## Chapter 5 – Technology Exploitation

**TM Activity – Exploitation:** Introduction, Definition, Commercialization/marketing, Marketing processes, Technology transfer, Technology utilization, Utilization processes, Case study. [TB 1:Ch. 5 )

## Contents

## Introduction

The process of exploitation is concerned with generating profit or achieving other benefits from technology. Exploitation can be defined as the utilization of new technology or scientific developments to improve the performance of products, services or manufacturing processes.

Exploitation of technological capability is more than just commercialization, since the expected benefits might be accrued through effective and efficient implementation, absorption and operation of the technology. If there is not a fully working product/process/service at hand, there will be no commercialization activity. So the exploitation activity includes three sets of sub-processes: commercialization/marketing, technology transfer and utilization.

The commercialization process is the launch of a product/service into the market based on a selected business model. Technology transfer consists of processes related to transferring technologies internally from an R&D unit to a manufacturing department, from an external company/partner to the internal manufacturing department or from an internal R&D unit to a partner company's manufacturing department. Utilization aims to put new technologies into use in such a way that they will be fully utilized. Utilization refers not only to adjusting/customizing/improving but also to maintaining and integrating technologies for synergy. The utilization process is intertwined with technology transfer activities, because each implementation or launch involves reconfigurations that will demand alignments between technology and its actual application.

## Commercialization/marketing

### Definition

Commercialization is the process of introducing a new product or service into the market. the definition of innovation clearly indicates that the commercialization process turns an invention into an innovation, a sellable product or service in the marketplace. Many companies are good at producing inventions but not all their inventions are put into use. For example, the case of P&G discussed in Chapter 2 shows that the company uses less than 10% of its own technologies in company products (Sakkab, 2002). So the technology acquisition capability is a good start but not enough to turn inventions into profits.

The first task is to decide on the commercialization method; to a large degree, this is made at the strategy level.

Technology exploitation can take one of three possible routes:

1. In-house development: the production and distribution of technology are carried out within the company.

2. Joint commercialization: production and distribution are carried out in collaboration with other organizations through joint ventures or other forms of alliance.
3. Selling technology: can take place at any stage of technology development, including idea, prototype, patent and licence sales.

Making an analogy to the make-buy-collaborate decision, the exploitation activity is involved with a make-sell-collaborate decision. Exploitation options refer to selecting a different business model for the commercialization of technologies. In other words, exploitation requires strategic thinking.

A company chooses its exploitation method/business model on the basis of its strategy and core competencies. Accordingly, its core technologies must be produced in-house but technologies that do not fit into the company's overall strategy might be sold. For example, the internal commercialization or make decision takes place when a company's relative standing is at all levels - technology is bask, urgency is the lowest, the need for supporting technology is lowest, commitment is highest, technology life cycle is earliest and potential application is narrowest.

Besides the criteria presented above, another set of popular criteria are complementary assets, dominant design and appropriability regime (Teece, 1986, 2006). A successful innovation consists not only of technical knowledge but also other capabilities and activities such as marketing, competitive manufacturing and after-sales support, referred to as 'complementary assets. Dominant design is an agreement on the basic features of a product or service, showing standardization. Appropriability regime refers to the regulatory system for intellectual assets that makes protection possible.

Commercialization is directly related to earning revenue from sales, derived from a set of processes, particularly marketing, since successfully introducing a new product or service into the market requires advertising, distribution and selling of a product or service. The company's exploitation task involves selling the products that are based on technologies developed in-house or acquired externally. This is why the marketing of technological products and services is highly critical. This chapter focuses on marketing in the context of understanding the commercialization process as a whole.

Marketing theory and practice are justified in the belief that customers use a product or service because they have a need or it provides a perceived benefit (Kotler and Keller, 2006). Thus, marketing is concerned with anticipating customers' future needs and wants, often through market research and creative imagination. Two major factors of marketing are the recruitment of new customers and the retention and expansion of relationships with existing customers. Once a marketer has converted the prospective buyer, base management marketing takes over. The process for base management shifts the marketer to building a relationship, nurturing the links, enhancing the benefits that interested the buyer in the first place and continuously improving the product/service to protect the business from competition.

For a marketing plan to be successful, the mix of the four Ps (product, price, promotion and place) should reflect the wants and desires of consumers in the target market (Dibb et al., 2001). Marketers depend on market research, formal and informal, to determine their markets, competitors, customers wants and needs. Market research aims to supply information to what, where, when, how and why questions about a company's business. Marketers use different methods to acquire data. Appropriate techniques used to capture the voice of the customer will depend on the nature of the customer relationship, as shown in Table 1. Direct tools in forming relationships with customers include customer meetings, while indirect methods range from surveys to focus groups.

Besides data on customers, the marketing department needs to gather data on competitors and the market/business environment such as regulations. There are different techniques used to identify markets. For example, 'Porter's diamond' (an analysis of firm strategy, factor conditions, demand conditions and related supporting industries) is a typical tool used to make a complete economic and commercial analysis for marketing that will help to segment the market and develop the marketing plan (Porter, 1985).

