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TECHNOLOGY NETWORKING AND PRODUCTION MANAGEMENT IN SPANISH AUTOMOTIVE SUPPLIER CLUSTERS

1.1. Inter-firm networks and strategic alliances - international versus regional patterns

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Abstract. The automotive industry has undergone tremendous transformation during the 1990s. One of them is the importance of knowledge-sharing networks to access to technology, innovation and training. Firms having a strong supplier network report higher leveles of productivity and quality than those reporting weak alliances over time. However, very few empirical studies exist on the relationship between networking and production and process innovativeness. This paper tests the underlying relationship between lean production and networking. Using data from an automotive supplier network in northeast Spain, the empirical results found that networking companies did more in-house training and teamwork than non-networking suppliers. No significant relationship was found with Just-in-Time delivery.

Key words: Automotive networks. Knowledge-sharing. Workforce flexibility. Just-in-Time.

1. Introduction

The automotive industry has undergone tremendous transformation during the 1990s. This transformation has occurred in may areas such as product development, inventory management, supplier involvement, amongs others (Freyssenet et al, 1998). Increasingly, the delivery of high quality products is taken as granted by the manufacturers, which are contracting-out development jobs and the integration of new components to their suppliers in order to optimize the whole supply chain. The repercussions of this process are starting to make themselves felt even on the level of the third-tier suppliers, mostly part suppliers, which have to adapt by increasing their product quality as well as their technical and technological competencies and by shortening the product cycle. Nowadays automobiles are developed and manufactured by Original Equipment Manufacturers (OEMs) and their supplier networks, who produce as much as 70 percent of the value of a vehicle. Consequently, the cost and quality of a vehicle are a function of the productivity of a network of firms working in collaboration. Thus, the need to have increased access to technology, innovation and training which regards all suppliers at the different levels of the supply chain.

Isolated from each other, single suppliers may not be in a position to meet the future market requirements. Enterprise cooperations offer small enterprises the opportunity to draw upon resources which enable to collectively master more complex challenges (Kleinknecht and Reijnen, 1992). However, small and medium sized enterprises (SMEs hereafter) are slow to seek such solutions and only rarely engage in an active search for partners. While SMEs face difficulties in actively engaging in cooperations, enterprise networks and clusters offer an adequate framework for responding to the increasingly demanding requirements from the leading companies. By joining forces, both horizontally and vertically, and learning from other partners from the supply chain, SMEs are put into a position to compete. Moreover, the importance of enterprise networks is increasing in terms of facilitating enterprise access to resources such as technology, qualification, information on market requirements, and business support services. Therefore, while trends towards globalization in the automotive industry appear to reduce the importance of regions, there are countervailing tendencies on the regional level with enterprises in the same or related industries developing an interest to cluster (Schlie and Yip, 2000).

The purpose of this paper is to test some production practices differences between networking and non-networking automotive suppliers. Even though there are some studies which have addressed the diffusion of best production practices through the supply chain (Helper and Sako, 1995; Dyer, 1996a; MacDuffie and Helper, 1997), there are very few studies of the influence from automotive networks and clusters on production practices. The paper is organised as follows. The second section reviews the literature on automotive networks and clusters, gives some background information on automotive networks, and establishes the paper´s research objectives. The third section briefs the methodology of the empirical study and shows the empirical results on the relationship between networking and transfer of information, workforce flexibility, training, and Just-in-Time delivery. Finally, some concluding remarks are included.

2. Networking and clustering in the automotive industry

2.1. Definitions

‘Network’ and ‘cluster’ are two related terms. By definition, a network encompass a firm´s set of relationships, both horizontal and vertical with other organizations including relationships across industries and countries. On the other hand, the term ‘cluster’ usually includes a ‘network’ of related firms and encompass one or more of the following dimensions: formal input-output of buyer-supplier linkages; geographic co-location; shared business-related local institutions; and evidence of formal or informal co-operative competition (Feser and Bergman, 2000). A definition proposed by the OECD characterised clusters ‘as being networks of production of strongly interdependent firms (including specialised suppliers), knowledge production agents (universities, research institutes, engineering companies), bridging institutions (brokers, consultants) and customers, linked to each other in a value adding production chain’. In short, a cluster is but one form of network, a strong collection of related companies located in a small geographical area and formally institutionalized.

2.2. Automotive supplier clusters

A number of cities, states and regions in the US and Europe developed cluster-based strategies in the 1990s, though the logic behind such initiatives is often poorly specified or simply not recognized as relevant (Doeringer and Terkla, 1995). In several European automotive regions regional development policies have promoted the development of regional technology networks, i.e. networking activities between SMEs clusters and technology poles. Although there is a great deal of variation in the structure and dynamics of different regional technology networks, they can operate in such a way that fosters regional innovation through enhancing the access of SMEs to technology, encourages technological spillovers and produces economies of scale and scope. Successful european automobile cluster and networks are the VIANRW in Nordheim-Westfalen (Germany), the ACstyria around Graz (Austria), the CISFI in Torino (Italy), or the WAF in Wales (United Kingdom).

