Instituto Superior de Economia e Gestão
UNIVERSIDADE TÉCNICA DE LISBOA

PATTERNS OF TECHNOLOGY EVOLUTION IN SMES IN THEIR RELATIONSHIP WITH MMCS. NEW CHALLENGES IN THE USER-PRODUCER RELATIONSHIP IN THE PORTUGUESE CONTEXT.*

António Carrizo Moreira
Auxiliar Professor at Instituto Superior da Maia

Abstract

This paper is part of a broader study about international production taking into account the relationships between Portuguese Small and Medium-sized firms (SMEs) and foreign multinationals (MNCs). Its importance lies in the complementary linkage MNCs exercise on SMEs.

This paper addresses and analyses the patterns of technology evolution in the relationship between SMEs and their MNC clients. The objective is to analyse the technology accumulation process among suppliers as a result of the supplier-client interface in the supply chain. It is assumed that the external network of relationships among suppliers is the result of their need to cope with technological change generated by their clients or the clients' generated context.

1. TECHNOLOGY

It has been widely recognised that technology, innovation and technological development are at the gist of competitive advantages of countries and therefore one of the main drivers of economic growth and development.

The pressure of new technologies on firms and individuals is certainly not a new phenomenon. Since the first industrial revolution technology has forced many firms to change, which had pervasive effects in social changes as well.

Technology is certainly a major input in economic development. Today it is considered a key success factor in the national competitiveness and an essential element of economic progress. Twiss (1978) noted that the most important indus-

* This paper was accepted for publication in this special issue of *Estudos de Gestão – Portuguese Journal of Management Studies* as a result of a selection criterion that elected it as one of the most significant papers in its field, from those presented at the XIIth Jornadas de Gestão Científica, na Universidade da Beira Interior, Covilhã, Portugal. Therefore, it did not pass our ordinary double blind referee process as it happens in our regular issues.

trial firms owe their existence to the correct application of technology, to the development of new products, and to the improvement of production systems. As technology is present in each activity in the value chain it must be taken into account because it might alter firm's competitive advantage as well as industry's structure (Porter, 1989).

Technology is certainly a volatile concept: it has been used in various ways (Cornwall, 1977; Woodward, 1977; Mañas, 1993) with different meanings and only recently it has been related to managerial systems in the management literature (Baranson, 1978). Nelson and Winter (1982) considered technology as a specific knowledge used in the context in which it has been developed. They claimed, for the first time, that technology depends upon the learning capacity of those who started its development. Rosenberg's (1982) contribution was also important: he argued that technology is the knowledge of techniques, methods and designs which work even when the reasons they work cannot always be explained, rather than the mere application of scientific knowledge.

More recently, Ribault et al (1995) provided a comprehensive definition of technology. They considered technology as the outcome of three components: knowledge, resources and know-how:

- *Knowledge* is part of the scientific subject, therefore alone it cannot be considered as technology;
- *Resources* will lead to a technology, but technology is not only resources; and
- *Know-how* without resources is understood as a specialisation, but only with know-how one can hardly obtain technology.

The three components are intertwined: leaving one concept behind jeopardises the balance of the three. A firm may know very well the production process and have the best production equipment, but in the absence of know-how it might not compete adequately. Equally, a firm may have specific know-how and enough resources to generate a new technology, but without the proper knowledge the firm will not surely succeed generating it. Finally, knowledge and know-how do certainly not lead to a new technology because resources are needed.

Pavitt (1985) synthesised technology clearly as differentiated knowledge about specific applications, tacit and often uncodified in nature and largely cumulative within firms. In a way, Ribault et al's definition (1995) matches Pavitt's concept (1985). Although Ribault et al's (1995) definition is not universal it suits the study of technology accumulation at inter-firm level and it is consistent with Pavitt's concept (1985) of technology: it is firm-specific, not broadly applicable and not easy to produce and use.

Technologies do have a competitive impact upon products because they affect their cost and performance. Technologies influence the way firms compete in

the market place. An interesting classification of technologies has been put forward by Little (1981): *Base technologies*, *Key technologies* and *Pacing technologies*. Dussauge et al (1992) points out clearly, it is not the characteristic of the technology that is important *per se*, but the competitive role it plays within a business. Consequently, a technology can be a base technology in one business, a key technology in another business, and a pacing technology in a third business. To exemplify they give the example of CAD and its influence in the aero-space, the automotive and the textile industries.

2. INNOVATION

Innovation, like technology, is a volatile concept. In wide terms it may be considered as one or several changes in organisational, technical, commercial or market level. In narrow terms innovation is considered as technological innovation, being either the result of the commercialisation of a new, or improved, product in the marketplace or the improvement of the production process.

In generic terms innovation only takes place when the new product or process is commercialised. Therefore, innovation implicitly demands the existence of both a potential market and a technical knowledge to satisfy it. The OECD (1993) synthesises innovation as the commercialisation of a product previously submitted to a technological modification.

