# Lean Production and Technology Networking in the Automotive Supplier Industry

*Conference Track: JIT Manufacturing/Lean Production*

**Abstract**. 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. The paper also compares the training needs of three automotive supplier networks, two in Spain and one in the United Kingdom to test the relationship between learning and networking.

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## Introduction

There is a growing evidence in the literature which indicates that it is necessary to take into account the strategic networks in which firms are embedded in order to completely understand a firm´s 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 (Dyer, 1996). 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. 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 incentives that Toyota uses in its network.

Firms collaborate for a number of reasons, the most common being access to complementary technology and access to new markets, but also to spread the high cost and risk associated with the development of new products based on technological breakthroughs (i.e. Hagedoorn, 1993). 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. The research hypotheses proposed in this paper try to establish an underlying relationship between lean production and networking. Lean production is a well-know production system in the automobile industry. Three key elements of a lean production system are: training, teamwork and Just-in-Time delivery (Womack et al, 1990). 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. The paper is structured as follows: the second section establishes the paper´s hypotheses; the third section briefs the methodology and the empirical base of the study; and fourth section explains and discusses the results.

## Research Hypotheses

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 through 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. 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). 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.

## Sample and Empirical Data: Networking Activities

The empirical data used from this paper come from a survey to automotive suppliers: most of those data are from the Spanish region of Aragón, but there are also data from another Spanish region (Castilla-León) and from Wales in the UK. These three european regions have automotive industries which account for at least a third of their regional industrial GDP. A survey was financed by the European Union to benchmark in the year 2000 the Operations and technology management among the automotive suppliers of the three regions. The authors collaborated in the latest stages of the survey and a few of its results are used in this paper. Besides the authors also did a survey to the automotive suppliers in Aragón (their home region) to get data on the networking and lean production practices implemented in order to test the paper´s hypotheses. Twenty-eight Aragonese companies (out of 53 first-tier suppliers) responded to both surveys. From the other three regions, fifty two companies gave eventually information for benchmarking. Response rates rose to 52% of companies and 91% of employment in the region of Aragón, while in the other two regions the response rates were 90% and 55% of companies.

Table 1 shows the percentage of Aragonese 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-cooperative 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).

*See Table 1*

Table 2 breaks down the cooperation activities along different dimensions. The level of cooperation is higher in the Aragonese network than in the other two regions. The main cooperation activity is training through Conferences and Workshops, followed by the benchmarking and exchange of best practices. Companies interviewed on their interest about cooperation activities in the future (Table 2) showed an increased interest that completely changes the data above. New tendencies and a trong competitiveness are forcing them to change their mind on the need to open themselves to cooperative activities in order to grow, improve and become enriched by other´s experiences. The surveyed companies from the three regions indicated at least by a third the increase between previous cooperative data and their foresight. The highest cooperative values are shown for most items in the Aragonese companies. Next paragraphs will detail a bit more the cooperation activities in this region.

*See Table 2*

Table 3 indicates the companies differences in Aragon 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 explained because even technological collaboration with research institutes or with other companies is facilitated when companies are competitive in R&D. 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.

*See Table 3*

## Hypotheses Test: Models and Results

To test the paper´s hypotheses, three models have been proposed, using data from the Aragon network. The first model uses as dependent variable the percentage of employees trained in each company. Other dependent variables used for this first model such as TRAIN (%training/sales) or training intensity (percentage of employees trained multiplied by training hours per employee) were strongly correlated (p = 0.004) and the results of the model were not different. The independent variables introduced in the first 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.

The second model tests the relationship between functional flexibility and networking. The dependent variable is the percentage of employees which participate regularly in teamworks. The proposed explanatory variables have been: the percentage of common parts 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 parts (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 product development companies. Finally, it is expected that automation (ROB) is negatively correlated with teamworking because more automated companies are less flexible. 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).

Finally, the third model test our third hypothesis about the relationship between networking and the percentage of the production delivered Just-in-Time. 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 in production and technology, 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 4 shows the results of the regression analysis of the three models. The first 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. In the second model, the results indicate that: the variable COM is significant at the 95% level and the variable NETW at 90%; and the model is also significant (p = 0.05). 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. Regarding the third model, all variables except networking behaved as expected and significantly explained the variance of Just-in-Time delivery. Networking had no significance on the model, which supports our third hypothesis.

Further support for some of the paper´s hypotheses are found in the survey to the three european automotive networks. Table 5 shows the training needs mean value of the surveyed companies in different issues. Quality, Information technologies and Production management were the three main training needs among these companies. The table also indicates that some training needs are higher in networking companies than in non-networking companies which comes back in support of the first paper´s hypothesis.

*See Tables 4 and 5*

## 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 and not only by benchmarking and adopting their best practices. For example, von Hippel (1988) found that a firm´s customers and suppliers were its primary source of innovative ideas. Similarly, Powell et al (1996) found that in the biotechnology industry the locus of innovation was the network, not the individual firm.