In Spain there are seven automobile regions. However, only two formally institutionalized automotive cluster organisations exist. The most important is located in the Basque Country with the name of ACICAE (*Agrupación Cluster de Industrias de Componentes de Automoción de Euskadi*). It was constituted in June 1993 by 12 founding companies, and by September 2000 ACICAE had evolved into a grouping of 27 leading automotive suppliers with a total workforce of around 12,200 (for fear of being dominated by the resourceful car manufacturers, the latter are barred from being members). In total, the Basque automotive cluster comprises nearly 250 firms with a total workforce of some 39,000 people. The turnover contributes to more than 25% to the Basque GDP and accounts for a third of Spain's automotive industry. The second Spanish automotive cluster is located in Galicia and it is very much smaller. Basque and Galicia clusters provide services to the member companies and promote horizontal cooperation throughout the industry and with technology poles. Other Spanish regions have groups of automotive suppliers which have business and technology relationships within the industry and with technology poles (universities and research centres) but they are not formally institutionalized. One of these regions, Aragon in the northeast of the country, is about to develop a cluster from the existing network and it will be the object of the empirical study.

2.3. Background theory: state of the art

There is a growing body of research in strategy that is coming to term with the economic consequences of firms participating in strategic networks: joint-ventures, strategic blocks, strategic supplier networks, learning in alliances, inter-firm trust, network resources, and social context. Given the rapid proliferation of alliances and other forms of interfim relationships in recent years in the automotive and other industries, neglecting the strategic networks in which firms are embedded can lead to an incomplete understanding of firm behaviour and performance (Gulati et al, 2000). For example, the strong, relational ties of the japanese automobile industry with their suppliers clearly played a role in its performance and profitability (Cusumano, 1985; Dyer, 1996a). Similarly, firm relationships allow to identify intra-industry groups of firms with alliances with each other but not to others in the industry, which lead to differences in profitability among the firms (Nohria and Pont, 1991).

Glaister and Buckley (1996) have proposed several reasons to explain why strategic alliances have become so trendy in the automotive industry. Firstly, the production process in the automobile sector is characterised by economies of scale and learning by doing: thus, firms may attempt to reduce costs expanding out to achieve these benefits. Secondly, strategic alliances may be used as a defensive ploy to reduce competition or in order to put some pressure on a common competitor. Thirdly, it may help firms to move to new foreign markets, and to the development of a global strategy. And finally, the alliances may be used to bring together complementary skills and talenty that cover different aspects of the know-how needed in the development of new automobiles.

Following the resource-based view of the firm, a firm´s network of ties represent a valuable resource that can yield differential returns in the same way as other tangible and intangible assets such as automobile brands or R&D capabilities. Firms having a strong supplier network report higher levels of productivity and quality than those reporting weak alliances over time (Stuart, 1997). Dyer and Nobeoka (2000) illustrate such a resource with the Toyota´s supplier network in the US and benefits that accrue to both Toyota and its suppliers as a result of the trust and complex incentive that Toyota uses in its network; however, an attempt to replicate some aspects of the network by General Motors failed. As any other strategic resource, networks may evolve over time shaped by exogeneous and endogeneous forces such as managerial action and/or policy events (Madhavan et al, 1998). For instance, the rise of japanese competition followed by the threat of US and european trade protectionism triggered the pattern of strategic alliances observed in the global automobile industry during the 1980s (Nohria and Pont, 1991).

According to the literature (Rothwell, 1991; Kleinknecht and Reijnen, 1992; Hagedoorn, 1993), firms collaborate for a number of reasons, the most common being access to complementary technology and access to new markets. In some cases the motive to collaborate is to spread the high cost and risk associated with the development of new products based on technological breakthroughs. Table 1 shows, as an example, the most important reasons cited by the Basque automotive cluster for participating in an enterprise network (Agiplan, 1999). Despite these apparent benefits, empirical evidence on the one hand suggests that cooperation carries a high risk of failure, while on the other hand many seemingly profitable cooperative partnerships are not consummated. High organizational costs and possible drain of knowledge are the two most frequent barriers against networking. Firms expose, transfer and develop valuable know-how within these cooperative technology ventures. Such information flows, when uncontrolled, can undermine the long-run technological advantage of firms.

Table 1. Reasons of Basque automotive suppliers for participating in enterprise networks

Reason	Very important	Important	Not important
Exchange of know-know/Access to new technologies	43	50	7
Strengthening client-supplier relationship	39	39	22
Use of comparative advantages	34	46	20
Access to new markets	32	58	10
Benchmarking	29	61	10

Source: Agiplan, 1999

The nature of technological innovation will affect the characteristics of interorganizational linkages. For example, products based on technological breakthroughs require substantial in-house R&D, but typically do not demand strong links with suppliers or customers. In the automobile industry, strategic alliances between competitors are increasingly common. Often development work is divided up on the basis of technological specialization, but the motivation is to share cost and risk, rather than seek complementary expertise (Alvarez and González, 1999). Gupta et al (2000) found a positive relationship between R&D and networking. In their study of US technology-based firms, they found that involvement of suppliers and participation in joint-venture/strategic alliances in the R&D process was greater in high-R&D effective organizations than in low R&D-effective. Similarly, Baptista and Swann (1998) found that firms in clusters were more product innovative. Following this line of research the purpose of this paper is to test the effect of networking on production and process innovativeness.

2.4. Research questions

Lean production is a well-know production system in the automobile industry. Many lean practices have been diffused through the supply chain (MacDuffie and Helper, 1997). Three key elements of a lean production system are: training, teamwork and Just-in-Time delivery (Womack et al, 1990). The research hypotheses proposed in this paper try to establish an underlying relationship between lean production and networking. Because access to technology and knowledge is a primary reason for a firm to join a network or cluster, automotive suppliers which do networking should be more process innovative and should have a greater diffusion rate of lean production practices than non-networking suppliers.