According to Schumpeter (1943) innovation ought to be understood as the engine of development as new firms would be created to exploit new opportunities in a creative destruction process. Innovation must be considered an attitude (Sánchez et al, 1988) i.e., the capacity of adaptation of the product/service to market and technological environment, which requires the adaptation of the whole organisation and its intra- and inter-organisational processes.

A key aspect of technological innovation is that it combines different phases that relate general knowledge to the utilisation of technology, called ***Innovation Process*** (Roberts et al, 1978; Utterback, 1971). This innovation process has different phases that link the process of opportunity identification and ideas generation to the process of implementation and diffusion of innovation. Although the number of phases varies for different authors (Roberts et al, 1978; Utterback, 1971) Mañas (1993) proposed a never-ending process that relates the conception, invention, innovation and diffusion phases, which is very advantageous for firms in the value chain.

Rothwell (1993) demerits the literature debate about the number of phases in the innovation process and the technology-push/innovation-pull approach and proposed a new school of thought in which the technology of the technological change was itself changing. Rothwell (1993) called this innovation process of the fifth generation as a *System Integration and Networking Model*. In it there is an

increased focus on non-price factors, as quality and design, as well as a strong linkage with leading-edge clients and suppliers along the value chain. The key features of this innovation process are integration, flexibility, networking, and real time information process

Although technological innovation has captured the interest of research, there are two questions that have no simple answer: a) What is behind innovation? and b) What is necessary to make it happen? (Tidd et al, 1997). As there are cases in which innovation happens in spite of poor management (Pildicht, 1991) and there are cases in which despite all the efforts and resources committed to the new product innovation is doomed to failure (Pearson, 1991), it is imperative to approach innovation as a concept perspective.

There are two studies that grounded the success of technological innovations. In the first one Langrish et al (1972) researching the Queen's Awards for technological innovation identified seven key success factors and six factors that delay innovations. The former seven factors are: a) the presence of a top person with authority; b) some other type of outstanding individual; c) a clear identification of the need to be served; d) the realisation of potential usefulness of a discovery; e) a good co-operation; f) the availability of resources; and g) the support from government sources. The six factors that delay innovations are: a) a technology not sufficiently developed; b) no market or no need; c) potential not recognised by management; d) resistance to new ideas; e) shortage of resources; and f) poor co-operation or communication.

In the second study, the Project SAPPHO came up with evidence that the distinguishing pattern between success and failure of an innovation could be summarised in five statements (Twiss, 1978; Coombs et al, 1987):

1. Successful innovators seem to have a better understanding of users' needs;
2. Successful innovators pay more attention to marketing;
3. Successful innovators perform the development work more efficiently, though not necessarily more quickly, than unsuccessful innovators;
4. Though successful innovators perform most of the work in-house, they use both outside technology and advice more efficiently than the unsuccessful ones; and
5. The responsible individuals in the successful attempts are more senior and have greater authority than their counterparts who fail.

Pavitt's work (1990) was a corner point in the study of innovation: he suggested that due to both the cumulative nature of the firm's competencies and the uncertainties around innovative activities the firm's learning capacity would be fundamental for success. He believed that successful technological innovation would be determined by two factors: firm's size and its accumulation of techno-

logical competencies. In his research he concluded that a successful management of technology requires three things from an innovative firm:

- the capacity to integrate functional and divisional boundaries for the implementation of innovation;
- a continuous questioning about appropriateness of markets, missions and skills for the exploitation of technological opportunities;
- the firm's willingness to take a long-term view of technology accumulation.

3. THE SUPPLIER-CLIENT RELATIONSHIP

The relationship between the suppliers and their clients has never been simple and only recently the word relationship has been used. Macaulay (1963) was among the firsts who claimed that the most important aspects in the user-client relationship were not explicitly mentioned in the contracts celebrated between the partners. He argued that it was necessary clear effective relationship between both.

Hakansson (1987) proposed an *interactive approach*, known as the IMP (*Industrial Marketing and Purchasing*) model, based on the observation of clients (large firms) and their suppliers in industrial environment. This model identified four types of variables that describe and influence the interaction between the supplier and the client: the elements and the interaction process, the participants in the interaction, the atmosphere where the interaction happens and finally the factors that affect the interaction. In agreement with this model the most important factors that affect the supplier-client relationship are the accumulated technology, the structure and the size of the firm. Nowadays it is recognised that the last two are strongly dependent on the first one.

It is clear that different authors approach the user-producer relationship through different perspectives. Williamson (1975), based on the transaction-cost economics, found two different situations: a market-based relationship and a hierarchical one, which led to an *obligational contracting* model (Williamson, 1979). Sako (1982) analysing the electronics industry in Japan presented the model ACR-OCR (*Arm's-length Contract Relation-Obligational Contract Relation*) with two extreme ends: remote relationship and close relationship. More recently, Lamming (1993) based on the automotive industry, proposed a model in which the customer-supplier relationship evolves from a '*traditional*' phase to a '*stress*' phase, then to '*resolution*' phase, and ultimately resulting in a '*partnership*'[1].

