three major awards: Japan's Deming Prize, America's Malcolm Baldrige National Quality Award and the European Quality Award. Obviously, adopting the benchmarking process was essential (Finnigan, 1996).

Kodak Model

The legal department may be more prestigious and the advertising department may be sexier, but the maintenance department is one of the unsung heroes of a manufacturing company. Neglect maintenance of the myriad pieces of equipment in a factory and someday soon the company will be devoting more time to the emergency repair of machinery than to the production of goods (Geber, 1994).

Kodak uses a six-step benchmarking process. The following is a description of benchmarking at Kodak's Rochester plant.

Step I: what to benchmark. There is no guessing about the impact of a poorly performing maintenance department on a company's fortunes. If a machine breaks down in the middle of a run, it is easy enough to measure how many widgets its operator would have produced during the idle time. That ability to measure most aspects of maintenance performance, along with a desire to lessen the maintenance department's drag on earnings, led themaintenance function at Rochester, NY-based Eastman Kodak Company to begin a benchmarking project in 1991.

As a large company with worldwide locations, Kodak had the luxury of measuring all its maintenance divisions against each other internally as it tried to find the exemplars for each of a long list of measurements. It then compared the various results to those of other companies with superior maintenance departments. As a result, Eastman Kodak was able to increase its planned maintenance work, reduce its inventory of parts for maintenance, and reduce the amount of time it spent on emergency repairs. Each one of those outcomes had an effect on the company's earnings.

Step II: establish teams. In 1990, the company's quality improvement director formalized ad hoc approaches to benchmarking by establishing the threeperson office under Mr Enustun. Besides acting as a port of entry for incoming benchmarking requests from other companies, Mr Enustun's office maintained a detailed internal database that described and quantified best practices within Kodak worldwide. In addition, he and his staff served as consultants for benchmarking projects undertaken throughout the company. In that role, they helped Harvey Berson get his project started in January 1992.
Berson, manager of Kodak's manufacturing engineering and maintenance organization, oversaw maintenance of the equipment the company used for film production in nine manufacturing plants scattered across the globe. Berson wanted to find the pockets of excellence around the world and bring the rest of the maintenance departments up to those standards, thereby reducing overall maintenance costs for the company.

Step III: identify partners and identify critical measures. Berson knew that some maintenance facilities within Kodak were doing much better on certain measures than Kodak-Park, the company's huge hometown facility in Rochester. He was determined to improve Kodak-Park's performance, while seeking top performers elsewhere within the company. Luckily for the benchmarking project, the maintenance function was easily tracked and measured. One of the first tasks for Berson and the other four members of the initial bench marking team was to identify which of those many measures were crucial to the business.
At about the same time as Kodak-Park was launching the internal benchmarking project, it was beginning to look outside its walls as well. It found willing benchmarking partners within two professional maintenance organizations. One, the Plant Engineering Maintenance Managers Conference (PEMMC), consisted of a group of maintenance managers at eight large companies who formed a once-a-year networking group.

Step IV: collect data. Collecting the information in the first rounds from all Kodak's maintenance operations worldwide was not an idle data-gathering exercise, Berson says. The company used a questionnaire to make sure that data were being assembled in a uniform manner, a necessity if the numbers were to have any validity. If a number seemed particularly high or low, a facility manager would be asked to check again. ``Consistency has to be one of the under-pinning's of a measurement system", Berson says. Once the data had been gathered from within Kodak, they was given to a second team, this one made up of the 36 Kodak managers responsible for maintenance functions. It was crucial to get them involved in analyzing the information since they were the ones who had to create individualized improvement plans based on the numbers. ``The whole point behind benchmarking is understanding where to make the improvement", Berson says. ``The number is only the trigger" (Geber, 1994).

Step V: gap analysis. Once Berson and the team had collected all the numbers,both internally and externally, they grouped the data into a number of charts that showed how Kodak-Park stacked up against its benchmarking partners. In some cases, the verdict was good, in other cases not so good. For instance, the data confirmed what Berson suspected, and what had prompted the study in the first place: Kodak-Park did too much reactive, or emergency, maintenance work. Its reactive work amounted to about 34 percent of the total time spent. That figure made Kodak-Park roughly equal to the rest of the company, better than the PEMMC average, but significantly behind the SMRP companies, which together spent an average of about 19 percent of their time doing reactive work. On the other hand, Kodak-Park had some of the lowest maintenance costs, as measured by the category of maintenance cost as a percentage of the cost of the product.