Most of the networks and clusters in the automobile industry are characterised by knowledge-sharing and technology flows. Supplier partners willing to achieve a sustainable competitive advantage for networking should try to acquire a specific knowledge, and develop a thorough understanding of the new knowledge, instead of limiting themselves to gain access to it from their strong partners. But externally-generated knowledge usually takes longer to integrate with the firm´s existing knowledge base because it may be harder to richly understand and interpret, and even more if the knowledge is mostly tacit and complex in nature and the firm lacks expertise in the area or the external learning comes in the later stages of technology development (Kessler et al, 2000). Therefore, developing knowledge capabilities in cooperation with other companies requires in-house training because a firm´s utility to continually learn, adapt, and upgrade its capabilities is key to competitive success. This leads to our first hypothesis:

H1: Networking suppliers will have more in-house training on production and technology than non-networking companies.

The production process in the automobile industry is characterised by economies of learning-by-doing and learning-by-using (Glaister and Buckley, 1996). This means that managers and technical employees can learn about how to innovate and increase efficiency by carrying out their activities of solving production problems and meeting customers´ requirements. Knowledge that is understood only by an individual or a small group of specialist does an organization little good. Organizational learning does not occur until the knowledge is transfered throughout the organization, integrated with other knowledge areas and applied to new products and processes. Successful automobile production networks like the Toyota case, use a variety of processes that facilitate knowledge transfers among members (Dyer and Nobeoka, 2000), but most of them make use of cross-functional teams and inter-firm employee transfers, which are in need of job rotation and teamwork within the companies. This leads to our second hypothesis:

H2: Networking suppliers will have more teamwork than non-networking companies.

Just-in-Time production delivery is perhaps the most common feature among the portfolios of buyer-supplier relationship in the automobile industry (Bensaou, 1999; Autochain, 2000). However, Just-in-Time delivery is not an objective of knowledge-sharing networks but a prerequisite of the automaker´s production system. Suppliers must apply to this practice, no matter their involvement in product design or in any other knowledge-sharing activity with the automakers. Therefore, and even though Just-in-Time delivery is a well-known lean production practice, we propose as our third hypothesis:

H3: Networking suppliers will have no difference deliveries of their production Just-in-Time than non-networking companies.

3. Technology networking and production management in the Aragonese automotive industry

To test these three hypotheses, an empirical study has been carried out among the automotive suppliers of an Spanish region. Next sections briefs the methodology followed by the results and their discussion.

3.1. Sample and data collection

In the northeast Spanish region of Aragón, there are an assembly plant of Opel-GM and 120 automotive suppliers -according to the 1998 regional Census of Manufacturers- that deliver to that plant and to other european automakers. Opel-GM located its assembly plant in 1982 and more than half of the suppliers were created since then. The automobile industry contributes to 15% of regional employment and 32% of industrial GDP. Approaches are being carried out by government agencies to establish a formally institutionalized automotive cluster in the region. There are very promising starting points for this cluster. Regional technology networking activities have grown bottom-up and encompass a wide range of institutions and companies. Some of the suppliers already do networking with other automotive companies and with research centers. The automobile industry has been one of the strategic sectors studied under the Regional Innovation Survey (RIS) financed by the European Union.

In order to get knowledge of the networking and production practices realized by the Aragonese automotive suppliers, a survey was made from January to April of 1999. The objective population for this study were the companies with more than 50 employees which account for 53 companies. The other companies are rather small (less than 10 employees in most cases) and are third-tier suppliers for many other industyries besides the automobile. The authors interviewed each company´s CEO or Operations Manager. Before each interview a questionnaire and an introductory letter were e-mailed or faxed to the company to let them elaborate a few quantitative data later needed during the interviews. The introductory letter described the purpose of the study and guaranteed confidentiality of individual responses. Seventeen out of the fifty three suppliers refused to participate in the study and eight more companies were later discarded from the study because of incomplete data. Eventually there were twenty eight useful questionnaires. This number represents 52% of the objective population of companies and 91% of the employment in the automotive supplier industry. Table 2 shows some descriptive data of the surveyed companies. Their turnover destination was 70% to the automakers and 30% to other automotive suppliers, and geographically 63% was sold in Spain, 30% in en European Union and 7% in other countries.

Table 2. Descriptive statistics of the surveyed Aragonese suppliers

Employment	Total	Sample	% sample
Less than 50	32	11	39.3
Between 50 and 250	17	13	46.4
More than 250employees	4	4	14.3

Company´s first year in business	Nº	%
Before 1980	12	42.8
Between 1980 and 1990	3	10.7
From 1991 onwards	13	46.4

Sales	Nº	%
Less than 6 millions of euros	8	28.5
Between 6 and 30 millions	11	39.3
More than 30 millions of euros	9	32.1

Capital-ownership	Nº	%
Spanish	18	64.3
Foreign	10	35.7

Source: Own elaboration. Number of companies = 28

Table 3 shows the descriptive statistics of the variables used in the empirical study to test the paper´s research hypotheses. The only bivariate correlations which are significant at least at the 95% level are between: TRAIN and R&D ($r = 0.52$ $p = 0.004$), ROT and EM.TR ($r = 0.49$ $p = 0.008$), and MHCN and ROB ($r = 0.48$ $p = 0.009$).