[1] The '*partnership*' phase was achieved based on a) reduced total value-chain cost, b) improved quality, c) continuous improvement and d) long-term commitment.

Bertodo (1991) proposed a co-operative view that makes the difference in the value chain. According to him, the relationship between manufacturers and their key suppliers is an important element of competitive advantage able to influence effectiveness, cost and cycle time. He proposed the concept of *co-producer*, which allowed mutual benefits for both producers and suppliers. The concept of co-producer departed from the concept of co-makership (Philips, 1985) and has evolved to the concept of co-specialisation (Dyer, 1996). It was Dyer's (1996) work that shed new light in the inter-firm production network specialisation. He demonstrated that quality, speed of new product development, inventory costs and profitability[2] were affected by the extent to which the firm and its suppliers make site, physical and human asset-specific investments.

4. RESEARCH QUESTIONS

The globalisation process has dramatically changed competition: if in former times it was heavily conducted at nation level, it is now much more dependent on firms' competitive behaviour. MNCs have been important players in the globalisation process. Their role in the transfer of technology has been subject to in-depth research though extremely focused in the classical perspective, i.e., much more oriented to the transfer between nations than between firms (Samli, 1985; Reddy et al, 1990).

MNCs use a diverse source of technology inputs and play a diverse role in host countries (White and Poynter, 1984). In Portugal the impact of MNCs has been addressed by Simões (1993) though information about the degree of autonomy, the complexity of industrial activities and the technology transfer upstream in the value chain is missing.

More recently, Ferdows (1997) addressed the strategic role played by foreign subsidiaries. His research has been important to study how different subsidiaries have evolved in their primary strategic role, nevertheless the role played by the subsidiaries' suppliers remained unaddressed.

It is clear that the relationship in the value chain is of fundamental importance for both the supplier and the client. It is also clear that a more co-operative behaviour is mandatory. What is not clear is how indigenous SMEs and foreign MNCs in Portugal interact with each other and how Portuguese SMEs accumulate technology from this relationship.

The importance of a dynamic organisation receptive to innovation is acknowledged as a critical success factor for technological development. What is not clear is the role MNCs play as major innovation players upstream in the value chain.

[2] Profitability was measured in terms of a) automaker ROA and b) suppliers ROA.

If a) technological innovations are highly differentiated, firm-specific, and cumulative in nature and b) the cumulative nature of firm's competencies play a major role in successful innovations, then one question arises: is it possible in a MNC-SME, user-producer relationship to witness cumulative technological innovations? If so, the questions seems to be pertinent not only from the technology accumulation perspective but also from the public policy one.

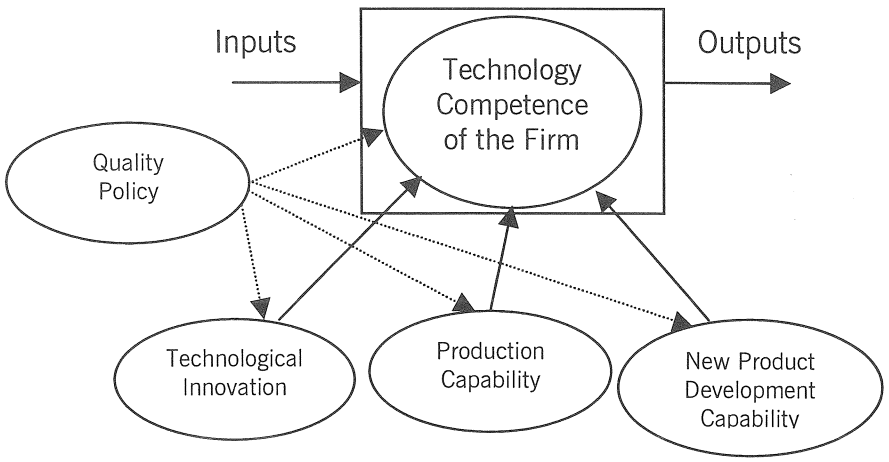
In summary, the international business literature about MNCs has focused on a) how local capabilities in foreign affiliates change relatively to headquarters and b) how foreign affiliates' roles varies at corporate level. What is not yet clear is how SMEs supplying to MNCs' affiliates can a) effectively build capabilities and accumulate technology and b) strategically underpin MNCs' affiliates strategic role relatively to headquarters level. Clearly this article addresses part of the first question.

5. RESEARCH METHODOLOGY

The research methodology consisted in four main steps. The ***first step*** consisted in the formulation of the analysis framework of the technology transfer mechanisms between MNCs and SMEs. This framework underpinned the subsequent work. The technology mechanisms are exhibited in figure 1 and were based on Simões' work (1995).

FIGURE 1

The Technology Competence of the Firm.



The selection of the firms took place in the ***second step***. The population for this study included two subsets of firms: the clients (MNCs) and the suppliers (SMEs). The definition of the sample to carry out the research was a major preoccupation. The absence of major sources from which information about SMEs could be easily obtained made the search for the population of firms an important aspect of the research process. The possible contribution of information, by MNCs, about their suppliers helped not only to overcome this difficulty but also influenced the methodological approach.

