

## ***“Production Networks in Old Sectors: Methodology and Evidence from Argentina”***

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### **Abstract**

The goal of this article is twofold: on the one hand, we intend to develop a systematic methodology that is able to quantify the knowledge circulation inside a production network (PNW). On the other hand, we will apply such methodology in order to study two Argentine industrial sectors (automotive and iron-and-steel industries) with differences in commercial results as well as in their participation in international markets. We will investigate whether or not differences in networking are significant to the understanding of different performances. From an empirical point of view, one of the results has shown that the PNW organised by the steel firms allows for a better knowledge circulation. Another result is that the density, frequency and stability of the linkages within the PNW are a significant variable for PNW techno-productive capabilities. Such relevance of the knowledge circuit and the way the PNW incentives it constitute an essential point that contributes with the comprehension of the different performances between both PNW.

### **Introduction**

In the history of economic thinking, the discussion about the nature of competitiveness of the firm is a classic and controversial topic. The center of the discussion has been the question of whether the dynamics of competitiveness is nurtured or not by systemic elements, which go beyond the individual behavior of the firm.

Meanwhile, firms have transformed and their organization has experienced notable changes stimulated and/or imposed by the adoption of new information and communication technologies. Facing this revolution, popularized as the emergence of a “new economy,” the controversy about the nature of competitiveness has lost its energy in so far as its own object of debate has put an end to it: the performance of the firm shows to be dependent on its inter-relationships not only with other firms but also with the environment in which it operates. This has originated a re-interpretation of micro and mesoeconomic aspects. The influence of the firm’s business framework and the development of productive networks have been particularly revalued because of the growing importance of knowledge flows and of learning for the generation of the agents’ competences. In this context, the formal and informal channels through which knowledge flows become of great interest. These channels are established by firms, not only between firms and organizations, but also between the firms and the institutional complex.

This phenomenon of great systemic significance is reflected in different types of literature, which emphasize different aspects of the firm’s dependence on the environment. We can mention, among others, those approaches which concentrate on *clusters* (Nadvi 1999, Schmitz, 1995 and 1999, Nadvi, K. and H. Schmitz

(1994 and 1999)), on the global chains of value set by producers and customers (Humphrey and Schmitz, 2001, Gereffi, 2001), on the advanced outsourcing (Coriat, 1992), as well as the literature about innovation systems, whether national (Freeman, 1994 and 1995, Metcalfe 1995), local (Scott, 1996, Camagni, 1991) or social (Amable, Barré and Boyer, 2001).

Each of these expressions represents different measurement units for the systemic behavior of the firm. However, such variety is a theoretical problem in itself: Which systemic aspect explains the behavior and the characteristics of the firm, and how is it formed? Our work emphasizes that the most appropriate systemic relationship to understand the present configuration of the firm is the productive network. A productive network consists of a firm (a “core”) and a group of relationships established with the providing companies. As it will be exposed in the theoretical discussion, these linkages have been enriched before purchase or sale by organizational innovations which are associated to “the new economy”, and have become fundamental for the transmission of knowledge, the capacity of the firm to differentiate its products and, as a result, its commercial performance (competitiveness). The “core” firm of the network, then, articulates a group of companies in which knowledge generated and circulating in it will be essential for its individual performance.

In this scheme, the quality and the price of intermediate goods are not the only key variable between the producer of the final product and its suppliers. The type of linkage, the flow of information and the capacity to generate and possess knowledge of the network gain growing importance.

If the limits of the firm become blurry, it is necessary to develop new techniques to account for its characteristics. This challenge poses the methodological problem that the relationships between firms increasingly involve intangible assets and, therefore, also involve a greater level of tacit elements, which are difficult to determine and quantify. Since methods to determine what is tacit are likely to be highly subjective, it is necessary to establish a systematic methodological framework. Such framework captures part of the tacit ingredients associated with the generation and circulation of knowledge within a network and allows evaluating whether they have been significant or not for any of the variables of the performance of the firm (in our case, we are particularly interested in the capacity of innovation of the firm). Applying this methodology to two different Argentine industrial networks, not only in connection to their economic performance but also to their structure of linkages (“iron-and-steel” and “automotive” networks), will enable us to explain part of these differences, thus proving the usefulness of the proposed methodology.