Step VI: feedback and review. One way to use the information to improve, Berson says, was to involve the maintenance managers' customers: the manufacturing heads. Consequently, the benchmarking group devised another survey, this one a 32-question instrument based on the 12 measures Kodak wanted to hack. Each maintenancemanager and themanufacturingmanager he served was asked to rate the performance of the maintenance department. Afterward, the two managers would sit down to figure out how to improve the maintenance department's performance. Aftermeasuring howit stacked up, and beginning to implement some of the things it learned from high-performing partners, the Kodak-Park maintenance unit increased the amount of preventivework by 6 percent in one year. It made great strides in increasing inventory turnover, saving more than $3 million in the process. Kodak-Park reports that it is on track for more improvement on turnover that would save an additional $5.5 million by the end of 1994.

Appendix: world-class operations factors emphasized by selected author (Kasul, Motwani, 1995)

Category	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Management commitment																		
Control through																		
Visibility			×	×	×	×	×	×					×	×	×	×	×	
Resource allocation			×	×	×	×	×	×					×			×	×	
Planning for change	×		×	×	×	×				×			×		×	×	×	
Monitoring progress	×		×	×	×	×	×	×		×			×	×	×	×	×	
Quality																		
Quality policies and plan						×	×	×		×			×	×		×		×
Use SPC for process control	×			×	×	×	×	×					×	×		×		
Supplier quality	×					×	×	×										
Cost of quality						×	×	×		×				×				
Quality training			×			×				×			×			×		
Product reliability		×		×	×	×						×						
Product functionality		×		×	×							×						
Conformance quality	×	×	×	×	×	×	×	×		×		×	×	×		×		×
Customer satisfaction																		
Reliable delivery time	×	×	×	×		×		×		×	×	×		×	×			
Prompt handling of complaints		×	×	×		×	×	×		×	×	×		×				×
Broad product lines		×		×														
Expand customer relationships		×		×		×					×	×						×
Rapidly confirm delivery dates		×		×		×	×				×			×	×			×
Broad distribution channels		×		×													×	×
Enhanced maintenance services		×		×				×										
Operations flexibility																		
Rapidly change production volumes		×			×		×					×		×				
Rapidly change product mix							×	×				×		×				
Rapid introduction of new products	×	×		×	×	×	×	×	×	×		×		×	×		×	×
Rapid method process changes		×		×			×	×	×			×		×			×	×
Reduce manufacturing lead time	×	×	×	×	×	×	×	×	×	×		×			×			×
Reduction of lot sizes	×		×		×	×	×	×						×		×		×
Flexibility/agility of workforce		×		×	×	×	×	×	×	×			×	×		×		
Delivery speed	×	×		×	×	×	×	×				×			×			
Innovation and technology																		
State-of-the-art manufacturing processes	×	×		×			×	×	×		×	×						
Innovative products		×		×			×	×	×			×						
Products high in R&D content		×					×		×			×						
Low set-up times	×		×		×	×	×	×		×				×		×		
Low/reduced cycle times	×		×	×	×	×	×	×			×	×		×	×	×	×	×
Facility control																		
Cell plant layouts					×	×	×	×		×	×	×		×		×		
Preventive/productive maintenance		×			×	×					×			×		×		×
Housekeeping						×										×		
Space optimization	×				×	×	×	×				×				×		×
Eliminating waste	×		×		×	×		×				×	×			×	×	×
Vendor management																		
Inventory turnover				×		×	×	×	×	×		×		×	×	×		

Inventory accuracy					×	×		×		×								

(Continued)

Appendix: world-class operations factors emphasized by selected author

Category	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Inventory reduction				×		×	×	×										
Inventory cost				×	×			×				×						
Supplier relations	×		×			×	×	×		×			×	×		×		×
Supplier development programme	×		×			×	×		×	×				×		×		×
Price/cost leadership																		
Lower unit manufacturing cost	×	×	×	×	×	×	×		×			×					×	
Competitive pricing		×					×							×			×	
Higher valued/quality products	×	×	×	×		×		×	×									
Labour utilization	×				×					×		×	×					
Labour efficiency	×	×			×	×			×			×						
Direct labour								×	×			×						
Overhead												×	×					
Materials cost									×	×								
Global competitiveness																		
Ability to manufacture off-shore		×																
Ability to assemble off-shore		×																
Offshore sourcing		×																
Offshore product R&D		×																
Strong offshore sales capabilities		×																
Strong relationships with foreign government		×																