The identification of foreign MNCs was based on a) the relative importance of the twenty-six different economic sectors involving the largest firms operating in Portugal, b) the industrial perspective of the economic sector c) the size of the firm and d) Pavitt's taxonomy of sectoral patterns of innovation (1984). The proposed theoretical match between the sectors and Pavitt's taxonomy (1984) is the following:

- Clothing, Footwear and Leather (supplier-dominated sector);
- Chemical Industry (science-based sector);
- Electronic and Electric Industry (scale-intensive sector); and
- Transport Industry (specialised suppliers).

As all MNCs contacted confirmed the presence of industrial subsidiaries it was decided to approve the sample and proceed with the research. The collection of data involved tape-recorded, in-depth, semi-structured interviews with top executives and favoured a qualitative approach.

The data from the suppliers was obtained from released information from MNCs. Originally, the objective was to select five suppliers from each multinational subsidiary and to reach a sample of forty firms. This turned out to be impossible due to the following reasons:

1. not all suppliers were indigenous SMEs. In fact, in several cases the suppliers were not only large foreign firms but also larger than their multinational clients;
2. Several suppliers refused to concede the interview and to participate in the research; and
3. Some suppliers were commercial firms with a local representation to exploit the Portuguese market and not industrial firms.

Thus, it was decided to proceed with a pilot study trying to reach a *balanced* sample. The original sample only included 21 firms: five firms supplying automakers, ten SMEs supplying electronics MNCs, one firm supplying the chemical cluster and five SMEs supplying shoemakers. As the sample was clearly *unbalanced*, and

as it was impossible to reach a better sample even using *purposive sampling* among the population of suppliers, it was decided to drop the chemical MNCs and their suppliers from the study. Accordingly, the final sample of SMEs has only 20 firms and their characteristics are summarily presented in table 2. As with MNCs, it was decided to proceed with semi-structured, in-depth interviews.

The ***third step*** consisted on *in loco* interviews in the eight MNCs selected. This pilot study was set up to analyse the technology transfer between MNCs and SMEs in Portugal. Its main purpose was to:

- Categorise the various factories visited;
- Categorise the technology management in MNCs;
- Categorise their relationship with suppliers in the value chain; and
- Set up a data base of Portuguese SMEs supplying MNCs.

The ***fourth step*** consisted in analysing how local firms supplying to MNC affiliates in Portugal accumulate technology from their relationship with their suppliers.

6. CHARACTERISATION OF THE SAMPLE STUDIED

The sample of MNCs is shown in table 1. The firms selected for the research were the largest ones of the industry. As can be seen there is a great difference between the firms, being the two automakers quite large when compared to the shoemakers.

TABLE 1

Characteristics of MNCs.

Industrial Sector	Firms	Sales Volume (%)	Number of Employees
Vehicle	A	100,00	3 655
Industry	B	60,83	1 100
Electronics	C	25,88	1 800
Industry	D	46,84	780
Shoe	E	11,14	1 264
Industry	F	6,63	1 400

The dichotomy between firms of different industries was clear: whereas shoemakers have a loose relationship with their suppliers in upstream activities in the supply chain, automakers invest much more on a technologically and organisationally-based relationship. The suppliers of the electronics industry fall in between those supplying to automakers and shoemakers. Technology imposes

a technology-based relationship in which product quality, product development activities, quality certification and product complexity play an important role. As just-in-time delivery, product cost and delivery reliability are among the most used performance indicators by MNCs to deal with their suppliers, it can be said that technology plays an important role in the user-producer relationship in the value chain. In technology-based clusters such as the vehicle industry the clients (MNCs) are bound to co-operate much more with their suppliers than in traditional industries as is the case of the shoe industry, basically because firms are in different technology paradigms.

The characteristics of the sample of SMEs are presented in tables two and three. Generically it can be said that the sample of SMEs is more centred in production-based activities than in the marketing ones, which confirms studies about Portuguese industrial firms (GEPIE, 1992; Simões, 1995). The combination of production-based activities, lack of proper marketing structures and lack of innovative marketing activities place some firms closer to the MAP paradigm than to the CAP paradigm (Von Hippel, 1976; 1979), which means that the lack of organisational structures hinders the technology accumulation process.

The technology competence of the firm, as shown in table 3, was assessed using ordinal variables so that the progression from a low level of technology to a larger one could easily be spotted. In average, the suppliers to automakers have not only a better relationship in the value chain with their MNC clients but also a more developed technological competence than their counterparts in the electronics and in the shoe industry. It is also evident that the suppliers to shoemakers are the weakest of the three subset of suppliers.