Table 3. Descriptive statistics

	EMPL	R&D	TECH	MHCN	ROB	COM
Mean	167	1.1	2.9	3.4	2.3	18.9
S.D.	242	1.2	3.8	4.8	3.6	31.9

	JIT	TRAIN	EM.TR	ROT	TEAM	PROP
Mean	30.6	0.4	41.8	41.9	23.6	1.1
S.D.	41.8	0.5	33.6	28.1	30.5	1.1

Notes: EMPL - Number of employees; R&D - %R&D/Sales; TECH - % employees in Technical Office; MHCN - Number of Numerically Controlled Machine Tools by 100 workers; ROB - Number of Robots by 100 workers; COM - % of modular components in the products; JIT - % production delivered Just-in-Time; TRAIN - % training/sales; EM.TR - % employees who were trained in production and technology; ROT - % employees in job rotation; TEAM - % employees in teamworks; PROP - Number of improvement proposals by employee and year.
Source: Own elaboration

3.2. Networking activities

Table 4 shows the percentage of companies which cooperated regularly with customers, suppliers and research institutions at least once a year in the period 1995-1999 and requiring substantial sharing of information, skills and/or resources. Cooperation activities included product development and/or technology transfer. In order to test our hypotheses, we have considered as networking companies those which cooperated regularly with both customers and suppliers. Nevertheless we later tested the hypotheses with subsamples of cooperative and non-ccoperative companies with customers and suppliers separately but we found no significant differences whatsoever. Cooperation with customers and cooperation with suppliers was positively related (Chi-square = 4.09 Phi = 0.38 $p = 0.04$).

Table 4. Percentage of surveyed automotive companies active in networking activities

Cooperation with customers	68%
Cooperation with suppliers	50%
Cooperation with customers and suppliers	43%
Cooperation with universities or research institutes	35%

Source: Own elaboration

Table 5 indicates the companies differences among some variables according to the existence of regular networking activities with their customers and suppliers. Networking companies show higher values in all but one of those variables: they invested more in R&D, automation and employee training, had more employees in task rotation and teams, and delivered a higher percentage of production Just-in-Time. That networking companies had higher technology ratios (R&D, automation) than non-networking companies is not surprising. In the Basque automotive cluster, as in other european networks, the great majority of enterprises was developing their technologies themselves (Agiplan, 1999) which require strong in-house R&D capabilities. Even technological collaboration with research institutes or with other companies is facilitated when companies are competitive in R&D (Sen and Rubenstein, 1990).

There was not significant difference of company size between networking and non-networking companies (187 versus 152 employees). However, an analysis of contingency revealed a positive relationship between cooperation with customers and company size: companies which cooperate with customers were larger than non-cooperative companies (Chi-square = 3.61 Phi = 0.36 p = 0.05). Neither company size or capital ownership showed any relationship when cooperation with suppliers was taken into account.

Networking activies mean transfer of information among cluster companies. The amount and type of technology information that the automotive suppliers transfered to the automakers allowed them to match components design and the production processes where they will be manufactured, and also helped to develop a mutual trust relationship between buyer and supplier. Nowadays more automotive suppliers transfer information to their customers and more frequently (Helper and Sako, 1995). Basque automotive companies cited surveys of latest technologies as the most important information service demanded on their cluster (Agiplan, 1999). The process of knowledge accumulation improves the competitive performance of organizations in the auto industry (Vekstein, 1998).

Table 5. Differences among Aragonese automotive suppliers according to their networking activities

	No	Yes
EMPL - No. of employees	152	187
R&D - % R&D/Sales	0.7	1.5
TECH - % employees in Technical Office	1.9	4.3
MHCN - No. of Numerically Controlled Machine Tools by 100 workers	2.5	4.5
ROB - No. of Robots by 100 workers	1.6	3.3***
COM - % of modular components in the products	25.3	10.3***
JIT - % production delivered Just-in-Time	28.9	32.8
TRAIN - % training/sales	0.27	0.55**
EM.TR - % employees who were trained in production and technology	35.1	50.7
ROT - % employees in job rotation	41.3	42.7
TEAM - % employees in teamworks	21.4	26.5
PROP - No. of improvement proposals by employee and year	0.9	1.4

Note: Mean differences tested with the Levene-test ***p<0.01 **p<0.05
Source: Own elaboration

In our study, 39% of the surveyed companies were visited by their customers to evaluate their production system and cooperated technologically to improve their production processes performance or to implement quality systems. This percentage of companies is still low in comparison with other studies (Cusumano and Takeishi, 1991) which suggest an indicator of early stage network development. Once a first-tier supplier was chosen, a few staff members from several Opel-GM departments formed a team with supplier employees to work for several weeks at the supplier´s facility. The team focused on improvements in specific areas: technology, work organization, problems with second-tier suppliers, or workforce issues.

Half of the companies were sharing information with their customers: description of their production process, production planning and quality controls methods used, and the costs structure of each production stage. The information on costs helped to establish long-term contracts because the auto manufacturer knew how much their suppliers could reduce prices without loses, and when and how to help them with performance improvement programs. The sharing of statistical or any other information is a fundamental feature of a network approach, regardless of who the supplier is whether an independent company or a member of the same group of companies. Networks enable firms to gather superior information on each other, and therefore reduce the informational asymmetries that increase contracting costs.

Respect to the information exchange with suppliers, half of the surveyed companies offered some guidelines in technical aspects, usually to define and quantify technical variables of the production process. On the other hand, 46% of the companies also had information on their suppliers´ costs structure, and they used it to better value their contract proposals in terms of price and benefits. The EDI (*Electronic Data Interchange*) and other ICT (*Information and Communication Technologies*) were less used with suppliers than with customers, due to the lesser and unfrequent technical information exchanged with the suppliers.

To improve the transfer of technology the suppliers sent "guest engineers" to work full-time for extended periods in their customers´ design offices alongside the customer´s design engineers. This management practice is common in the automobile industry and facilitates the transfer of the complex information involved in a new model development and helps to create long-term relationships and mutual trust between a manufacturer and their suppliers (Dyer, 1996b). According to the interviewed companies, other management practices used by the auto manufacturers were the development of an intranet with their suppliers, the creation of advising Committees with some directors from the main suppliers, and having periodical meetings to revise priorities or discuss strategies. Customers who want their suppliers to improve must balance the need to monitor the suppliers´ existing performance while encouraging them to learn new skills, which in short term might disrupt that performance. However, while some tension between learning and monitoring is inevitable, the more capable suppliers become, the more they can participate in discussion in which both sides benefit.

The networking transfer of technology and information contributes to develop mutual trust and trust is an essential prerequisite in inter-firm technology collaboration (Häusler et al, 1994). A buyer-supplier relationship which generates high motivation for learning and high trust between provider and recipient is a crucial condition for any transfer of large knowledge like the required in the automobile industry to develop a new model. According to Jarillo (1988), the establishment of trust and perceived goal congruence are two factors that assist in the development of organizational networks. This scholar states that trust is an essential element to maintaining both effectiveness and efficiency in a network relationship, and sees the presence of trust as an indicator that the relationship is one of value; therefore, opportunistic behaviour is less likely. If parties participating in this network exchange realize the opportunity for joint value creation, then the network can act to emphasize the individual firm´s competitive advantage by allowing that firm to specialize in the activities it performs best.

The process of inter-firm trust is an extraordinay lubricant for alliances that involve considerable interdependence and task coordination between firms such as in joint automobile components design. Sako (1992) distinguishes among three types of trust: competence trust (a belief that the customer is capable of doing what it says it will do); contractual trust (a belief that the customer will abide by its agreement); and goodwill trust (a belief that the customer will take initiatives for mutual benefit, and refrain from unfair advantage-taking). All types of trust are important to develop networking activities and to implement some buyer-supplier partnership practices. Trust-based reputation takes time to build but can be destroyed quickly, and then networks can create strong disincentives for opportunistic behaviour.

One of them is the reduction in the number of suppliers: the automotive manufacturers have reduced their number of first-tier suppliers by component since the mid-1980s, but at the same time they have increased the average contract length with first-tier suppliers throughout the life-cycle of a model and the joint resolution of problems during that period. Twenty per cent of the companies studied had reduced their number of suppliers during the last two years and even more during the early 1990s. Other companies still had several suppliers listed for a particular component. This was to ensure that the supplier was not overcharging, and that they had a readily available alternative in case of supplier problems. These companies had not established trust in their buyer-supplier relationships and did not participate in networking activities in the industry. Eighty per cent of the companies studied had contracts with their customers for a length over than three years, which denotes a strong commitment with their customers. Besides, more than sixty per cent of companies had simultaneously contracts of over three years lenght and cooperated with their customers in the components development.

Emphasis on long-term relationships may mitigate the risks of knowledge spillovers during cooperation activities (Cassiman and Veugelers, 1998). The problem of spill-over disappears in a world of radical speed of change in complex technologies and markets but this is only the case for some automobile systems and suppliers (Noteboom, 1999). Networking is certainly beneficial in serving other customers than the helping automaker that transfer practices and knowledge to the supplier. However, efforts to eliminate the spillover of knowledge to competitors might run the risk of suppliers gaining only some of the benefits that accrue to the diffusion of best practices through the supply chain. Having only one customer reduces anyway the risk of knowledge spillover and at the same time the supplier remain more responsive and loyal due to the knowledge transfer process from its customer.

A high level of customer´s competence is needed for overcoming the initial skepticism of some suppliers towards networking implementation. Later, because the knowledge transfer process opens up so many ways for improvement, it is essential that the supplier believe that its customer is trustworthy in a goodwill sense and it will not use the information transfered from the supplier opportunistically. The cases studied indicate that firms can develop trust over time, progressively moving towards more and more mutual responsability and open information exchange over time. A knowledge transfer program makes an important part of this trust-building process, since the customer´s investment in teaching a supplier is specific to that supplier. Some automotive manufacturers have established programs so that the suppliers may contribute with their ideas to reduce costs or improve the quality. The supplier may share the savings or the profits that the automaker obtains with that idea, or it may used it as a platform to gain future business. The manufacturers may therefore achieve economies thanks to the innovation inputs from their suppliers through networking.

However, the experience of some of our cases studied indicates that just as supplier management needs to trust customer management, supplier workers need to trust their managers, on both the competence and the goodwill dimensions. Some supplier managers underestimated the importance of the changes required in labour-management relations: for example, managers in three companies did not respond favourably towards employee suggestions which constituted a serious obstacle to continuing forward in the development of networking activities.

3.3. Networking, workforce flexibility and training

Networking needs a flexible and multi-skilled workforce in order to accomodate the changes in cross-functional teams and outsourcing innovation (Quinn, 2000). This functional flexibility requires some organizational measures such as job rotation or teamwork, and both need a in-house training effort. Table 6 indicates several data of workforce functional flexibility in the surveyed companies according to their networking activities. Job rotation is one of the measures that contribute positively to the workforce functional flexibility. The workers learn a greater number of tasks in their workplace that enables them to replace other workers by illness or other motives. The rotation of tasks facilitates the running in the production process when any substitution is required and allows to establish cross-functional teams to get involved in component development within a network. Job and task rotation enriches furthermore the content of the work. The limit to the use of job rotation have its root sometimes in the union barriers to change workplaces, but mostly in a defficient amount of training.

Table 6. Measures of workforce functional flexibility according to the networking activities of the surveyed companies

	No	Yes
Percentage of companies with job rotations	89	100
Percentage of employees who participate in job rotations	41.3	42.7
Percentage of companies with teamworks	78	100
Percentage of employees who participate in teamworks	21.4	26.5
No. of proposals by team member and year	0.9	1.4
Percent. of savings to sales made with the proposals received	0.1	0.3
% training/sales	0.27	0.55
% employees who were trained in production and technology	35.1	50.7

Source: Own elaboration

An innovative and flexible workforce demands a continuous in-house training effort so that all the employees are able to solve problems, and to suggest and implement improvements in the production process. Networking activities increase the demand on employees´ training because they have to join cross-functional teams and must interact with ‘guest-engineers’. As a result, we would expect to find networking an explanatory variable of the differences in training investment among the studied companies. In successful supplier networks like the case of Toyota, companies are in a ‘learning race’ with the other supplier(s) that produce similar parts in the sense that the fastest-learning suppliers are more likely to get the business for new models (Dyer and Nobeoka, 2000).

Table 6 already showed that networking companies do more effort in training than non-networking companies. But in order to explain further the differences and test our first hypothesis, a regression analysis has been made, using as dependent variable the percentage of employees trained in each company. The regression was also made with other independent variables like TRAIN (%training/sales) or training intensity (percentage of employees trained multiplied by training hours per employee) but all these variables were strongly correlated ($p = 0.004$) and the results of the model were not different. The independent variables introduced in the model have been: the percentage of employees which do job and task rotation (ROT), the percentage of employees in the company´s Engineering Office (TECH), and the networking activities with customers and suppliers as a dummy (NETW).

It was expected that job rotation (ROT) were positively correlated with training because job and task rotation need multi-skilled workers, and multi-skilling needs training to perform efficiently (Boyer, 1996). In this way, the greater would be the percentage of workers participating in job and task rotation, the greater should be the percentage of workers trained in the company. The variable TECH was expected to be negatively correlated with employee training because a greater percentage of personnel in a Technical Office indicates a more qualified staff in that company (engineers) that would be in less need of training than those in a company with lower qualifications. Finally, the performance of networking activities is expected to explain positively the percentage of trained employees because they must learn new skills to cope with the speed-up development of higher technology-content products, or to interface with research institutions or other companies through cross-functional teams. Table 7 shows the results of the regression analysis. The model is significant ($p = 0.003$) and it explains 44% of the changes in employee training among the studied companies. The proposed variables are all significant and behaved as expected.

Then, to test our second hypothesis on the relationship between functional flexibility and networking another regression analysis was carried out. The dependent variable is the percentage of employees which participate regularly in teamworks. The proposed explanatory variables have been: the percentage of components used in several products (COM), the networking activities with customers and suppliers as a dummy variable (NETW), the percentage of turnover invested in technological activities (R&D) and the number of industrial robots by 100 workers (ROB). The percentage of common components (COM) is expected to explain positively the degree of participation in teamworks because the modularity makes possible teamworking techniques such as concurrent engineering or design cross-functional teams (Suarez et al, 1995). On the other hand, networking (NETW) is expected to be positively correlated with teamworking because the supplier involvement in component design is in need of cross-functional teams from the developing companies. Finally, it is expected that automation (ROB) is negatively correlated with teamworking because more automated companies are less flexible. As Table 4 indicated, networking companies were more automated but they had less modularity. A higher percentage of common components and parts across the company product line, requires a lower level of flexible automation technologies like robots or NCMT (Martínez, 1991). The results of the regression analysis are presented in Table 8: the variable COM is significant at the 95% level and the variable NETW at 90%; the model is also significant (p = 0.05).

Table 7. Regression analysis of employee training

Constant	18.26* (1.74)
ROT	0.57*** (3.15)
TECH	-3.56** (2.52)
NETW	23.14** (2.18)
R^2 = 0.441 F = 6.315 p = 0.003 n = 28	

Notes: ROT - percentage of employees which perform job and task rotation; TECH - percentage of employees in the company´s Engineering Office; NETW - (dummy) Networking activities with customers and suppliers. t-values between brackets. ***p<0.01 **p<0.05 *p<0.1
Source: Own elaboration

Therefore both hypotheses are supported by the empirical data. Companies which network with customers and suppliers do more training and teamwork than non networking companies.

The implication for managers is that companies which want to join a network should be ready to improve and increase their learning capabilities.

Table 8. Regression analysis of teamworking

Constant	21.39** (2.23)
COM	0.37** (2.13)
NETW	19.64* (1.73)
R&D	-7.55* (1.69)
ROB	-2.07 (1.40)
$R^2 = 0.326$ F = 2.781 p = 0.05 n = 28	

Notes: COM - percentage of components used in several products; NETW - (dummy) Networking activities with customers and suppliers; R&D - percentage of turnover invested in R&D; ROB - number of industrial robots by 100 workers. t-values between brackets. **p<0.05 *p<0.1

Source: Own elaboration

3.4. Networking and Just-in-Time delivery

A main feature of the buyer-supplier relationships in the automotive industry is Just-in-Time delivery (Womack et al, 1990). These are a few indicators of Just-in-Time delivery in the surveyed companies: 57% of these companies delivered Just-in-Time all or part of its production to their customers; 64% of the companies delivered directly to the assembly line of the customer; 39% of the companies had warehouses near the customer; and more than 75% of the companies were delivering at least once a day to their customers. Table 9 shows that there are differences between networking and non-networking suppliers although not significant.

Table 9. Measures of Just-in-Time delivery according to the networking activities of the surveyed companies

	No	Yes
% production delivered Just-in-Time	28.9	32.8
Delivery frequency to customers	2.0	2.1
% companies delivering directly to the customer´s assembly line	63	58
% companies with warehouses by the customer´s assembly plant	31	50

Note: The delivery frequency was measured with a four-step scale - 1 (several times a day), 2 (daily), 3 (weekly) and 4 (several weeks or months).
Source: Own elaboration

However Just-in-Time delivery is not easy to accomplish because requires a flexible organization, flexible technology and flexible human resources (White et al, 1999). In order to explain the differences in the percentage of the production delivered Just-in-Time and test our third hypothesis, the next variables have been proposed: the percentage of workers trained in production and technology in the company (TRAIN), the percentage of common components (COM), the number of robots by 100 workers (ROB), and the networking activities with customers and suppliers as a dummy (NETW). All these variables except networking are expected to correlate positively with the percentage of production delivered Just-in-Time. The more employees are trained, the easier is to solve problems and to improve the production process to follow this delivery system (Boyer, 1996). In the same way, a greater proportion of modular components facilitates the production and delivery of components to the customers, because lot production sizes may be larger and in need of fewer set-ups (Duimering et al, 1993). On the other hand, the use of technologies such as industrial robots gives flexibility to the production process to accomodate the changes that a Just-in-Time delivery arises in the production level. Finally, networking is not expected to have a significant influence on Just-in-Time delivery since this lean production practice is well-diffused among suppliers no matter which type of relationship they may have with their buyers (Bensaou, 1999).

Table 10. Regression analysis of Just-in-Time delivery

Constant	-4.99 (0.36)
TRAIN	0.51** (2.34)
COM	0.41* (1.79)
ROB	3.42* (1.72)
NETW	-3.65 (0.24)
R^2 = 0.341 F = 2.979 p = 0.04 n = 28	

Notes: TRAIN - percentage of employees that received training in production and technology in the company; COM - percentage of common components; ROB - number of industrial robots by 100 workers; NETW - (dummy) Networking activities with customers and suppliers. t-values between brackets. **p<0.05 *p<0.1
Source: Own elaboration

The results of the regression analysis are shown in Table 10. All variables, except networking, behaved as expected and significantly explained the variance of Just-in-Time delivery. Networking had no significance on the model and was even correlated negatively with Just-in-Time delivery.

Concluding remarks

When interpreting our results, two cautionary statements are in order. First, due to the small number of companies, no claim of generality to other population of companies can be made from the primary data and their analysis. And secondly, as in most network studies, our conclusions are based on the experience of one industry network, i.e. the automobile supplier industry which it may differ from another type of industry.

Nevertheless, the empirical results supported our hypotheses which may be a good base for further studies. Networking suppliers did more in-house training and teamwork than non-networking companies. The implication for managers is that companies willing to join a knowledge-sharing network or cluster should have (or invest in) a solid in-house training and teamwork performance record. Other studies have already found that networking suppliers report higher levels of productivity and quality. But setting up an efficient network requires considerable resources (effort, time and money). Companies which want to benefit from interorganizational or network-level learning must adapt and upgrade some of their capabilities.

This implication is extensive to any knowledge-based industry, because various scholars have recognized that inter-organizational learning is critical to competitive success, noting that organizations learn by collaborating with other firms as well as by observing and importing their practices. For example, von Hippel (1988) found that a firm´s customers and suppliers were its primary sources of innovative ideas. Similarly, Powell et al (1996) found that in the biotechnology industry the focus of innovation was the network, not the individual firm.

References

- Agiplan. 1999. Analysis of transnational technology networking between existing clusters of SMEs and one or more technology poles. Directorate General Enterprise. Brussels: European Commision.
- Autochain. 2000. The automotive supply chain project. Directorate General Enterprise. Brussels: European Commision.
- Alvarez, María José and González, Pedro. 1999. Strategic alliances, organisational learning and new product development: the cases of Rover and Seat. R&D Management, 29(4): 391-404.
- Baptista, Rui and Swann, Peter. 1998. Do firms in clusters innovate more? Research Policy, 22(5): 525-540.
- Bensaou, M. 1999. Portfolios of buyer-supplier relationships. Sloan Management Review, 40(1): 35-44.
- Boyer, Kenneth. 1996. An assessment of managerial commitment to lean production. International Journal of Operations and Production Management, 16(1): 48-58.
- Cassiman, Bruno and Veugelers, Reinhilde. 1998. R&D cooperation and spillovers: some empirical evidence. Economics and Business Working Paper Series No. 328. Universitat Pompeu Fabra. Barcelona, Spain.

- Clark, Kim and Fujimoto, Takahiro. 1991. Product development performance: strategy, organization and management in the world auto industry. Boston: Harvard Business School Press.
- Cusumano, Michael. 1985. The japanese automobile industry. Cambridge, M.A.: Harvad University Press.
- Cusumano, Michael and Takeishi, Akira. 1991. Supplier relations and management: a survey of japanese, japanese-transplant, and U.S. auto plants. Strategic Management Journal, 12(8): 563-88.
- Doeringer, Paul and Terkla, Donald. 1995. Business strategy and cross-country clusters. Economic Development Quarterly, 9(4): 225-37.
- Duimering, Robert; Safayeni, Frank and Purdy, Lyn. 1993. Integrated manufacturing: redesign the organization before implementing flexible technology. Sloan Management Review, 34(4): 47-56.
- Dyer, Jeffrey. 1996a. Specialized supplier networks as a source of competitive advantage: evidence from the auto industry. Strategic Management Journal, 17(3): 271-91.
- Dyer, Jeffrey. 1996b. How Chrysler created an American Keiretsu. Harvard Business Review, 74(4): 42-56.
- Dyer, Jeffrey and Nobeoka, Kentaro. 2000. Creating and managing a high-performance knowledge-sharing network: the Toyota case. Strategic Management Journal, 21(3): 345-367.
- Feser, Edward and Bergman, Edward. 2000. National industry cluster templates: a framework for applied regional cluster analysis. Regional Studies, 34(1): 1-19.
- Freyssenet, Michael. 1998. One best way? Trajectories and industrial models of the world´s automobile producers. Oxford: Oxford University Press.
- Glaister, Keith and Buckley, Peter. 1996. Strategic motives for international alliance formation. Journal of Management Studies, 33(3): 301-332.
- Gulati, Ranjay; Nohria, Nitin and Zaheer, Akbar. 2000. Strategic networks. Strategic Management Journal, 21(3): 203-215.
- Gupta, Ashok; Wilemon, David and Atuahene-Gima, Kwaku. 2000. Excelling in R&D. Research-Technology Management, 43(3): 52-58.
- Hagedoorn, John. 1993. Understanding the rationale of strategic technology partnering: interorganizational modes of cooperation and sectoral differences. Strategic Management Journal, 14(5): 371-385.
- Häusler, Jürgen; Hohn, Hans-Willy and Lütz, Susanne. 1994. Contingencies of innovative networks: a case study of successful interfirm R&D collaboration. Research Policy, 23(1): 47-66.
- Helper, Susan and Sako, Mari. 1995. Supplier relations in Japan and the United Stats: are they converging?. Sloan Management Review, 36(2): 77-84.
- Jarillo, Juan Carlos. 1988. On strategic networks. Strategic Management Journal, 9(1): 31-41.
- Kessler, Eric; Bierly, Paul and Gopalakrishnan, Shanthi. 2000. Internal vs. external learning in new product development: effects on speed, costs and competitive advantage. R&D Management, 30(3): 213-223.
- Kleinknech, Alfred and Reijnen, Jeroen. 1992. Why do firms cooperate on R&D? An empirical study. Research Policy, 21(5): 347-360.
- Liker, Jeffrey et al. 1996. Supplier involvement in automotive component design: are there really large US Japan differences?. Research Policy, 25(1): 59-89.
- MacDuffie, John and Helper, Susan. 1997. Creating lean suppliers: diffusing lean production throughout the supply chain. California Management Review, 3(2): 118-51.

- Madhavan, Ravindranath; Koka, Balagi and Prescott, John. 1998. Networks in transition: how industry events (re)shape interfirm relationships. Strategic Management Journal, 19(5): 439-459.
- Martínez, Angel. 1991. Advanced manufacturing technologies: an integrated model of diffusion. International Journal of Operations and Production Management, 11(9): 48-63.
- Nohria, Nitin and Pont, Garcia. 1991. Global strategic linkages and industry structure. Strategic Management Journal, 12(2): 105-124.
- Notebbom, Bart. 1999. Innovation and inter-firm linkages: new implications for policy. Research Policy, 28(8): 793-805.
- Powell, William; Koput, Kim and Smith-Doerr, Lewis. 1996. Interorganizational collaboration and the locus of innovation: networks of learning in biotechnology. Administrative Science Quarterly, 41(3): 116-145.
- Quinn, James Brian. 2000. Outsourcing innovation: the new engine of growth. Sloan Management Review, 41(4): 13-28.
- Rothwell, Roy. 1991. External networking and innovation in small and medium-sized manufacturing firms in Europe. Technovation, 11(2): 93-112.
- Sako, Mari. 1992. Prices, quality and trust. Oxford. UK.: Oxford University Press.
- Sen, F. and Rubenstein, Albert. 1990. An exploration on factors affecting the integration of in-house R&D with external acquisition strategies of a firm. IEEE Transactions on Engineering Management, 4(3): 246-58.
- Schlie, Erik and Yip, George. 2000. Regional follows global: strategy mixes in the world automotive industry. European Management Journal, 18(4): 343-54.
- Stuart, Ian. 1997. Supplier alliance success and failure: a longitudinal dyadic perspective. International Journal of Operations and Production Management, 17(6): 539-557.
- Suarez, Fernando; Cusumano, Michael and Fine, Charles. 1995. An empirical study of flexibility in manufacturing. Sloan Management Review, 36(1): 25-32.
- Vekstein, Daniel. 1998. Managing knowledge and corporate performance: an empirical analysis of the world automobile industry. Omega International Journal of Management Science, 26(5): 551-68.
- von Hippel, Eric. 1988. The sources of innovation. New York: Oxford University Press.
- White, Richard; Pearson, John and Wilson, Jeffrey. 1999. JIT manufacturing: a survey of implementation in small and large US manufacturers. Management Science, 45(1): 1-15.
- Womack, Jones *et al*. 1990. The machine than changed the world. New York: Maxwell Macmillan International.