Selected authors are as follows:

1 Azzone, *et al.*
2 Deloitte & Touche
3 Evans
4 Geber
5 Heizer
6 Kasul and Motwani
7 Kumar and Motwani
8 Maskell
9 Musselwhite
10 Reed
11 Rhodes
12 Richardson and Gordon
13 Ross
14 Sheridan
15 Stalk
16 Stickler
17 Stonich
18 Weimer *et al.*

What is Best Practice? (adopted by Seen, Beaumont, 2001)

Relatively few writers have defined Best Practice (BP), perhaps because the term's meaning is ostensibly obvious. Almost all writers define BP in terms of components (summarised in Table I). A more fundamental examination of BP entails examining its definition, its implementation and criteria for assessing BP programs. The following discussion draws especially on Fitz-enz (1993). Fitz-enz notes that BP is not unique, and that different practices can work well in different contexts, cultures and organisations (Thompson, 1967). There are many kinds of work; manual work is usually easier to measure than intellectual work or work involving people. Creating quality software is a difficult and demanding process.

Amongst the difficulties are: communications amongst users and project team members; a chronic shortage of resources; estimation and scheduling and the intrinsic difficulties of programming, testing and implementation. There is a tendency, especially in popular literature, to ignore stake-holding issues and to assume that the interests of the firm and workers are at least similar; Wright and Lund (1996) provide an interesting counter-example.

Most writers stress tangible measures but intangible measures may be very important (the development of pervasive quality programs or long-term relationships with customers may be valuable long-term investments). Financial measures of performance may be distorted by inappropriate transfer prices or the way overheads or depreciation are distributed amongst time periods or departments. Assessment of a unit's performance may be affected by external and transitory factors (about half the ``excellent'' companies identified in Waterman and Peters (1982) have since suffered major reversals) or simply luck.

These problems create methodological difficulties: some astonishing ``proofs'' of BP are based on small samples (Fitz-enz, 1993). An improvement in results following the implementation of BP does not prove that the latter caused the former. A firm may be consistently successful, not because it uses BP, but because it has intrinsic advantages such as economies of scale, some kind of monopoly power or effective management. A typical definition of BP is: Best Practice is the co-operative way in which firms and their employees undertake business activities in all key processes: leadership, planning, customers, suppliers, community relations, production and supply of products and services, and the use of benchmarking. These practices, when effectively linked together, can be expected to lead to sustainable world-class outcomes in quality and customer service, flexibility, timeliness, innovation, cost and competitiveness (Australian Manufacturing Council, 1994).

There can be no universally agreed operational definition of BP; every organization will operationalize BP to suit its own circumstances and preconceptions. Defining BP simply as a list of components is unsatisfying, but the elements can be classified in various ways: e.g. as primarily internal and external (relations with customers and suppliers); as direct and indirect (training) or as pertaining to people or processes. We opine that BP is best treated as a mechanism for expressing and implementing a strategy. Motivated by the strategic context, we identify three aspects of BP:

(1) *Operational Best Practice*: optimises production of goods and services.

(2) *Internal Best Practice*: optimises structure, staffing, systems and culture so that strategy is optimally expressed. If, for example, rapid fulfilment is emphasised, customers will be able to order goods and services through web pages, these orders will be made available to factory schedulers instantly, and there will be sophisticated scheduling and order tracking systems and flexible production systems.

(3) *External Best Practice*: optimises relations with and from external parties, especially customers and suppliers but also with legislators, regulators, communities and labour; obtains required resources (e.g. raw materials and labour) on the best possible terms and conditions; and sells finished goods on the best possible terms and conditions.

The development of a best practice business process improvement methodology
(adapted by Barry Povey, 1998)

A representative selection of BPI methodologies from the relevant literature are compared in Table I. The methodologies included in this comparison are:

(1) The O&M approach (Webster, 1973). Selected because it can be considered as a "baseline" of how process improvement was conducted originally.