An analysis of tables 2 and 3 points to the following conclusions:

- The SMEs supplying the shoe industry are, in general, the least developed in the sample, being the automakers suppliers the most developed ones.
- The relationship with clients varies extensively:
  - Those firms supplying shoemakers normally have episodic contracts with their clients, which is close to what Sako (1982) called *remote* relationship.
  - Those firms supplying automakers have *high-trust relationships* with their clients. This behaviour is underpinned on a strong quality/logistics shared management system and is very close to the *partnership* relationship proposed by Lamming (1993).
- The production capability of those firms supplying the shoe industry are quite modest when compared with the firms supplying the automakers. As in former cases the SMEs supplying the electronics industry closely follow those of the vehicle industry.

TABLE 2

Characteristics of SMEs

		Carmakers Suppliers	Electronics Suppliers	Shoemakers Suppliers	Total
Number of Employees	(0 - 24)		3		3
	(25 - 49)		1		1
	(50 - 99)	2	3	3	8
	(100 - 249)	3	3	2	8
Sales Volume	(0 - 249K)		3		3
	(250K - 499K)		2		2
	(500K - 999K)	2		1	3
	(1000K - 2399K)	3	5	4	12
Set up Date	(..... – 1954)	1	1	2	4
	(1955 - 1964)	1		1	2
	(1965 - 1974)	1	3	1	5
	(1975 - 1984)	2	4	1	7
	(1985 - .....)		2		2
Spatial Distri-bution	North	2	6	5	13
	Centre	3	3		6
	South		1		1
Sectoral Distribution	Package, Labels & Paper		1	1	2
	Metallic Products	5	5		10
	Plastic Injection		3		3
	Automation Eng.		1		1
	Chemical Firms			1	1
	Leather & Textiles			2	2
	Cork			1	1
Sectoral Patterns	Supplier-Dominated	1	4	4	9
	Specialised Supplier	4	3		7
	Science-Based			1	1
	Scale-Intensive		3		3
Exports (%)	(0 - 9)	1	5		6
	(10 - 19)		2	2	4
	(20 - 29)		2		2
	(30 - 69)	1		2	3
	(70 - ...)	3	1	1	5
Type of Owner.	Family-owned/Controlled	2	5	2	9
	Partnership	2	5	1	8
	Corporate Shareholders	1		2	3
Relation with Clients	Episodic Contracts		5	4	9
	Serial Contracts		3	1	4
	High-Trust Relationship	5	2		7
Production Capability	Elementary		5	2	7
	Standard	1	1	3	5
	Advanced	3	4		7
	Integrative	1			1
Devel. Capabil.	Absent / Limited	1	4	3	8
	Reactive	3	5	2	10
	Active	1	1		2
Technology Innovation Strategy	Traditional /Dependent	1	4	4	9
	Product Follower	2	5	0	7
	Product Specialist	1		1	2
	Innovator	1	1		1
Quality Registr.	No Registration		3	2	5
	ISO 9000 in Process		3	2	5
	ISO 9000 Registered	5	4	1	10
	Total number of firms	5	10	5	20

TABLE 3

Technological characterisation of SMEs

	Carmakers Suppliers	Electronics Suppliers	Shoemakers Suppliers	Average Firm
Relationship with Clients (3)	3	1,7	1,2	1,9
Production Capability (4)	3	1,9	1,2	2,1
Developmental Capability (3)	2	1,7	1,4	1,7
Tech. Innovation Strategy (4)	2,4	1,8	1,4	1,45
Quality Registration (3)	3	2,1	1,8	2,3

- The new product development capability as well as the technological innovation strategy follow the same patterns of the variables above-mentioned, being the suppliers of the auto industry well ahead of the rest of the sample.

As mentioned before, if the MNCs' sourcing behaviour varies according to industry then it is possible to assert that SMEs in different industries should have not only different types of relationship with their clients but also a different degree of induced technological competence. An example of this induced competence is shown by the variable quality registration: whereas all SMEs supplying the vehicle industry are ISO 9000 quality-certified firms, in the shoe and electronics industry the level of quality-certified SMEs is quite lower. It is obvious that the ISO certification is not important *per se*. What matters is that some competitive pressures are transferred upstream in the supply chain from the MNC to their indigenous suppliers. In this situation, those SMEs able to cope with the changes imposed in this demanding environment have been able to develop firm-specific learning capabilities in terms of new organisational behaviour as well in terms of technology management characteristics.

Although all the MNCs transfer part of their pressure to their local suppliers, in the automobile industry this process is clearer than in the shoe manufacturing industry. In the automobile industry the user-producer relationship has the following characteristics:

- Information flows easily from client to supplier;
- Product quality is emphasised. Product quality is an indicator of the supplier's effort to provide the best choice to the client;
- As information and quality are broadly available to MNCs, JIT delivery is implemented and suppliers are forced to source the clients on a more competitive basis;
- Once product cost, product quality, JIT delivery are part of the operational relationship between suppliers and clients, the product development capabilities play a more strategic role: they open a window of opportunity that assures the relationship based on the next generation product cycle.