Therefore, this article seeks a double initial objective: on the one hand, we will develop a uniform methodology capturing part of the circulation of knowledge within a network. On the other hand, we will analyze two Argentine industrial sectors: the automotive and iron-and-steel industries, both with different international insertion and commercial results. We will also analyze whether the differences in the network configuration are useful to understand part of the differences in their results. As it will be explained later, the productive network formed by the iron-and-steel firms allows a greater circulation of knowledge where the density, frequency and stability of the association within the network become a main issue of its techno productive capacity. The importance of the circuit and its being activated by the network is an essential difference, which contributes to the understanding of the different performances of the networks.

This article will be structured as follows: the first section will deal with the theoretical framework. In this section, the notion of productive network and the dimensions involved are discussed. We will define its ideal aspects (the productive and knowledge networks) as a “benchmark” on which to base our evaluation of the configurations of real networks (in our case, the iron-and-steel and automotive networks) and we will provide an abridged version of the developed methodology and the indicators that evidence the creation and circulation of knowledge within the network. In the second section, we will introduce the networks under study; describing their composition and the main differences regarding their general performance, the origin of their capital and their commercial prospective. Following that, we will apply and describe the results of the methodology employed and, by applying econometrics, we will investigate the degree of significance of the different aspects that define the productive network in regards to the innovation capacity of the firms which constitute it. In the conclusions, the main results are summarized and interpreted according to their importance for policy making.

## **I. Theoretical-Methodological frame: the concept of Productive Network and Knowledge Network.**

### ***I.1. Theoretical prolegomena***

For the purpose of this article, a productive network (PNW henceforward) will be considered as a particular form of articulation of firms constituted by an organizing firm (from now on “core”) and its suppliers, involving flows of goods and services in a stable and long-term relationship. The main potential advantage of a PNW configuration for the suppliers, the core and the network as a whole derives from the interchange and accumulation of knowledge, mainly tacit, which the components generate throughout a commercial relationship (Nonaka and Takeuchi, 1995; Amable et al, 1997; Ducatel, 1998; Rullani, 2000). According to this, within a PNW, knowledge (considering its creation, dissemination, appropriation and accumulation) constitutes a critical element for the competitive strategy of the core firm and for the survival of the rest of the firms in the network (i.e. Suppliers). However, the presence of knowledge can be significant or scarce. In the first case (significant presence of generation and circulation of knowledge), a special type of PNW is configured, which will be called “Productive and Knowledge Network” (KPNW).

The concept of network used in this article differs not only from the literature about clusters (Schmitz, 1995; Meyer-Stammer, 1998) but also from the one on value chains and global commodity chain (Gereffi 2001; Humphrey y Schmitz, 2000 and 2001). The differences between PNW and “cluster” are based on the fact that the former determines the structure of hierarchies between firms and, to a lesser degree, makes more flexible the requirement that the firms should share the same geographic location (without annulling it). According to the notion of productive networks, flows of knowledge between suppliers and customers, as well as with the rest of the agents within their productive environment, constitute a strategic variable, essential to understand the economic results of individual companies. As regards literature about “*global commodity chains*,” they both incorporate the notion of hierarchy, which is not present in the concept of “*clusters*” and they both require certain “*governance*” from the core of the PNW. Said governance is an action of important

influence on the techno-productive and organizational capacities of the rest of the firms in the network. However, the differences are focused on the fact that the concept of PNW takes into consideration the internal organization of each firm and how the ways of organizing work, controlling quality and the training strategies are connected in order to conduct knowledge<sup>1</sup>.

Likewise, the PNW representation competes with the classical one based on sectors. Both concepts take into consideration part of the same firms. This intersection of the object under study is not complete: all the suppliers of the network will not necessarily be part of the same sector to which the “core” firm belongs and, likewise, components of the same sector can be part of different networks. In any case, both views can complement each other. Without doubt, the sector determines a type of particular behavior of the companies integrating it. This descriptive character is useful but it does not enable the investigation of the sources of the qualities specific to each sector. Consequently, the PNW concept incorporates one more dimension, which might afford a reason for the specific qualities observed in the analyses of sectors.

The competition among networks is revealed by the way the core firm takes possession of knowledge and by the intensity of such appropriation. This fact is reflected in differences in internationalization, accumulation paths and benefit rates. In turn, special linkages are generated: the commercial relationships with other companies and in particular with the core firm are enriched by factors which are not evidenced in the prices (or costs) in a tangible way. These tacit or intangible aspects are increasingly significant for the performance of firms; as emphasized by the authors who highlight the role of non-price factors in competitiveness (Lundvall, 1992 and 1996; Coriat 1992; Coriat and Taddei, 1993; Nonaka and Takeuchi, 1995; among others).