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Table 1. Percentage of Aragonese surveyed automotive companies in networking activities

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

Table 2. Level of cooperation activities at present adn interesting for the future

| | Aragón | | Castilla | | Wales | |
|---|---|---|---|---|---|---|
| | Present | Future | Present | Future | Present | Future |
| R&D/product development projects | 1.75 | 2.42 | 1.75 | 2.31 | 1.50 | 1.85 |
| Conferences, workshops, etc | 2.42 | 2.71 | 1.91 | 2.12 | 1.85 | 1.95 |
| Technology discussion forums | 2.04 | 2.50 | 1.65 | 1.94 | 1.50 | 1.90 |
| Benchmarking of best practices | 2.08 | 2.58 | 1.91 | 2.62 | 1.60 | 1.95 |
| Knowledge exchange networks | 1.62 | 2.12 | 1.22 | 1.75 | 1.30 | 1.90 |
| Joint product development | 1.46 | 1.92 | 1.47 | 2.09 | 1.55 | 2.40 |
| Joint marketing actions | 1.33 | 1.87 | 1.25 | 1.65 | 1.30 | 1.70 |

Note: The intensity of the cooperation was measured with a four point Likert scale from 1 (never) to 4 (continously)

Table 3. Differences among Aragonese automotive suppliers according to their networking activities

| | No | Yes |
|---|---|---|
| Number of employees | 152 | 187 |
| % R&D/Sales | 0.7 | 1.5 |
| % employees in Technical Office | 1.9 | 4.3 |
| Number of Numerically Controlled Machine Tools by 100 workers | 2.5 | 4.5 |
| Number of Robots by 100 workers | 1.6 | 3.3*** |
| % of modular components in the products | 25.3 | 10.3*** |
| % production delivered Just-in-Time | 28.9 | 32.8 |
| % training/sales | 0.27 | 0.55** |
| % employees who were trained in production and technology | 35.1 | 50.7 |
| % companies with job rotation | 89 | 100 |
| % employees in job rotation | 41.3 | 42.7 |
| % companies with teamworks | 78 | 100 |
| % employees in teamworks | 21.4 | 26.5 |
| Number of improvement proposals by employee and year | 0.9 | 1.4 |
| % savings to sales made from the employees proposals | 0.1 | 0.3 |

Note: Mean differences significance: ***p<0.01 **p<0.05

Table 4. Models and hypotheses tests results

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| Constant | 18.26*<br>(1.74) | 21.39**<br>(2.23) | -4.99<br>(0.36) |
| NETW | 23.14**<br>(2.18) | 19.64*<br>(1.73) | -3.65<br>(0.24) |
| ROT | 0.57***<br>(3.15) | | |
| TECH | -3.56**<br>(2.52) | | |
| COM | | 0.37**<br>(2.13) | 0.41*<br>(1.79) |
| ROB | | -2.07<br>(1.40) | 3.42*<br>(1.72) |
| R&D | | -7.55*<br>(1.69) | |
| TRAIN | | | 0.51**<br>(2.34) |
| | $R^2$ = 0.441 F = 6.315<br>p = 0.003 n = 28 | $R^2$ = 0.326 F = 2.781<br>p = 0.05 n = 28 | $R^2$ = 0.341 F = 2.979<br>p = 0.04 n = 28 |

Notes: Model 1 tests the first paper´s hypothesis -networking and training-; model 2 tests the second hypothesis –networking and teamwork-; and the third model tests the third hypothesis –networking and Just-in-Time delivery-. The dependent variables used have been: NETW - (dummy) Networking activities with customers and suppliers; ROT - percentage of employees which perform job and task rotation; TECH - percentage of employees in the company´s Engineering Office; COM - percentage of components used in several products; R&D - percentage of turnover invested in R&D; ROB - number of industrial robots by 100 workers; TRAIN - percentage of employees that received training in production and technology in the company. The only bivariate correlations among these variables 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). t-values between brackets. ***p<0.01 **p<0.05 *p<0.1

Table 5. Training needs (mean values) of the automotive suppliers in three European regions

| | Aragón | Castilla | Wales |
|---|---|---|---|
| Quality | 2.79** | 2.25* | 2.45* |
| Human resources management | 2.46 | 2.09 | 2.30 |
| Information technologies | 2.75** | 2.12* | 2.45** |
| Languages | 2.67 | 2.50 | 1.85 |
| Safe and work risk prevention | 2.50 | 2.37 | 1.95 |
| Regulations and standards | 1.62 | 1.75* | 1.70* |
| Advanced tests | 1.83 | 1.47 | 1.50 |
| Stock management | 2.58* | 1.91* | 1.75 |
| Production planning and management | 2.79* | 2.15 | 2.25* |
| New materials | 1.79 | 2.22* | 2.20* |
| Manufaturing processes | 2.50 | 2.34* | 2.45** |
| Product technologies | 2.37 | 1.94 | 2.15* |
| Maintenance | 2.83* | 2.15 | 2.35 |

Notes: The training needs were measured with a Likert scale from 1 (low) to 4 (very high). Significant differences between networling and non-networking companies **p<0.05 *p<0.1