Product cost and JIT delivery are two important variables underpinning the firms' quality management system. While the former one is strongly related to production capability, the latter one affects technological innovation strategies as well as the user-producer relationship. New product developmental capabilities underpin a dynamic relationship between the supplier and the client: it gives the opportunity to the supplier not only to deepen its R&D capabilities but also to co-operatively develop the next generation product. Thus, it can be said that whilst product cost, product quality and JIT delivery are operational variables of the user-producer relationship, new product development capabilities play an important strategic role in underpinning the evolution from a *serial-contract* to a *high-trust relationship*. In conclusion, it is clear that a bi-directional relationship is needed so that the endogenous capabilities of SMEs are broadly used by their MNC clients.

7. PRELIMINARY RESULTS AND DISCUSSION

As supplying an automaker requires different combination of skills and organisational, technological, and managerial capabilities than supplying a shoe manufacturer, it can be argued that the user-producer relationship is dependent upon two variables: the level of product/system technology and the degree of involvement of the supplier.

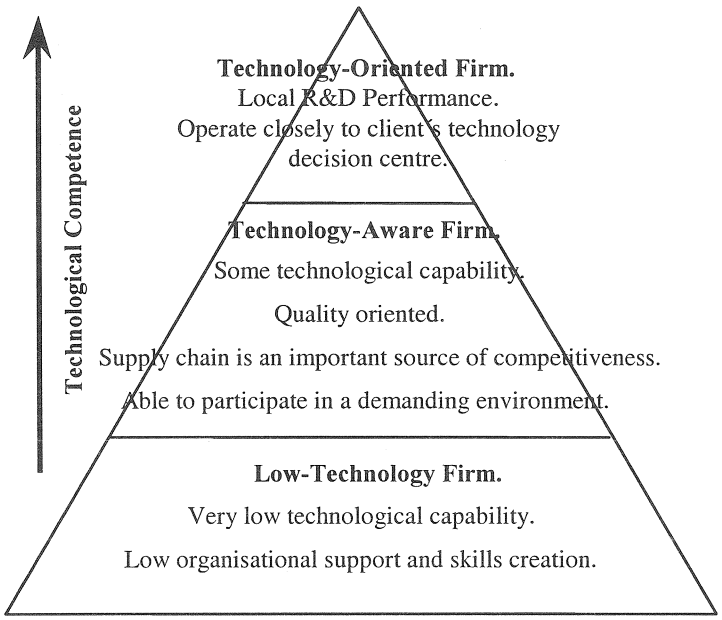
In order to approach the suppliers' evolution in the SME-MNC relationship a three-category pyramid is proposed, as showed in figure 2. It is clear that the firms are divided in three hierarchical categories of technological capability: the *Technology-oriented firm*, *the Technology-aware firm* and the *Low-technology firm*.

At the bottom of the pyramid most of the *low-technology firms* lack the minimum skills to either develop internally or acquire externally the technological capabilities to have a clear relationship with the customer. Necessarily, those firms have troubles identifying organisational, technological and managerial solutions to their problems. As they belong to the Manufacturing-Active Paradigm (Von Hippel, 1976) they have deep problems interpreting market needs. In this type of firms problem is twofold: they do not have the ability to accumulate knowledge due to lack of skills and consequently they are in no means to have a clear relationship with external sources of knowledge.

Technology-oriented firms are at the top of the pyramid. As they have broad market knowledge and tend to use their technological knowledge as competitive weapons they can be considered as part of the Customer-Active Paradigm (Von Hippel, 1979) and they use innovative processes of the fourth and fifth generation (Rothwell, 1993). For these firms the R&D function is always present. They use both internal and external means of technology. As opposed to low-technology

FIGURE 2

Categorisation of Types of Suppliers to MNCs.



firms, technology-oriented firms have developed the skills to manage a clear relationship with the customer. In this way the technology source has shifted from a unilateral to a bilateral relationship. They operate in a complex, competitive environment and are able to compete in technological terms.

The third category, *technology-aware firms*, lay in between the other two. Firms operating in this category have some technological capabilities, but do not take technology as a core competence. Consequently, they lack the technological knowledge to compete using technology as a competitive weapon. They have developed some organisational, technological and managerial skills, and are able to participate in a demanding environment. In their relationship with MNCs they have developed an important deal of competitiveness. As opposed to low-technology firms, they have been able to cope with the competitive pressures of their customers. This demanding environment forced the firms to a) extensively assimilate the new technologies they were in contact with, b) improve product quality and c) improve plant layout and production practices. As opposed to technology-oriented firms, they have not yet been able to extensively replace old processes and products by new ones. Their lack of technological capabilities have hindered the creation of internal innovation.

The great advantage of the categorisation is that it reflects a dynamic performance perspective and not a static one. Its main disadvantage is related to the weighted average that should be given to each individual variable used, which is still unknown.