The PNW is characterized by the synergy in the learning processes, revealed by a great presence and complexity of tacit elements of the interchange between the firms and in the competencies developed by them. They constitute real barriers for agents not belonging to the network (Yoguel, 2000). Thus, for two agents belonging to a PNW, their added competitiveness will be greater than the simple addition of their individual advantages. Therefore, the generated efficiency profits can be assimilated to economies of scale and variety and to the appropriation of knowledge by the network. However, at the same time, the greater capacity in the generation and interchange of knowledge can also be reflected in its growing codification, which will favor its dissemination through formal languages (Poma, 1998); codified knowledge susceptible of being mediated by a purchase relationship.

Thus, the PNW constitutes an economic area for the creation of competencies, including not only a core company, its suppliers and their mutual relationships arising from purchase transactions but also the information flow, the productive experiences and the codified and tacit knowledge obtained through formal and informal channels. In this context, channels generated by companies to interchange various intangible assets become especially important as they have an effect on the development of competence in the PNW. These channels not

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<sup>1</sup> As it will be noticed in the conclusion, this different perception is more significantly revealed in the policy recommendations that arise from both analytical views.

only communicate the companies of the network with the core company but also with other companies and organizations they interact with to improve their endogenous competencies.

Even when the core company is considered a production unit, which coordinates intermediate goods and services purchased in the market, suppliers may or may not be in the same geographic location. The nature of the relationship between the supplier and the core company varies according to the origin (domestic or international) of the traded intermediate good. When the core company and its suppliers share the same economic area, the core-supplier connections (beyond commercial relationships) are easier. However, as it has been explained in the literature about “clusters” (Lundvall, 1993, Storper, 1995, Meyer-Stamer, 1998, Cassiolato and Lastres, 2000, Nadvi and Schmitz, 1999), the geographic or economic closeness favors technological and organizational synergies as well as new monetary conditions and opportunities for the coordination of goals and strategies. The style of linkage is not restricted to supplier-core interaction, but relationships with institutions and other firms not belonging to the network should also be considered from the proposed systemic perspective of competitiveness. Therefore, in an open network the endogenous learning process (individual and collective) of its components is believed to be strengthened (Rullani, 2000; Poma, 2000).

The learning process in PNW depends on a complex group of dimensions, such as (i) the degree of development of the suppliers’ endogenous competencies, (ii) the existing internal hierarchy of the network, (iii) the degree of self organization, (iv) the tacit elements developed in the different dimensions, (v) the deepness of the interchange of experiences and shared works (vi) the circulation of the information within each of the components, and (vii) the interactions with companies and institutions of their productive environment, which imply an increase in the competence of the firms. According to Cowan, David and Foray (2000), the PNW could be considered as an epistemic community, that can share the same “codified and disarticulated” language and knowledge difficult to be understood by the ones not belonging to it and that can be considered as tacit. The degree of development reached by the network will depend on the knowledge metabolism process summarized by Nonaka and Takeuchi (1995) in the internalization phases (from codified external knowledge to tacit knowledge), combination (compatibility and mixture of codified knowledge), socialization (combination of tacit knowledge) and externalization (codification of tacit knowledge). This process of generation and circulation of knowledge is influenced by the capacity to absorb and generate knowledge not only of the productive scheme as a whole but also of each of its components<sup>2</sup>.

According to what was mentioned above, our characterization of the KPNW involves (a) the existence of a commercial relationship between the core company and its suppliers; (b) a common economic area, and (c) the appearance and dissemination of knowledge processes in three levels: within each firm, within the firms of the PNW, and between these firms, the institutional system and other firms.

We therefore need to state which the dimensions are determining the development of endogenous capabilities. We can highlight three dimensions which reveal the knowledge flow inside each firm: (i) the innovative capacity

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<sup>2</sup> A very similar analysis applied to the case of Cluster structures is explained by Giuliani (2002). Differing from classic literature about the topic, he explains the idea of Capacity of absorption of the cluster, defined as the capacity of the cluster and the agents which are part of it, to identify, assimilate and exploit knowledge coming from external sources of the cluster.

as main source of new knowledge (ii) the organization of the prevailing work- basically defined by the type of work organization, role of the supervisor and type of polyvalence used-, as an informal source of new incremental knowledge and (iii) the training efforts that constitute a complementary dimension for the development of learning processes. These three areas and their degree of interaction are determining the development of the obtained endogenous capabilities.