Table 1 Methods of direct and indirect relationships with customers

| Direct relationship | Indirect relationship |
|---|---|
| Direct relationship could be development through methods such as:<br>• Requirements specification<br>• Contract or order<br>• Customer meetings<br>• Warranty and repair data<br>• Customer representative | Distributors and retailers interface with customers and try to capture requirements by applying methods such as:<br>• Surveys<br>• Focus groups<br>• Market research<br>• Interviews<br>• Customer service feedback |

Marketing focuses on basic concepts like the four Ps as well as on the psychological and sociological aspects of marketing. Competitive advantage is created by directly appealing. better than the competition, to the needs, wants and behaviours of customers. Successful marketing involves creating brands and building relationships (such as one-to-one marketing and customer relations management) and offering business models that other companies cannot offer.

Marketing technology is distinct from any other product or service marketing (Navens et al_, 1990; Easingwood and Koustelos, 2000). The distinctive characteristic of technology is its innovativeness. The history of technological advancements shows that the time-lag from invention to innovation is very high; for example it took 58 years for the ballpoint pen to become a sellable product after it was invented in 1888. But once the innovation is diffused, it might prevail for a long time. A famous example is the use of the QWFRTY keyboard, invented in 1873 to reduce the speed of typists but which has persisted ever since (Rogers, 1995).

There might be many reasons why the time-lag exists between invention and innovation: non-existent complementary technologies, existence of low-cost alternatives, standards and government regulations (Shapiro and Varian, 1999). In the 20th century. the choice between gas, electric and steam technologies for automobile engines was not driven by technical criteria. Instead, assessment was based on different dimensions such as cost, safety, range, noise and power (David. 1990).

The diffusion process is related to five main elements (Rogers, 1995):

1. The characteristics of an innovation that may influence its adoption.
2. The decision-making process that occurs when individuals consider adopting a new idea, product or practice.
3. The characteristics of individuals that make them likely to adopt an innovation.
4. The consequences for individuals and society of adopting an innovation.
5. The communication channels used in the adoption process.

## Marketing processes

Among the elements of the diffusion of innovation, the adopter categories have a specific importance for marketing activities. Their role in marketing is discussed on the basis of four major marketing processes (Easingwood and Koustelos, 2000; Jobber, 2001):

1. Market preparation.
2. Targeting.
3. Positioning.
4. Execution.

These are now discussed in more detail.

## Market preparation

Preparing the market refers to readying customers and other companies for the change by educating the market on a product or service. This stage might take place while the product is still in development. In the case of technology marketing, getting the market ready involves building awareness of the new technology as well as forming relationships with customers and suppliers. As technology products are complex and expensive, educating customers beforehand may improve the perception of the product. A good example is the reaction to biotechnology-based foods in Europe, where producers have neglected to educate the public.

For many technology products, standards play a role in influencing the commitment of customers. Hence, alliances and licensing arrangements with other companies and even with competitors might help the adoption of technological standards. For example, Nokia, Sony and NTT DoCoMo formed a consortium called Symbian to develop an open source operating system for mobile devices (Easingwood and Koustelos, 2000). Another possible alliance mechanism is to share the new technology with original equipment manufacturers (OEMs) so that they get used to the technology and contribute to the development and promotion of standards, becoming partners. Besides setting standards, alliances might also help to supply the complementary technologies needed for the success of an innovation. For example, the success of IBM's personal computer compared to Apple in the 1980s was due to a wide variety of software offerings from suppliers that IBM outsourced. Software was a critical complementary technology for the success of the hardware.

### Targeting

Targeting refers to finding the right customers and learning their characteristics in order to decide on the marketing features to direct to the varying customer segments, for which it is important to understand adopter types. The innovation adoption curve is a model that classifies innovation adopters into various categories, based on the idea that certain distinguish the firm from its competitors. The typical strategies for positioning are low cost, niche and product differentiation. But for technology marketing, a blue-ocean strategy is an option, aiming to develop a new market space that makes the competition irrelevant (Kim and Mauborgne, 2005). Many new products, such as mobile phones, created a completely new industry.

In the case of technology, customers need to feel secure that their move to a new technology is low risk. This is possible by offering a product that is standard or going to be standard. Another way of making the customer feel secure about technology is using technological superiority as the key distinguishing element/value proposition for customers (Kotler and Keller, 2006).

### Positioning

Technology marketing builds its positioning according to the adopter type. While innovators might be interested in technological superiority, the early-majority type is likely to be motivated by a well-functioning, low-cost version of the new technology. In fact, the main difficulty in marketing technology happens in the interval of going from early adopters to the early majority. This is often termed 'crossing the chasm, since the early adopter and majority types have completely different concerns and new technology firms can struggle to satisfy their concerns with their limited resources (Moore, 1991). This is why crossing the chasm requires a clear-cut positioning strategy based on developing a completely working product/application rather than diversification. Once the product/ application works, marketing to the early majority type is a matter of:

- Attending industry conferences and trade shows.
- Frequent mentions in industry magazines.
- Being installed in other companies in the same industry.
- Developing industry-specific applications.
- Alliances with other key suppliers to the industry.