The patterns of technology evolution among suppliers using the proposed categorisation is shown in table 4. The differences between the suppliers are clear and reflect the industrial technological intensity under consideration. Among suppliers a snowball effect seems to be present in some circumstances. In the auto industry as most SMEs have developed an initial critical mass in terms of knowledge/technology, the relationship with multinational clients has generated a cumulative effect in organisational, technological and managerial skills. This created a virtuous circle of development among the suppliers, and one of them can be considered as *technology-oriented firm*.

TABLE 4

Technological Categories among SMEs.

	Carmakers Suppliers	Electronics Suppliers	Shoemakers Suppliers	Total
Technology-oriented firms	1			1
Technology-aware firms	4	5	2	11
Low-technology firms		5	3	8

Most of the firms supplying to the shoe industry have not yet developed a critical mass and consequently their relationship with their multinational clients have not yet sparked a cumulative effect in organisational, technological and managerial skills. Clearly, the suppliers to the electronics MNCs are somehow in an intermediary position between those supplying the automakers and the shoemakers. Thus, it seems that if SMEs are to take full advantage of the MNCs contribution, a minimum level of technology/knowledge is needed to develop a full abortive capacity among suppliers to those MNCs.

8. CONCLUSIONS

One conclusion seems to be clear: the user-producer relationship seems to be technology dependent and sector-specific: the greater a) the technical complexity of the product and b) the subsystems involved in the relationship, the deeper the relationship between both partners. This is why the quality-logistics-developmental activities seem to be differently endowed in different firms of different industries.

The client plays an important role: the greater the technology intensity of the industrial sector the greater the likelihood the clients are bound to co-operate with their suppliers. In another vein, the presence of strong technically oriented customers, committed to superior quality achievements is of fundamental importance as a pull mechanism in the upgrading of the quality performance of their suppliers.

Quality management seems to underpin the supplier-client relationship in two ways: firstly, it is the bedrock of the firm's capability to supply products reliably and secondly, it is the first step to develop a more fluid relationship in the value chain. The lack of proper quality systems hinders the evolution from traditional/dependent strategies to product specialist/innovator strategies.

Product development capabilities are important as well: they underpin a bi-directional relationship, based not only on operational performance, but also on technological capabilities, which creates a more trustworthy environment between the supplier and the client.

In order to properly develop a secure source of inputs the client's role is also important in imposing high quality standards and proper developmental capabilities: it sparks off high quality levels and transfers some technological knowledge backwards in the supply chain.

In order to evolve from a *low-technology firm* to a *technology-oriented firm* some supply and demand conditions are necessary. The presence of R&D capabilities and high quality standards among suppliers is important to diminish the impact of markets dificulties (especially from MNCs) and accelerates the trajectory to higher levels of technology competence. The demand side plays the complementary role in the supply side: whilst the presence of tough, technology-oriented MNC clients normally force suppliers to focus their strategic approach towards a fluid, technology-based relationship, the presence of less sophisticated clients tend to create an *episodic-contract* atmosphere based on *traditional/dependent* strategies. In conclusion, the presence of sophisticated MNCs in technology intense industries facilitates the evolution of SMEs from lower levels of technology to more advanced ones.

An interesting question that deserves a closer approach in the near future is whether/how organisational inadequacies hinder technology evolution. Finally, two important limitations deserve to be mentioned. The first one is related with the limited sample size. In order to circumvent the problems of a balanced sample it should be advisable to include larger firms as well. The second limitation of the study is that success/failure cases of evolution from one level of technology to the following one were not presented. Thus, in order to come up with distinguishing patterns of success and failure, as in the Queen's Awards study and project SAPPHO, the endogenous characteristics of SMEs should be studied deeply.

Bibliography

BARANSON J. (1978), "Technology Transfer: Effects on US Competitiveness and Employment", in US Department of Labor. *The Impact of International Trade and Investment on Employment*, Washington.

BERTODO, R. (1991), "The Role of Suppliers in Implementing a Strategic Vision", *Long Range Planning*, Vol. 22, pp. 40-48.

COOMBS, R., SAVIOTTI, P. and WALSH, V. (1987), *Economics and Technological Change*, Macmillan, London.

CORNWALL, (1977), *Modern Capitalism: Its Growth and Transformation*, Martin Robertson, London.

DUSSAUGE, P., HART, S. and RAMANANTSOA, B. (1992), *Strategic Technology Management*, John Wiley & Sons, Chichester.

DYER, J. H. (1996) "Specialised Supplier Networks as a Source of Competitive Advantage: Evidence from the Auto Industry", *Strategic Management Journal*, Vol. 15, pp. 271-291.

FERDOWS, K. (1997), "Making the Most of Foreign Factories", *Harvard Business Review*, March-April, pp. 73-88.

HAKANSSON, H. (1987), *International Marketing and Purchasing of Industrial Goods: An Interaction Approach*, Wiley: Chichester.

LAMMING, R. (1993), *Beyond Partnership. Strategies for Innovation and Lean Supply*, Prentice-Hall, Cornwall.

LANGRISH, J., GIBBONS, M., EVANS, W. and JEVANS, F. (1972), *Wealth from Knowledge*, Macmillan, London.