The main point connecting individual suppliers with their PNW framework is expressed based on the area called “linkage style,” which includes the importance reached by the circulation of information and knowledge, by external aspects and by the synergy of the network. The linkage pattern is considered as the union of the development processes of organizational and technological competencies of the firms constituting the productive network.

### ***1.2. A methodological approach to the generation, dissemination, and appropriation of knowledge in productive networks***

We develop a methodology to study a PNW, its profile and the generation, appropriation and spreading of knowledge within it. This methodology identifies the PNW’s strength and weakness, concerning both the suppliers’ competitive capabilities and the linkages with the core-firm as well as with firms and institutions outside the PNW. In order to evaluate a PNW we have set up a wide range of indicators which address the following three main dimensions (see methodological appendix for the details) the: (a) endogenous capabilities, (b) the linkage style within the PNW –between core-firm and their suppliers- and (c) the linkages beyond the PNW –between firms belonging to a PNW and agents not belonging to that PNW-.

#### ***1.2.a. Endogenous competencies***

The analysis of suppliers endogenous competencies starts from considering that to improve the learning processes, the firm needs: i) a process of creation of technological and organizational capabilities (innovative capability) that facilitates them to generate, to circulate and to appropriate tacit and coded knowledge ii) an appropriate level of quality, iii) a particular organization of the work for optimizing competencies and developing better skills, and iv) a work training process linked to previous dimensions. Due to the systemic character of competitiveness, to identify the level of endogenous competencies reached by firms, it is important to analyze not only the level achieved in each one of these four dimensions, but also the degree of association between them.

In general terms, the innovative capability refers to the potentiality of firms to transform their generic knowledge in specific one, based on their initial competencies and on a process of dynamic accumulation, that involves formal and informal learning (Lall 1992, Yoguel and Boscherini 1996, Ernst and Lundvall 1997). These competencies can be defined as the set of knowledge and technological and organizational skills that agents generate to carry out the mentioned process. (Yoguel, Novick, Marin, 2000). Firms develop these capabilities to be able to introduce differentiation and to create competitive advantages.

To determine the innovative capability of the agents of a PNW a group of qualitative and quantitative indicators is defined. These indicators reflect the potential capacity of human resources to make R&D, the degree of formality of R&D, results obtained, the degree of use of ICT and practices for environmental protection (see methodological appendix).

In second place, a compound indicator that captures the effort of firms to assure the quality of the product is defined. It evaluates the importance of the control that is exercised along the productive process, fundamentally taking into account, the existence of control points and the systematizing and use of the information picked up in those points to carry out corrections in the work positions. In turn, the external look about the quality of the product and the process is given by the certification of norms (ISO and others).

In third place, the work organization has a key influence in the possibilities of circulating of tacit knowledge among workers and of obtaining results in development and quality. Teams and interaction spaces, contrary to individual assignment of positions, allow to exchange experiences and opinions and to improve the possibility to diffuse tacit knowledge among individuals, through observation, imitation and empiric experiences. Consequently, the form the work process is organized at the firm level influences decisively the process of generation and socialization of knowledge. The indicator of work organization defined tries to capture these questions considering three elements: i) percentage of posts organized in cells or teams; ii) the degree of autonomy of these cells and iii) the supervisor's role<sup>3</sup>.

At the same time, these new forms of work organization at plant level, *postfordist so to speak*, require changes in traditional approaches to treatment of labor relationships. Criteria used to determine remuneration and labor conditions can have a decisive incidence in workers' involvedness and, therefore, in the specific effect a certain organization of the work has on learning and circulation of knowledge. Contrary to *fordist* pattern, where institutional forms were based on collectively negotiated agreements -at branch or sector level-, new scenarios tend to transfer negotiation mechanisms to the level of the firm. The heterogeneity of technological strategies, types of insertion in the market, and the different performance of productive units, even in the same sector, induces a process of decentralization of negotiation levels, increasing the number of possible alternatives.

In the three dimensions presented it is evaluated the development and use of the competencies of work force dedicated to production, quality and development activities. In such a sense, the processes of formal and informal training are a central element for achieving competitive advantages (Novick, 1999). Therefore, complementing the analysis it is constructed an indicator about training that includes i) the analysis of resources devoted to training (structure and financial resources) and ii) percentage of human resources involved in these activities.