### Execution

The way across the chasm is to target the company's resources to one or two specific niche markets where it can dominate rapidly and force out competitors. It can then use the dominance of the first niche to attack the surrounding niches and eventually reach the broader early majority group (Easingwood and Koustelos, 2000). This progressive approach will ultimately build a winning image and develop the trust of customers in the company. Customer trust and company image reduce the risk of adoption, but technology firms need to do more than that. There is a risk associated with learning new technology and there may be substantial assets committed to old/different technology. For example, changing a computer hardware platform may require changes in software and peripherals. Another dimension of risk of adoption in the eyes of customers is network externalities. Customers build relationships around their technologies, such as trusted suppliers and service providers. Network externality is built over time and might become binding. To reduce the risk of adoption, technology companies might consider offering a trial version, training customers in using the new technology and making the application as compatible as possible. Thus technology producers need to focus on strategic alliances as a critical marketing tool.

## Technology transfer

### Definition

Technology transfer is the process by which the technology, knowledge and information developed by a creator is applied and utilized by an applier (Khalil, 2000). Creators might be an individual, an R&D department within a company, another commercial developer company, a partner company doing collaborative R&D, a non-profit organization or a government agency. The applier might be a manufacturing department of the company where technology is developed internally or cooperatively, it might be a commercial company, a competitor or the government. If either the creator or applier is from a different country, technology transfer takes place at the international level. As Steele (1989) highlights:

[The] term technology transfer is a misnomer because it implies that something is moved, more or less untouched, from one place or one organization to another.

The process is more complicated than that because the technology itself is changed as a part of its movement from one organization to another. This is because technology incorporates not only equipment but also know-how and skills, which in turn necessitates the transfer of tacit knowledge. Moreover, technology transfer becomes complicated due to the feelings and attitudes required in both organizations/units in order for two sets of people with different skills, values and priorities to become successful in passing the capability from one to the other.

The transfer of technology from creator to applier is frequently the point at which the system breaks down (Williams and Gibson, 1990). It therefore needs to be managed well. The following factors affect the success of technology transfer (Burgelman et al.. 2004):

- High level of technical understanding where transfer is done.
- Feasibility findings of the technology are high.
- Advanced development activities overlap with the new technology.

- Growth potential of the application is high.
- The existence of an advocate of the transferred technology.
- The existence of advanced technology activities in a development laboratory to complement the transferred technology.
- External pressures from competitors and markets enforcing quick adoption.
- Joint programmes between technology developer and technology buyer.

Technology transfer has been one of the most important technology policy issues for developing countries importing their technologies. In recent years, it has become a popular policy item for developed countries. Considering that the majority of research in many countries is performed by state-owned research units and non-profit organizations such as universities, transferring knowledge from these organizations might benefit the economy in a larger context. Research institutions and experts in developing technologies but they do not apply them in production, so governments have put a high priority on the transfer of knowledge generated in research organizations to firms that will utilize it and create economic value. This is why the technology transfer activity has become an important dimension of industrial and technological policies in many countries. In practice, governments have set up many institutions to initiate and support technology transfer between research organizations and companies. For example, the USA has developed national technology transfer centers across the country that have special budgets to help SMEs to access technologies developed in government research organizations and universities. Similarly, technologies developed in government research organizations and universities. Similarly, the European Technology Transfer Initiative has developed special technology transfer programmes operating at the European level, including innovation relay centers, technology transfer funds, the European Centre for Innovation and Spin-Offs and the European Technology Transfer Network.

## Technology transfer processes

Transferring a technology can he considered as a stand-alone project, so project management steps are the usual activities that need to be carried out. However, four specific managerial tasks are considered here in some detail (Beruvides and Khalil, 1990):

1. Determining the transfer method, actors and timing.
2. Pre-transfer activities
3. Transfer activities.
4. Evaluations and improvements.

## Determining the transfer method, actors and timing

Before a technology transfer decision is made, the maturity of evolving technologies needs to be assessed prior to incorporating the technology of interest into a system or sub-system. Generally speaking, when a new technology is first invented or conceptualized, it is not suitable for immediate application. Instead, new technologies are usually subjected to experimentation, refinement and increasingly realistic testing. Once the technology is sufficiently proven, it can be incorporated into a system/sub-system. However, this is easier said than done. One measure for assessing the maturity of technology is the 'technology readiness level scale', used by some US government agencies and many international companies/agencies (Graettinger et al, 2002).

Once the decision is made to transfer a technology, there are a number of possible methods that can be used, informal and formal. Informal processes include technical information exchange through published material, in the form of printed or electronic information exchange through published material, in the form of printed or electronic media, meetings, symposia, individual exchanges or reverse engineering. The process of training scientists in academic research institutions or acquiring critical technical personnel might also he considered as informal methods of technology transfer. The case of BICC Cables Ltd at the end of the chapter presents an example of the use of informal and formal transfers.

Formal technology transfer approaches are based on legal arrangements between the participants in the transfer process. The major methods of external technology transfer are:

- OEMs.
- Turnkey plants.
- Licensing (in and out).
- Acquisition.
- Collaborative R&D.

Once the method is decided, potential partners need to be identified and selected. Here the process is similar to finding technology suppliers for acquisition.