LITTLE, A. D. (1981), *The Strategic Management of Technology*, European Management Forum, Davos.

MACAULAY, S. (1963), "Non-contractual relations in business: a preliminary study", *American Sociological Review*, vol. 28, nº1, pp. 55-66.

MAÑAS, V. A. (1993), *Gestão da Tecnologia e Inovação*, Érica, São Paulo.

NELSON, R. and WINTER, S. G. (1982), *An Evolutionary Theory of Economic Change*, Harvard University Press, Cambridge.

OCDE (1993), *Principes Directeurs Proposés par l´OCDE pour le Récueil et l´Interpretation des Donées sur l´Innovation Technologique* - Manuel d´Oslo, Paris.

PAVITT, K. (1984), "Sectoral Patterns of Technical Change: Towards a Taxonomy and a Theory", *Research Policy*, Vol. 13, pp. 343-373.

PAVITT, K. (1985), "Technology Transfer among the Industrially Advanced Countries: An Overview", in ROSENBERG, N. and FRISCHTAK, C., *International Technology Transfer: Concepts, Measures, and Comparisons*, Praeger, New York.

PAVITT, K. (1990), "What we Know About Strategic Management of Technology", *California Management Review*, Spring.

Pearson, A. W. (1991), "Managing Innovation: An Uncertainty Reduction Process" in Tidd, J., BESSANT, J. and PAVITT, K. (Eds.), *Managing Innovation*, Wiley & Sons, Chichester.

PHILIPS N. V. (1985), *Co-makership: Purchasing in Benelux*, Philips NV, Eindhoven,.

PILDICHT, A. W. (1991), "What Makes a Winning Company?" in TIDD, J., BESSANT, J. and PAVITT, K. (Eds.), *Managing Innovation*, Wiley & Sons, Chichester.

PORTER, M. E. (1989), *Vantagem Competitiva*, Editora Campus, Rio de Janeiro.

REDDY, N.M. and ZHAO L. (1990), "International Technology Transfer: A Review", *Research Policy*, Vol. 19, pp. 285-307.

RIBAULT, J. M., MARTINET, B. and LEBIDOIS, D. (1995), *A Gestão das Tecnologias*, Publicações Dom Quixote, Lisboa.

ROBERTS, E. B. and FROHMAN, A.L. (1978), "Strategies for Improving Research Utilization", *Technology Review*, March-April.

ROSENBERG, N. (1982), *Inside the Black Box*, Cambridge University Press, Cambridge.
ROTHWELL, R. (1993), "Systems Integration and Networking: The Fifth Generation Innovation Process", presented at Chaire Hydro-Québec, Conference en Gestion de la Technologie, Université de Québec à Montreal.
SAMLI, A. C. (1985), "Technology Transfer: the General Model", in Samli, A.C. *Technology Transfer, Geographic, Economic, Cultural and Technical Dimensions*, Quorum Books, London.
SÁNCHEZ, E. F. and CASARIEGO, Z. F. (1988), *Manual de Dirección Estratégica de la Tecnologia, La producción como ventaja competitiva*, Ariel Económica, Barcelona.
SAKO, M. (1982), *Prices, Quality and Trust: Inter-firm relations in Britain and Japan*, Cambridge University Press: Cambridge.
SCHUMPETER, J. A. (1943), *Capitalism, Socialism and Democracy*, Allen & Unwin, London.
TIDD, J., BESSANT, J. and PAVITT, K. (1997), *Managing Innovation*, Wiley & Sons, Chichester.
TWISS, B. C. (1978), *Gestión de la Innovación Tecnológica*, Deusto, Bilbao.
SIMÕES, V. C. (1993), *Impacto do Investimento Directo Estrangeiro na Estrutura Industrial Portuguesa*, Direcção Geral da Indústria e CGTP-in, Lisboa.
SIMÕES, V. C. (1995), *Inovação e Gestão em PME Industriais Portuguesas*, GEP - Gabinete de Estudos e Planeamento do Ministério da Economia, Lisbon.
UTTERBACK, J. M. (1971), "The Process of Technological Innovation within the Firm", *Academy of Management Journal*, Vol.80, pp 75-88.
VON HIPPEL, E. (1976), "The dominant Role of Users in the Scientific Instruments Innovation Process", *Research Policy*, Vol. 5.
VON HIPPEL, E. (1979), "A Customer-Active Paradigm for Industrial Product Idea Generation", in BAKER, M. J. (ed.) *Industrial Innovation*, Macmillan, London.
WHITE R. E. and POYNTER, T. (1984), "Strategies for Foreign-Owned Subsidiaries in Canada", *Business Quarterly*, Summer.
WILLIANSON, O. E. (1975), *Markets and Hierarchies*, The Free Press: New York.
WILLIANSON, O. E. (1986), *Economic Organization: Firms, markets and policy control*, Wheatsheaf: Brighton.
WOODWARD, J. (1977), *Organização Industrial: Teoria e Prática*, Atlas, São Paulo.