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<sup>3</sup> Unfortunately, we have not taken into account a very important dimension of the work organisation that may modify the effects on the learning processes: the way the firm remunerates their workers and the in-house labour conditions.

### *1.2.b. Interaction inside the PNW: suppliers and core firm*

The generation of competitive advantages of the PNW does not rely only on the decisive dimensions of belonging firms endogenous competencies. The intensity and reach of the interaction between the core firm and its suppliers, beyond the exchanges of goods and services, have a key role. The analysis of this interaction level emphasizes on the dependence degree and existent hierarchy between the agents and the non-price exchange mechanisms between them. The relationships inside the PNW are conditioned, in turn, among other factors, by the contractual dynamics and by the implicit scheme of incentives.

Beyond the contractual linkages between the core-firm and its suppliers we attempt to capture and analyze those interactions possessing a significant impact on the learning path and on the accumulation of new capabilities. In that sense, we consider two additional dimensions for the purpose of capturing the codified and tacit elements of the non-price exchanges between the PNW firms.

The first case, which is more related to the codified elements of the exchanges, deals with the intensity of the core-firm assistance to its suppliers, who may eventually enhance the synergy within the PNW. More specifically, we focus on the activities targeting the development and strengthening of suppliers' capabilities on the dimensions discussed above: development and technology transfers, quality assurance, work process organization and training activities.

In the second case, we develop a proxy indicator of horizontal linkages that involves not only codified elements but also tacit information by considering the (i) relevance and frequency of technical meetings, (ii) core firm visits to their suppliers and (iii) technical and commercial assistance offered by the core-firm.

### *1.2.c. Interactions outside the PNW: other firms and institutions*

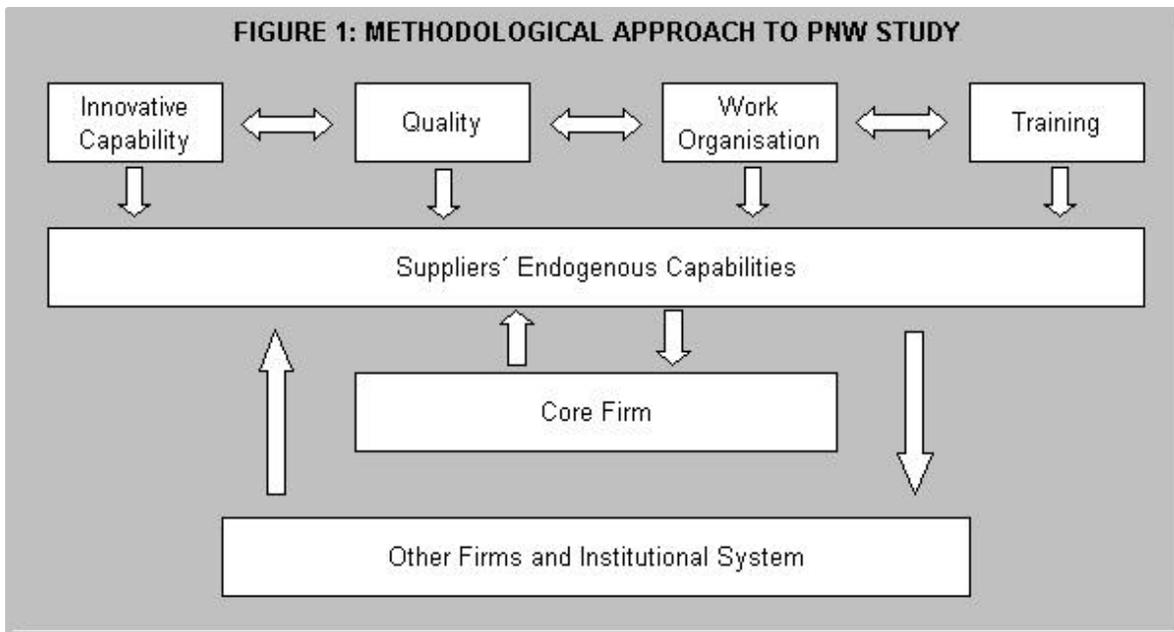
A third question that influences the development of competencies in the network is the importance achieved by linkages between PNW firms, the institutional system and firms not belonging to the network. This reflects the idea that the openness of the network favors its endogenous learning process (Rullani, 2000; