3. TECHNOLOGY MIGRATION AND TRADE

In this chapter it is confirmed that technology is valuable; that its migration cannot be stopped and should rather be managed; that learning determines transfer; and that appropriability can be crucial.

3.1 Technology is valuable

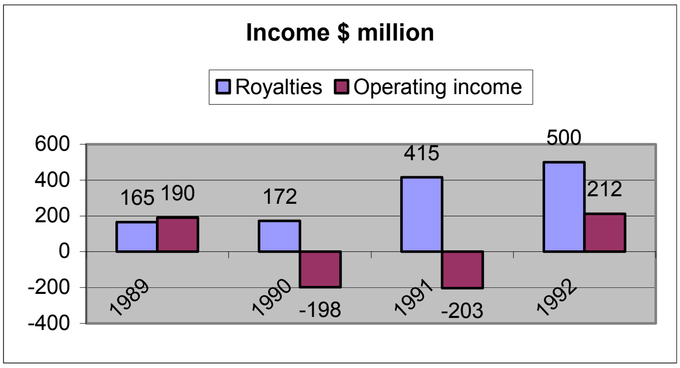
The value of technology in its encompassing sense has long been acknowledged and is demonstrated by the fact that technology is traded in various forms including product-, process- or person-embodied and by licensing. It is generally accepted that technology is at least one of the major drivers of economic prosperity, if not the dominant one. Without technology a company may find itself gutted. Former technology leader AECI's competitive abilities were eroded severely by the loss of its research facility when shareholder ICI withdrew in 1992 and moved its international research interests to Canada, running down those of AECI. AECI had a licence on explosives from ICI but would now lose the ability to develop new generation explosives, lacking other technology partners. It was hoped that technology synergies with Sasol would put Sasol in a good position to restructure AECI. (Pretoria News, Business Report, 24 September 1998, p3.)

Four days later the Competition Board refused to allow Sasol to take over AECI's explosives and fertiliser business and AECI's share price immediately dropped by 42% from R23-95 while Sasol's share price increased by 7½%. The value placed by the stock market on even the promise of new technology is clearly demonstrated.

Not only competitive abilities as explosives manufacturer were necessarily lost. The ability to develop an own technology was lost; as was the concomitant possibility to out-license it.

In joint ventures of various kinds technology is often explicitly recognised as an asset contributed by one or more of the parties and appropriately valued. Information technology companies have especially during the first half of 1998 effectively sold their purported knowledge in terms of a share premium when listing on the Johannesburg Securities Exchange. Goodwill, generally vested in well-known brands or trade marks – and also in the Coca Cola concentrate recipe - have commanded huge amounts of money.

Texas Instruments showed what monetary awards are obtainable, following enforcement and subsequent licensing of its master patents for integrated circuits:



Merryll Lynch from Lawrenson, 1992: 340)
Figure 5. Texas Instruments royalty and semiconductor income.

This example is not intended to imply that huge profits are to be made from all licence agreements. Many render small profits and several result in losses. Ford and Ryan argue that a company must plan for the fullest market exploitation of all its technologies to maximise returns on its technology investment. The technology may but need not be incorporated in that company's own products, processes or services. Considering the growth of lower cost Third World producers, companies in the developed world will find it increasingly difficult to exploit their technologies through their own production alone. (Ford and Ryan, 1996: 107.) NEC was reported as planning to expand its traditional use of its patents to defend itself. It would be pro-active and hoped to earn US$375 million per year from licensing its patents. NEC is the biggest patent holder in Japan and the second biggest in the USA, with respectively 38509 and 1966 patents. (Beeld, 4 April 2002, p7.)

Indicative international royalty amounts that could be statistically suspect but give a good idea of volumes and the value of technology traded are presented in Table 1 and can be contrasted to some extent with South Africa's payments of up to R2,5x 10^9 mentioned in the Introduction. It is interesting to note that of the countries listed, all but the developed USA are net importers of technology. At the same time it should be noted that Japan is almost breaking even and is only bettered by the UK.

Country	Royalties earned ($bill.)	Royalties paid ($bill.)	Earned/paid	Year
Japan	3,20	3,40	0,94	1991
USA	19,10	3,99	4,78	1991
Germany	1,70	3,76	0,45	1991
France	1,73	2,60	0,67	1990
UK	2,36	2,47	0,96	1989

* Exchange rate used was $1 = Y115.

Table 1. Royalties paid and received.

(Ishii and Fujino, 1994: 130)

There is more behind Japan's position and to be a net importer is not necessarily not good. In the 1950s Japan entered into 2500 in-licences with the USA and Europe. These contributed crucially to Japan's industrial and economic success. This was similar to the transformation of US industry following substantial purchases of technology from Europe earlier in the 20th century. The countries and economies whose manufacturing industries had shown the greatest strength during the 1980s, Japan and Germany, had been net importers in contrast with the UK. (Lawrenson, 1992: 342.)

3.2 Migration of technology is unstoppable

Not only is technology highly valued. It is actually not possible to stop technology transfer. In stead of trying to do so, it is better to manage the transfer.

> Domestic firms seem able to circumvent restrictions on the export of know-how, while foreign firms can engage in "reverse engineering of products and designs" to circumvent many controls. (Teece, 1981: 95.)

Kim (1997: 221 *et seq.*) shows succinctly how Korea expedited technological learning by acquiring foreign technologies through formal and informal mechanisms and then poses the question whether international firms should and can stop technology transfers to "catching-up" countries - of which South Africa can be argued to be one - to prevent any long term negative effect on themselves. He convincingly sets about answering the question in the negative. Restricting foreign direct investment may jeopardise the global strategy of multinational firms while restricting foreign licences risks shortening the economic life cycle of their technologies and products. Further, if one supplier firm or nation refuses to transfer technology, a sophisticated buyer of technology in catching-up countries can usually turn to an alternative source. Reverse engineering can also be employed or retired foreign experts can be hired as consultants. South Africa's armaments industry for example showed that

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technology can be obtained even though a comprehensive arms embargo against it was in place.

Attempting to limit transfers by passive supply of *e.g.* capital goods appears also to be self-defeating. Korean firms seem to have learned more from imported capital goods than from other types of technology transfer.

Firms in advanced countries are dependent on original equipment manufacture in catching-up countries to sustain price competitiveness in both domestic and international markets and they cannot stop activities such as observation and reading.

On the supply side, alternative sources of technology are proliferating and the firms that possess it may have to transfer it to expand sales and extend the economic life of their technologies to maximise their return. (See also 3.4, p35: Appropriability.) On the demand side, catching-up firms have developed increasing capabilities to master imported technologies and to undertake research and development to create their own innovations. Only through continual innovation can technology suppliers in advanced countries maintain their position of leadership.

Kim's summary of his discussion from the suppliers' point of view appears in the matrix in Figure 6.

		Strategy for suppliers of technology	
		Absorptive capacity of recipients	
		High	Low
Suppliers willing to transfer technology to recipients through formal mechanisms	Yes	Technology transfer takes place. Both suppliers and recipients gain. (1)	Technology transfer takes place. Suppliers gain but recipients become dependent. (2)
	No	Technology transfer takes place. Suppliers lose but recipients gain. (3)	Technology transfer does not take place. Neither suppliers nor recipients gain. (4)

Figure 6. Technology transfer strategy for suppliers of technology.
(Kim, 1997: 224)

It is in quadrants 1 and 3 that technology suppliers worry about backfiring effects of transfer. But whether they supply or not, catching-up countries will be able to acquire technology.

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Suppliers should consider foreign direct investment as well as licensing to extend the economic life of their technologies.

Kim's matrix summary of his equivalent discussion from the recipients' point of view appears in Figure 7. Recipients who invest aggressively in acquiring technology should take care when getting involved in joint ventures and foreign equity participation, to avoid conflicts. (Quadrant 3). Non-aggressive recipients can benefit from such ventures but risks becoming totally dependent on the parent company. (Quadrant 4).

Strategy for recipients of technology			
		Strategy for technological learning	
		Aggressive	Unaggressive
Association with foreign firms	Independent	Slow initial learning but dynamic long-run learning. (1)	Slow learning throughout. (2)
	Joint venture	Rapid initial learning. Conflicts restrict dynamic long-run learning. (3)	Learning at the pace of the parent firm's strategy. Dependancy. (4)

Figure 7. Technology transfer strategy for recipients of technology.
(Kim, 1997: 226)

In 1987 Hyundai's Excel became the best selling import car of the year in the USA. Inspired by the second oil crisis, Hyundai had decided to make a major investment to develop the next generation front engine front wheel drive car (FF) for North America. It approached major car makers such as Volkswagen, Renault and Alfa Romeo for FF technology. These wanted equity and management participation while viewing Hyundai as a local assembly subsidiary for their own FF cars. In the end Mitsubishi licensed engine, transaxle, chassis and emission technology for a 10% equity share in Hyundai. Hyundai reserved the right to import, the right to technology from Mitsubishi's competitors and the right to compete directly in Mitsubishi's own markets. It sourced body styling from Italdesign and constant velocity joint technology from British GKN and Japanese NTN. (Kim: 117.)

During 1985 Hyundai entered into 54 licences: Japan 22 (only half from Mitsubishi), UK 14, US 5, Italy 5, West Germany 3 and 5 others. Hyundai's independence or unstoppability in acquiring technological expertise is abundantly clear. It is also clear that it searched far and wide as an aspiring acquirer.

Kim contends that creative imitation is not only more abundant than innovation but also a much more prevalent and smarter strategy for growth and profit. Licensing could be one way to limit and control competitors' urge to imitate creatively and thus to manage the imitation.

The Hyundai example illustrates that technology acquisition in an ethical manner is and will be advantageous. The intensification and spread of global competition even across sectors are incontrovertible and South Africa, with its newly open economy, cannot expect to escape. To become and remain competitive industrial companies will need ever more complex skills sets, in shorter time spans; while keeping a rein on cost. Few if any firms have or can develop for themselves the multitude of capabilities they will need to compete effectively, including new product and market ideas, access to markets, management and operational disciplines and critical technologies. Most need to complement internal capabilities and to bolster core capabilities. There are various ways to do so, including hiring personnel, joint venturing and forming strategic alliances. They will also need to acquire technology through buying and in-licensing.

It also illustrates the futility of refusing disposition of technology. Technology disposition is and will be desirable. Different companies including South African industrial companies possess various types of technology which are continually augmented and used to advance their own products and services that are of value to their customers as well as to their competitors or would-be competitors. They should guard against erosion.

Although there are many companies that are not technology-trading sensitive, many such as Hyundai are and the sole business of several consists of selling or licensing technology, which they may develop themselves or obtain from inventors and developers. Examples of these non-industrial companies which are specifically excluded from this research are Technifin (Pty) Ltd in South Africa and BTG of the United Kingdom.

3.3 Transfer of technology and learning

Technology trading and licensing is but a part of, or a tool related to, technology transfer.

> Technology transfer …… refers to the application of technology to a new use, or to a new user for

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> economic gain. (Gee, 1981 as quoted by Agmon and Von Glinow, 1991: 1.)

Again, as is the case with technology and innovation as such, the value added aspect which is included should be noted. Transfer of technology does not take place or is not planned for curiosity's sake.

Agmon and Von Glinow further point out that technology transfer is mostly seen as product-, process- or person-embodied and that emphasis in research and practitioner literature has been on the latter two types. They correctly point out that these types of transfer cannot occur without an overarching organisational framework and if this is added to the first three types the processes of international business and those of technology transfer become virtually inseparable.

A valid admonition is to think things and not words to deal effectively with the application of industrial innovation; or the transfer of technology. The things tend to become obscured by the phrase 'the transfer of technology" which suggests that "technology" is

> ….some sort of chromosome consommé that can be drawn from the veins of one society and injected into the arteries of another where it will faithfully replicate the skills of the transferor in the activities of the transferee. Worse: by using the one-way verb "transfer" the magic phrase hints that transfusing …..requires only action by the transferor and entails no corresponding effort on the part of the transferee. (Mr Justice Holmes as quoted by Murphy, 1986: 1129.)

Technology transfer is indeed an integral and continuing part of transnational business - as well as domestic business. A firm seeking to transfer, in or out, some comparative advantage it possesses, or hopes to obtain, will have to align the overall effectiveness of its products, people, processes and organisation. It must do this with both the macro and transaction environment in mind. It is clear that the transfer process is only complete when the transferee is applying the technology for economic gain.

A taxonomy of technology transfer could be considered to include the following elements (Aharoni, 1991: 84):

(i) The technology donor or source - could include government, a university, a commercial firm or an individual.

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(ii) The recipient - could be as varied as the donor and be at various levels of education or skills.
(iii) The type of technology - could range from a single complete machine sale at the one extreme to at the other extreme transfer in a process of joint development at the preference of the recipient with in-between various degrees of intensity involving amongst others technical data, drawings, patents, trade marks, copyright, visits and lectures. It could be classified as civilian, or military or dual purpose.
(iv) The technology life-cycle stage.
(v) The channels of transfer - could include foreign direct investment, joint ventures which could stand alone, turn-key projects, licence agreements including cross-licensing, co-production, marketing agreements and training.
(vi) The cost of transfer.

Technology transfer is a complex process and it is doubtful that any two transactions will ever be the same, although common characteristics will be identifiable. From a global perspective Simon (1991: 7) identifies five generic transfer categories:
(i) The international and domestic technology market which is made up of independent buyers and suppliers.
(ii) Intrafirm transfer involving joint ventures or subsidiaries.
(iii) Government-directed agreements or exchanges involving public or private actors.
(iv) Education, training and conferences.
(v) Pirating or reverse engineering at the expense of the proprietary rights of the owner of the technology.

Technology transfer, also through licensing, implies collaboration between at least the provider and the recipient, one important objective being to convey information. For this to be successful learning has to take place. A systematic effort is required to reduce organisational obstacles to learning, to prevent this strategic priority being buried under the daily operational pressures. The objective could be seen to be the prevention of loss of control over the technological domain of each of the companies which may be involved, which may even lead to the loss of the company. (Pucik (1991: 128, 135.) See also Figure 12 at 4.3.2, p55 which indicates the position of learning schematically.

Some reasons impeding learning in competitive collaboration, which were identified from Western joint ventures with Japan and others, appear in Figure 8. Their classification and nature clearly show that they have their roots in strategic planning or in other words, that they originate from the higher hierarchical levels of a company.

Pucik provides valuable insights in his discussion of them but it is clear even from the listing that encompassing and intensive consideration should be given as part of competitive and technology strategy to the challenge of attaining effective learning in the technology transfer, and thus licensing, process.

Functional areas	**Principal barriers**
Strategic planning	[1] Short term and static planning horizon [2] No appreciation of incremental learning [3] Strategic intent not communicated [4] Low priority of learning activities [5] Fragmentation of the learning process
Human resource planning	[6] Lack of involvement of the human resource function [7] Insufficient lead-time for staffing decisions [8] Resource-poor human resource strategy [9] Surrendering control over the human resource function [10] Staffing dependence on the partner
Management development	[11] Low quality of staff assigned to the alliance [12] Lack of cross-cultural competence [13] Unidirectional personnel transfer [14] Career structure not conducive to learning [15] Poor climate for transfer of knowledge
Control systems	[16] Responsibility for learning not clear [17] Short-term performance measures [18] Limited incentives for learning [19] Tolerance of learning barriers [20] Rewards not tied to global strategy

Figure 8. Barriers to organisational learning in strategic alliances
(Pucik, 1991 : 128)

Survey objectives. (Results are presented in 8.9.)

While several elements such as agreements and intellectual property are required in the transfer process, it was proposed that learning by licensees is dominant. Such learning was therefore to be profiled and characteristics proposed were planning horizon, communication,

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priority, involvement of Human Resources, process of staffing assignments, quality of team members, exercise of control, dependence on partner, cross-cultural competence, cross-disciplinary competence, career structure plan, responsibility for learning, performance measures, rewards and tolerance of learning barriers.

3.4 Appropriability

Any company showing or having technological leadership at any moment in time cannot be certain that it will reap the economic benefits of that leadership and certainly will not do so automatically. Well-documented examples of losses are the large-scale De Havilland Comet system which lost to Boeing and the consumer durable BETA video recorder from Sony which lost to JVC/Matsushita's VHS design. On the other hand, a company like Pilkington capitalised on its float glass process and Microsoft can be said to have been built around the DOS source code.

> The aim of this article is to explain why a fast second or even a slow third might outperform the innovator. The message is particularly pertinent to those science- and engineering-driven companies that harbour the mistaken illusion that developing new products which meet consumer needs will ensure fabulous success. It may possibly do so for the product, but not for the innovator. (Teece, 1996: 232.)

Teece develops his explanatory theory around three main themes, *viz*. appropriability, dominant design and complementary assets.

The term "appropriability" can refer to two closely intertwined aspects, *viz*. the reaping of profits from the exploitation of technology by the owner either through his own use thereof or his licensing or selling thereof, or through the reservation of ownership - which is a pre-requisite for the first aspect. Put differently: it can refer to the reaping of profits through pro-active application or through preventing others from applying the technology; both cases based on reserved ownership.

Ownership can be reserved by making use of legal instruments or the inherent characteristics of the technology. Teece presents a simple taxonomy of legal instruments which has been expanded to some extent to create Table 2 (‘Nature of technology’ column added).

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Legal instruments	Nature of technology
[Petty] Patents	Product
Copyright	Process
Trade secrets	Tacit
[Trade marks/names]	Codified
[Designs]	

Table 2. Appropriability regime: key dimensions
(Teece, 1996: 233)

Each method of appropriation is characterised by various advantages and disadvantages, again depending on the technology as such, as well as on the intended application. They are not mutually exclusive. The protection can also be placed in one of two classes: one that can and one that cannot invoke statutory protection. The first class would comprise patents and petty patents, registered designs of both the functional and aesthetic types, trade marks and copyright. The technology in the second class is generally known as "know-how" and may include trade secrets.

The would-be protectee has to take steps to reserve ownership. Except for copyright which vests automatically, technology is not automatically statutorily protected. Official steps are required to obtain official legal protection through patenting, and trade mark and design registration. In general, application has to be made in prescribed manner to a government institution in each country in which protection is desired, to obtain a limited monopoly which is enforceable through civil proceedings at the initiative of the protectee or often, its exclusive licensee. Many arguments have been conducted and will be conducted concerning the value or not of the available instruments. Even a single instrument such as a patent is not equally enforceable but dependent on many factors including the underlying technology, the specification drafting process, the law in a particular country and the will and means to enforce.

Action is likewise required to keep secret knowledge secret, at least for limited durations and to build a specific tacit knowledge. This kind of knowledge could include the know-how of a tradesman. The tradesman sells his time and with it the know-how or a part thereof by doing a

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job for remuneration. Process technology could also nominally be in the public domain but still be sold in a "show-how" transaction. This kind of transaction underlies the teacher – student relationship. The knowledge could also factually be secret or confidential to the would-be offeror as chemical process technologies often are. Even if the constituents in an end product could be identified it would not necessarily be apparent how they came together. But also seemingly very simple technologies could be involved:

> It is pathetic to watch the endless efforts - equipped with microscopy and chemistry, with mathematics and electronics - to reproduce a single violin of the kind the half literate Stradivarius turned out as a matter of routine more than 200 years ago. (Polanyi as quoted by Teece, 1981: 86.)