Deciding which staff members should be involved in the transfer process is an element of the technology transfer process. Forming multifunctional teams and establishing communication among them improves the overall process and facilitates learning. But the staffing decision should include not only the receiving organization's/unit's staff but also the developer's staff. All parties involved in the technology organization's/unit's staff but also the developer's staff. All parties involved in the technology transfer process should assign staff who will participate in the whole process to make it smooth and consistent.

The technology transfer method puts limits on the structure of technology transfer. Some modes of technology transfer are (Williams and Gibson, 1990):

- ***Over-the-wall mode:*** Receivers have no close contact with developers. Examples arc licensing and turnkey plants.
- ***Receivers-as-consultants mode:*** Developers have the main responsibility but they consult frequently with receivers. Some licensing and collaborative R&D might be performed in this mode.
- ***Team mode:*** Receivers and developers work together to develop and transfer technology, for example through collaborative R&D.

- ***Apprenticeship mode:*** Receivers become developers under the direction of the main technology or knowledge owner, for example OEM.

After determining the technology transfer method, timing issues need to be decided, such as when the technology is ready to move from R&D to production and finally to market. Timing depends on the degree to which the technology satisfies customer needs and ensures efficient and repeatable production.

## Pre-transfer activities

Formal technology transfer relies on legal documentation, a contract including binding conditions on what will be transferred, between whom, when, how and for what price. Depending on the actors involved in the agreement, the type and extent of the contract might change. For reliable partners, the contract might be more flexible, while for developers who are not trusted, it might need to be more detailed. The contract preparation is even more complicated when the technology transfer is international, since the contract should be structured according to international regulations. After the contract is prepared either by the developer or the receiver, it is jointly negotiated and a final form is reached.

Before the technology transfer starts, there might be a number of adjustments to physical facilities and workforce. Depending on the location of the technology transfer, in an existing or new portion of the enterprise, there might be new installations or changes needed for the incoming technology to function. The new technology might work with special inputs that might not be available in the premises of the receiver organization and it might take time to acquire them. So the pre-transfer phase should consider all inputs and make a procurement plan accordingly.

Preparing the workforce is a multifaceted issue (Khalil, 2000). The receiving organization must be capable of and interested in receiving the information. The members of the organizations involved in the technology transfer must, to some extent, have some over-lapping training, skills and experience. Without some common base, those in the recipient organization will lack assurance that they truly understand what is being transmitted. So training might be an integral part of the recipient organization's role to ensure that its employees reach a comparable level. Another way of matching two organizations' skills can be through transfer of people from the original R&D group. Temporary assignments of people to the other organization, from operations to the R&D group or vice versa, can be useful. Alternatively, hiring or transferring the requisite skills from other organizations may be a solution. In fact, before technology transfer is achieved, management needs to assess staffing needs for the operation of the new technology, possibly leading to recruitment of new staff with the right skills and knowledge.

In some cases, developers and receivers/appliers might come together in the development phase before the project ends and the transfer starts. The process is an iterative one between developer and receiver that requires easy and frequently intense interactions. As a development progresses, the skills and equipment available in operations become valuable in performing tests and measurements (Steele, 1989). Consequently, the programme can become a joint development well before it officially transfers to operations.

## Transfer activities

Physical installations and adjustments take place mainly before the transfer process starts, although further changes may be needed after technology is transferred in-house, depending on whether problems arise and to accommodate unforeseen application needs. These installations may necessitate additional site arrangements such as updating electricity and transport infrastructure.

After physical installation, tests are carried out at different levels and, depending on the results, new sets of arrangements are undertaken. Other actions are needed during the actual start-up of the new technology, involving migration from the old process to the new (ICS UNIDO, 2008). If the company has the luxury of setting up the new equipment in a new area, it can keep material flowing to the old process until the new one is run-ning smoothly. If the new process has to be conducted in the same space as the old, there might be a hectic shutdown of the old process and last-minute installation and start-up of the new one. If this is the case, careful planning will be required to make the transition as smooth as possible. Timing of the start-up depends on many factors, including physical utilities, employee training, new process measurement systems and the processing of the data from those systems.

In technology collaborations, the risk of wasting outsourced R&D might be reduced by taking precautions. For example, the company might put in place a well-defined 'home' for the technology in the form of an in-house development project that builds on the results obtained but is more tightly focused on explicit commercial objectives (Steele, 1989). There is a need to set a handover period, in which the researchers stay in close contact with the R&D staff in the business so that they can communicate everything that was left unsaid in the reports. It is also important to minimize the time-lag between the outsourced emerging technology project and the subsequent focused development project, to ensure that information is not lost or forgotten and to maintain momentum.

During the technology transfer, a critical management task is to secure learning and efficient communication. Transfer includes tangible as well as intangible knowledge. In addition, those creating a new technology rarely perceive with sufficient clarity what in fact they really do. They might not discern the truly critical information from other details. Thus skilled receivers are needed to pin down the information needed by them. In other words, receivers should pay special attention to capturing the intangible knowledge associated with the technology by actively putting learning as an item in the technology transfer process. In fact, it is not only the capturing and learning of knowledge, but also its diffusion across the company that makes it valuable, since some knowledge might be valid for some other units in the organization rather than the unit responsible for the transfer, increasing the opportunities for synergy.

In terms of communication, culture-building activities involving manufacturing, marketing and R&D people should aim to establish a common language. For example, R&D people must recognize the enormous, overriding commitment that manufacturing people make to achieve uninterrupted output (Steele, 1989). Manufacturing is conservative with regard to incorporating new technology that is not yet proven. The factory environment poses much more severe constraints on adopting new manufacturing technology com-pared to new product technology. Thus it is better to start by working on carefully limited problems that only demand incremental changes. Another step is to establish credibility with manufacturing by showing the value of new technology to manufacturing people, the internal consumer of the new technology.

All these factors clearly indicate the importance of communication between the R&D, production and marketing departments of a company. Communication must be formal and informal and should deal with (Burgelman et al., 2004):

- Introducing new products from the development lab to the production floor.
- Providing the optimum level of documentation on existing products.
- Becoming multilingual, fluent in the language of customers, marketers, engineers and designers.
- Facilitating orderly and cost-effective changes to products now in production.

As technology transfer involves uncertainties in knowing what will work and what will not work, it is important to keep detailed records of the information produced, irrespective of its apparent significance at the time. These documents provide formal communication but, importantly, they might also help to understand what went right and wrong and to make adjustments, especially after technology transfer evaluations are carried out and improvements are planned.

## Evaluations and improvements

When full production starts, feedback starts to flow either from internal production departments or from markets/customers, which creates another round of evaluation and improvement activity. This is why, in the days immediately following the start-up, a process of refinement and improvement of the new technology takes place in order to fine-tune the operations involved in the new technology. The process is monitored closely and any substandard performance is identified, the cause isolated and the problem rectified (ICS UNIDO, 2008). The cause could be technical or it could be due to inadequate training. Whatever the cause, it needs careful attention until the technology is producing products in line with the specifications in the contract with the technology supplier. The refinement and improvement process does not end there, however. The company needs to constantly work towards achieving an attitude of continuous improvement.

There are difficulties in measuring the success of technology transfer. The degree of technological innovation, the level of application and the purpose of transferring the technology play a role in determining the effectiveness of technology transfer. The evaluation might be carried out in any combination of the following effectiveness dimensions: benefits, system, availability, capacity and supply. The complexity is clearly observed in some of the measures used in technology transfer evaluations (Williams and Gibson, 1990) - licences, requests for help, competitive advantage gains, cost savings, site visits, technology briefs, jobs created, market share gains, technical presentations, new businesses started, new products, time spent, transfer budgets, new customers, new sales, transfer expenditures, productivity gains, royalties, return on investment (ROI), success stories, technical problems solved and user satisfaction.

Measures of the success of technology transfer are complicated and difficult to apply. Developers may understand the technology better, but operators have a greater under-standing of the application environment. An effective approach might be to ask operations to take the lead in developing data and work closely with developers to ensure that the data reflect the special nature of the technology and are representative of cost and market factors (Steele, 1989),

Another critical issue with measurement is the degree of qualitative data to be employed, ROI can be a rudimentary measure to use since technologies contribute in many ways other than quantifiable dimensions, including quality enhancements. In evaluating an acquired technology, the situation may be complicated by the fact that products utilize many technologies and the technology may have a number of applications.

Once the evaluation is done, a plan for improvements may need to be designed. Besides the evaluation, all documentation in the technology transfer process can be screened to discover the best ways of finding out what needs to be done to improve the results, which might include factors other than those relating to technology transfer. Thus, improvement activities might be related to the general technology utilization tasks described below as the third sub-process of the exploitation activity.

An important aspect of improvements is change management. Transferring the commitment and enthusiasm of those who are creating a new technology to those who will develop and apply it can be challenging. Naturally, the degree of challenge depends on whether top management of the recipient firm of a new technology is supportive of transfer or not, as well as if the recipient firm is unclear about what it really wants from the company originating the new technology. The actions that need to be taken are the same in both cases, but the care and attention devoted to them will vary. This necessitates additional management mechanisms that are related to change.

## Technology utilization

### Definition

Although the technology transfer might have been successful, the results from the exploitation of technology might not be as expected or designed. Technology utilization might be considered in the lines of re-engineering and total quality management (TQM), since the goal is either maintenance or continuous improvement of the use of existing technologies. As the case of USG Corporation (see Chapter S) shows, productivity gains in the commercialization of new technology platforms differ a lot, so by measuring performance and focusing on learning, firms might increase their returns from technologies.

## Utilization processes

Utilization processes consist of three major steps:

1. Measure technology utilization/performance.
2. Identify priorities and develop a business case to improve utilization.

3. Implement changes.

Depending on the firm's structure and the aim of the utilization exercise, technology utilization might be carried out at the technology, plant or multi-plant level.

### Measure technology utilization/performance

Most capital investments can be assessed quantitatively, helping to form an objective view on the worth of the investment. In contrast; technology investments may have a substantial but far less visible impact on the business, especially in the short term. In the long run, the firm may have a better product, with broader international application, based on shared new core technologies, providing the foundation for a new generation of profitable, standardized products. Technology evaluation raises the following questions for technology managers: What is to be evaluated? Who is to be involved in evaluation? What roles do they play? What criteria arc to be used in the evaluation? How they are weighted? How arc the criteria to be measured?

Although there are no simple, directly quantifiable measures of the value of technology, a measurement approach that relies on an input-process-output evaluation framework is adopted here due to the difficulties of measuring technical work directly (Coffin and Mitchell, 2005). This method combines a balanced scorecard approach with operations management of the input-output model, offering a wide base for the evaluation of technology including the process.

By doing so, it can help to include the qualitative advantages and intangible sides of technologies in the overall performance audit.

In the input-process-output model:
- Input measures are the time and resources required, such as people or information technology.
- Process measures are the indicators of efficiency of the innovation process within an organization, such as the time required to bring an innovation to market.
- Output measures are directly related to the commercial impact of innovations, such as revenues generated by a new service or product.

A list of potential measures developed for innovation management might also be valid for TM (Coffin and Mitchell, 200S). For example, financial input measures might be: percentage of revenues invested in product R&D; percentage of revenues invested in technology acquisition; and percentage of projects delayed or cancelled. Customer-related input measures could be the percentage mix of projects by their strategic drivers. Resource-related measures for input could be: percentage of total employees involved in innovation projects; number of ideas per source; and number of ideas considered per year for new products, services and processes.

TM involves an element of creativity, which should be reflected in the process measures used. Typical inputs and outputs are R&D personnel and the number of new products and patents, respectively. But managers should try to measure not only how creative the organization is but also how well it uses that creativity. Output process measures may include milestone hit rate, budget hit rate and time to commercialization.

Organizations need to choose measures in each of the categories based on their needs, while recognizing the danger of attempting to measure too much. Criteria for judging the importance of potential measures include strategic importance to firm, actionability, validity, appropriateness, clarity and cost-effectiveness.

Besides general measures, there might be specific micro-measures applied by operational managers to track a weakness and indicate progress in remedying it. Typically, only a few measures are used at a time, always linked to an internal customer need. Once an improvement has been made, the relevant measure can be dropped and replaced with another that tackles a different problem. The micro-measures chosen will depend on the desired improvement. For example, the number of unplanned changes might be tracked to understand how consistent the design is. Micro-measures arc used predominantly to help local management in the drive for continuous improvement. They need to be simple, relevant and communicated widely. In addition, the organization needs to decide on the timeliness of performance evaluation. It might be a regular period or a variable one, depending on the life cycle of the technologies.

Performance measures alone do not mean much unless they are made in comparison to other companies' performance. Thus, the final activity in performance measurement is benchmarking. Benchmarking is the systematic comparison of organizational processes and performance to create new standards or to improve processes.

Benchmarking models are used to determine how well a business unit, division, organization or corporation is performing compared with other similar organizations. A benchmark is often used for improving communication, professionalizing the organization/processes or for budgetary reasons. Benchmarking is not just a comparative tool; it also stimulates questioning and learning. If the firm benchmarks widely within its own business, sharing objectives and pooling best practice understanding, the firm can achieve performance improvement without looking at other companies. With a good foundation of internal benchmarking, the firm can begin to look outside. Benchmarking against other companies can give the firm valuable insights into the structure and implementation of all the firm's technology development processes, from managing long-term research to product development and launch. Benchmarking can be at several different levels, starting with hard measures of output and moving towards process comparisons. The firm might look at how world-class companies across a range of industries manage their technology development and adopt the best elements.

## Identify priorities and develop a business case to improve utilization

Performance evaluations can give conflicting results and prioritizing the improvements might be difficult, so criteria should be established for determining which measures are most appropriate and helpful.

One consideration is to understand the role of the external environment in utilizing the technology. If demand changes are the main reason for underutilization, there might not be enough room to make changes. A helpful mechanism for managing demand changes is increasing supplier and customer involvement at the early stages of technology development (Tushman and Andersen. 2004). For example, the lead user method might help to gain close contact with the main customers and integrate their views into the process.

Another mechanism is diversification. The core technology approach suggests focusing on core technologies that make it possible to diversify the product/market range based on the core capabilities developed. Thus, companies need to find ways of diversifying the use of technologies and to take appropriate actions.

Demand changes in the market can initiate a chain effect within the company. Besides technology adjustments for market needs, the company might need to make adjustments to match internal strengths, to eliminate weaknesses and to improve competitiveness in global markets.

Reliability concerns are also important when prioritizing improvement efforts. Potential direct and/or indirect losses due to the failure of a product may be detrimental to the reputation of a manufacturer. Special attention must be paid to the prevention or reduction of downtime and to the minimization of repair costs. To meet this long-term challenge, a technology manager needs to develop a process perspective on three interrelated features of a product in its life cycle: reliability, maintainability and availability (Gaynor. 1996):

- Reliability is centered on the frequency of breakdowns.
- Maintainability is focused on the time of breakdown.
- Availability is the consequence of reliability and maintainability. It is measured by the proportion of time during which a product is effectively available for operational use.

Although maintainability requirements are built into the product or system during the design and manufacturing stages, the causes of failure are realized during the operation or use of the product or system. During usage, the product or system generates information chat can be systematically collected and analyzed to initiate the required maintenance actions.