(2) The soft systems methodology (SSM) (Checkland, 1981). Selected because it recognised that "hard" approaches are not always appropriate and that considering the problem in the context of a human activity system can yield better results.

(3) A generic model developed by Elzinga *et al.* (1995). This is based on two national surveys on BPM practices in the USA that found that the 72 *Fortune* 500 companies that responded all shared some common process improvement practices.

(4) The international benchmarking clearinghouse benchmarking methodology (Zairi and Leonard, 1994). This benchmarking methodology was identified by Zairi as the best of several that he analysed.

(5) POPI – the process of process improvement (Abbott, 1991). An improvement methodology from IBM that typifies the "hard" approaches used in manufacturing.

(6) Davenport and Short (1990). Davenport, along with Hammer and Champy, is one of the key driving forces behind BPR, and this methodology is representative of the BPR approach.

(7) Kaplan and Murdock (1991). This approach to core process redesign represents a business school view of the subject and is included to provide a comparison between theory and practice.

(8) IBM (1992). This approach to BPI was introduced into the marketing and services units of IBM and was designed to be more appropriate in those areas than the "hard" approaches from manufacturing.

(9) Hardaker and Ward (1987). Perhaps not a full BPI methodology, but this approach was included because it demonstrated an approach for linking process improvement to what is strategically important to an organisation.
(10) TQMI (1994). Selected because the methodology originates from a wellregarded organisation in this field and has been strongly influenced by Deming's work.

	Organisation and methods (Webster, 1973)	Soft systems methodology (Macdonald, 1985)	Generic model (Elzinga *et al.*, 1995)	Benchmarking (Zairi and Leonard, 1994)	Process of process improvement (Abbott, 1991)	Business process re-engineering (Davenport and Short, 1990)	Core process redesign management (Kaplan and Murdock, 1991)	IBM (1992)	Process quality (Hardaker and Ward, 1987)	TQMI (1994)
1	Determine the purpose and scope of the study	Real world unstructured problems	Prepare for BPM	Select process	Initialise process improvement identify the business processes and establish process owners	Develop business vision and process objectives	Identify core processes, focusing on major strategic directions and customer needs	Get organised	Develop mission statement	Process selection
2	Obtain facts relating to the existing situation	Real world structured problem into issues	Process selection	Select leader and team	Analyse customer expectations	Identify processes to be redesigned	Define customer and financial performance requirements. Identify the gaps between current and required performance	Talk to your customers	Develop CSFs	Preparation for improvement
3	Study the data and form conclusions	Develop root definition	Process description	Identify customer expectations	Analyse process flow	Understand and measure existing processes	Pinpoint problems. Map process and information flows. Do root cause analysis and prioritise problems	Walk the process	Identify key processes	Process analysis and redesign
4	Formulate proposals	Develop conceptual model (ideal world)	Process quantification	Analyse process flow and measures	Measurement for process effectiveness	Identify IT levers	Develop a vision. Identify options. Set stretch goals. Evaluate alternatives and develop action plans	Set priorities	Rank processes by importance	Implementation and improvement

(Continued)

Organisation and methods ([illegible])	Soft systems methodology (Checkland [illegible])	Generic model ([illegible])	Benchmarking ([illegible])	Proposed process improvement ([illegible])	Business process re-engineering (Davenport and Short [illegible])	Core process redesign management ([illegible])	[illegible]	Process quality ([illegible])	[illegible]
5 Obtain approvals	Compare real world models with what is and to be	Process improvement selection	Collect internal data	Measurement for process efficiency	Design and build a prototype of the process	Make it happen. Roll out the change. Success requires strong leadership, cross functional teams, cross functional teams, single accountability	Benchmark your process	Rate process performance	
6 Implement proposals	Identify feasible desirable changes	Implementation	Perform a secondary research	Improve process effectiveness			Develop solutions	Compare importance and performance	
7	Action to improve the problem situation	Continuous improvement cycle	Identify partners and develop surveys, visit	Improve process efficiency			Get buy-in	Select processes for improvement	
8		Benchmarking	Compare data, identify performance gaps and root causes	Improve process flow			Finalise your improvement plan		
9			Set goals	Measure supplier performance			Pilot your solution		
10			Develop action plans, gain support	Ensure supplier improvements			Roll out your solution		
11			Communicate plan						