A first goal of reservation of ownership is to be in a position to influence and steer the evolution of the dominant design, that is to say be in control during the pre-paradigmatic phase and ideally, to be in sole position to supply or have the market supplied once the paradigmatic phase is reached or the dominant design emerges. Thus, simply, reserve for own use or for trading, with the realisation that without actual or deemed appropriation technology as such will not be tradeable for profit. The would-be seller or licensor of technology must be in a position to offer value which must be wanted by the buyer or licensee to render a mutually acceptable agreement feasible. Implicitly the licensee must perceive that the subject technology has economic value and that the offeror has some ownership or licensed rights to it. Appropriation and the perception thereof is a pre-condition to all these actions.

A second goal of appropriation is to manage the delivery of the dominant design, that is evolution around complementary assets. Almost always, the innovative technology cannot be exploited without the use of other capabilities or assets including manufacturing, marketing and support capabilities. Teece defines complementary assets in four classes. Generic assets are general purpose and need not be tailored to the innovation in question. Specialised assets are those where there is unilateral dependence between innovation and complementary asset. In one class the asset is dependent on the innovation (coking coal is used in steelmaking) and in the other the innovation is dependent on the asset (software requires a processor). Co-specialised assets are those where bilateral dependence exists, such as between containers and their specialised handling equipment and the Wankel rotary engine and its repair facilities.

Teece correctly argues that as the leading design or designs are revealed by the market, islands of specialised capital will begin to appear in industry. Especially if the core technology is easy to imitate, specialised and co-specialised assets, which likely involve irreversible investments, become increasingly important as competition increases. So, for example, personal computer manufacturers are competing for a very important specialised asset, *viz*. shelf space.

Amongst many other forms of contracting and alliance and strategic partnering, technology trading and thus licensing, built on appropriability, emerge as important methods to manage complementary assets, be it design or production capacity or distribution or advertising means and methods, or credibility and reputation.

Pilkington licensed its (proprietary in important respects) float glass technology under close control and aggressively continued developing it, thus maintaining a technological lead and effectively tying producers and would-be developers into its capital intensive process. JVC and its parent Matsushita widely and pre-emptively licensed other potential manufacturers and even and especially distributors applying their own brands, thus drawing the industry into using its technology while Matsushita excelled in supplying at low cost. Sony at first refused to rope in others to its design and its initially leading BETA design lost out in what was a vast market. The Comet was perhaps unfortunate in that it suffered metal fatigue leading to a loss of reputation. Its already sunk investment in specialized assets could however not be changed in time to meet Boeing's challenge. IBM ceded control of its personal computer operating system to Microsoft (and of its microprocessor architectures to Intel) who had free reign to use it and make it available to other manufacturers, thus helping it on its way to becoming the *de facto* operating system and allowing a host of clone manufacturers into the market, eroding IBM's position. Microsoft has also very successfully established its Windows operating system as a widely used standard.

The system for the legal protection by statute and otherwise of technology is evolving through the efforts of amongst others the World Intellectual Property Organisation (WIPO) and becoming ever more encompassing and sophisticated. This simplifies matters to some extent in that it brings more global certainty while increasing awareness. However, sophisticated legal systems and requirements in turn require sophisticated interpretation and application. In

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other cases, the real or technological world can be said to be outrunning the legal world. For example, a most interesting puzzle regarding ownership of the various parts of multimedia to be found on the Internet already exists.

Intensive and extensive global competition is in many cases resulting in huge investments in complementary assets, sometimes with great success and sometimes with disastrous consequences, as transpires from the examples above.

Means of utilising appropriated assets, also to extend control, is discussed in more detail in 4.2, p45 and 4.3, p50 below.

It is clear that South African industrial companies should take cognisance of and plan for the appropriability of core technology as well as complementary assets to be successful in licensing technology.

Survey objectives. (Results are presented in 8.10.)

It was deemed necessary to establish South African manufacturing companies' appropriability awareness in terms of the intensity and spread of use of appropriability instruments and their relevant organisation. Characteristics surveyed included intellectual property (IP) holdings, presence of IP data bases, IP planning, confidentiality agreements, use of lawyers and international use of patent systems.