Another dimension in evaluating performance is to consider the characteristics of the technology itself. Due to technical limitations, utilization might not exceed a certain level. Bottlenecks and capacity limits arc well-known problems causing underutilization and they are valid for technologies too. In some cases, brand new technologies might experience many technical problems that have a substantial impact on their application, opening the door for substitute technologies.

Technology integration and synergy are also critical aspects to consider, especially when a company uses multiple technologies for a similar purpose, leading to underutilization. The reasons why companies end up with different technologies include:

- The specialized needs of one line of products drive improvements in other lines.

- Partial investments/installations.
- Different standards of technologies.

Therefore, firms need to integrate and standardize manufacturing and process developments so that the harmonious contribution of different technologies can be achieved. This will bring many advantages, including synergies, and will prevent a misfit between technologies.

Another type of performance problem can arise from a misfit between technological innovation and organizational structure. If the organization cannot adapt itself to use a technology efficiently, the benefits significantly drop. Some managerial practices might become unsuitable for the technologies developed. Technological innovations do not exist alone; they influence organizational Innovations and demand a fit between hardware and software parts of technologies. For example, computer-aided design, computer-aided manufacturing and flexible manufacturing systems are widely used, but have different implications in terms of organizational structures and processes. If there is a poor fit between the technological infrastructure and the business process, there will be problems. Hence, strategy makers need to consider the implications of their technology decisions on their organizational techniques and develop strategies to manage the fit by developing special structures and organizational innovations.

Another problem causing underutilization is the limited set of competencies the company might have. New technologies and changes in technologies might necessitate changes in the set of available competencies. This can be done through human resource adjustments.

After considering all the factors of underutilization, a priority list might be developed for improvement activities. This should include all suggested performance improvement plans and the reasons why they should be carried out. Senior management should under-take an evaluation using technology assessment techniques and draw up a final list. The improvement list should initiate projects for the R&D department where TQM techniques are applied.

### Implement changes

Improvement projects are similar to new product or process projects and need to be implemented following approaches similar to those for R&D management. Improving performance requires the management of a wide range of issues, including ideas, technologies, culture and organizational change. Therefore learning and change management become indispensable parts of the implementation.

## Reverse innovation

Emerging markets/rapidly growing developing countries such as China arc becoming centres of attention for many businesses around the globe (Khanna and Palcpu, 2010). This is because emerging markets offer many business opportunities to aspiring firms who wish to grow their businesses and do so rapidly: these are markets with high population and economic growth, revolution in consumers' rising expectations, urbanization, increasing numbers of middle and upper-middle-income segments composed of consumers who are hungry for goods and services, expanding distributor and telecommunication networks and exploding market demand. Further, many emerging market firms themselves arc becoming highly successful abroad, exemplified by Haier of China, Tata of India, SAB Miller of South Africa, Embraer of Brazil, Arcelik of Turkey and Teva Pharmaceuticals of Israel. Many of these firms are growing into global champions carrying their local market success based on unique firm-specific and country-specific competitive advantages into international expansion (Ramamurti and Singh, 2009).

Reverse innovation is a set of innovations targeted for emerging/developing country populations. Reverse innovation attempts to understand the customer problem and come up with a solution that will take into consideration a variety of factors: availability of electricity, portability, durability and price. This type of innovation is not limited to disruptive innovations. The goal is to fill five gaps in a developing country that lead to reverse innovation: the performance gap, the infrastructure gap, the sustainability gap. The preference gap and the regulatory gap (Govmdarajan and luchner, 2012). For example, an Indian cardiac hospital offers cardiac surgery for 52,000 whose American equivalent would cost up to $20,000. It is important to note that the difference in price doesn't mean it is bad quality. This cardiac hospital has built a facility in the Cayman Islands to attract customers from advanced countries, because they create solutions that are affordable and of good quality.

Reverse innovation is a new wave of innovation that might bring variety into business making. In addition, a large subset of reverse innovation is based on social innovations that are human-centred and give opportunity to question the meaning of products and services produced for the sake of social and environmental concerns. By exploiting technologies in new geographies, the democratization of innovation tends to become more realistic (Green, 2007).

***Suzlon: India's major wind power provider***

Suzlon has become the world's fifth largest wind turbine manufacturer with a market share of 6%. Suzlon's founder Mr Tanti was unhappy with the erratic power supplies and rising energy costs at his textile mill in Gujarat, India. Therefore, he set up two windmills in 1990 with turbines imported from the German company Suedwind. He soon discovered that the windmills provided a reliable source of cheap energy, much cheaper than conventional energy and they were also environmentally friendly. Mr Tanti exited his textile business and set up Suzlon Energy in 1995 with a strategy of capitalizing on India's low manufacturing costs and providing end-to-end customized solutions at affordable prices to its Indian industrial clients.

When Suzlon's initial turbine supplier failed in 1997, Suzlon bought it and kept its R&D centres and turbine manufacturing facilities in Germany. Suzlon also acquired a rotor-blade manufacturer in the Netherlands; the acquisitions broadened Suzlon's reach, bringing a product range that now includes wind turbine generators in capaci-ties from 350 KW to 2.1 MW with customized versions suitable for a variety of cli-mates. Although Suzlon's products are not suitable for conventional power generation in urban areas, they were welcomed by customers with large manufacturing or other operations in rural areas that had poor or costly access to conventional power supplies. Soon, Suzlon discovered that its products could find markets globally, including in developed countries seeking greener energy sources to supplement conventional power plants. Suzlon's business grew rapidly and has captured more than a 50% share in developed countries seeking greener energy sources to supplement conventional power plants. Suzlohs business grew rapidly and has captured more than a 50% share of the wind power market in recent years. While its Indian business continues to grow steadily, its overseas sales have seen even greater growth, rising from 8% of total rev-enues in 2004 to over 70% in 2006. Orders have come in from Australia, China, South Korea, Brazil. Italy, Portugal and Spain. Its global revenue in 2007 exceeded 5900 mil lion. Suzlon has a bright future as the global wind power market is expected to grow at an annual rate of over 25% during the next five years.

Suzlon succeeded where Suedwind had failed because it understood the market position of its products. Tanti perceived the potential of the wind turbine generators as disruptive products in the energy market and pursued a market strategy to exploit that potential. Understanding and developing the disruptive potential of a product is a key component of a disruptive innovation strategy.

Source. Summary from Hang, C. C., jin. C. and Subramian, A. M. (2010) 'Developing Disruptivc Products for Emerging Motets: lessons horn Asian cases; *Reseacch-Technolov Management*, 53(4), 21-26.

## Case Study

Managers cannot relax once technology is in place, since technological exploitation depends on how efficiently and effectively managers handle commercialization, trans-fer and utilization- The case of BICC Cables Ltd, the UK's largest cable manufacturing company in the 1990s, with annual revenues of approximately E1.3bn and employing about 10,000 people, illustrates how technology transfer and utilization activities arc carried out for an internal R&D invention.

**BICC Cables Ltd**

BICC developed a new process technology in-house through its R&D unit, which was the process plant machinery used to manufacture a particular type of optical fibre cable known as 'tight buffered fibre cable'. MCC had wanted to produce this type of cable in volume and thereby satisfy demand from the UK and European markets.

The process plant technology was designed as a flexible plant that could work in stand-alone mode to manufacture single optical fibres or multi-element optical fibre ribbon and in tandem with an existing cable extrusion line to manufacture tight buff-ered fibre cables. -1he latter operation enabled the extrusion line to apply the plastic coatings over the fibres (like a skin covering) after they had been produced in the first stage of the operation.

The process technology was designed and developed at BICC Cable's Helsby Technology Centre (HTC). The technology-receiving factory, BICC Brand-Rex, was based at the same site. Two reasons motivated the choice of in-house production: high demand and the high cost of bought-in fibre.

HTC had designed and specified the requirements for the tight buffered fibre process plant for a UK-based engineering firm, from which it purchased the initial plant. The plant was then successfully run and tested by HTC, producing the tight buffered cable in its lab for the internal customer Brand-Rex, which could sell this buffered cable in its lab for the internal customer Brand-Rex, which could sell this initial cable production to its end customers. Hence, a unique situation had arisen, an R&D unit running a three-shift operation not only to test the process plant but to meet the initial production demands placed on it by the internal customer's market demands.

After these tests and pre-production runs were completed at the prototype plant, the technology was transferred to the Brand-Rex manufacturing factory. In addition to the physical plant, this technology transfer process also included a set of process instructions, training procedures and plant operation and maintenance manuals.

During the tests and pre-production runs at HTC, some manufacturing engineers from Brand-Rex had been seconded to HTC for short periods to receive training on the plant technology under the supervision of HTC staff. Since there is tacit knowledge embodied in most cable production processes, which the Hit development team had accumulated over a period of 18 months, much of this knowledge was transferred to the Brand-Rex engineers training at the plant. The tacit knowledge related to fault-finding and problem-solving skills, process optimization and start-up procedures that could not be fully codified into a specification format.

The success of this technology transfer process could be traced to the technology sender and receiver serving a common mission that was compatible with a TQM philosophy. BICC employees were acting towards other internal customers in the supply chain as if they were dealing with external customers, by striving to deliver excellence. The receiving organization (Brand-Rex) did not have problems associated with quality control, operation or maintainability, since these had been dealt with in the test and pre-production phases.

The involvement of Brand-Rex senior management in this project was seen as a major catalyst for promoting successful technology transfer. The marketing information was consistent in outlining sales forecasts for the months ahead, the technology transfer process was driven by external market signals and the R&D department was aware of the wider business implications for tight buffered fibre cable development. This ensured that everyone involved in developing and transferring this technology within BICC was also aware of the wider business implications. This meant, in turn, that everybody involved realized that this was not just a speculative R&D project but had real goals and targets to achieve.

*Source: Malik. K. (2001) 'Now MCC Cables Transferred a New Process Technology from R&D to Manufacturing', Research-Technology Management, 44(4), 55-60.*

## Summary

The exploitation activity consists of a number of critical sub-processes, the three major ones bring commercialization/marketing, technology transfer and utilization. All these sub-processes help to find the right business models for commercialization, transferring technology in an effective and efficient manner and achieving incremental improvements continuously in order to achieve day-to-day operational efficiency. If exploitation capabilities are not developed, returns on technologies are low.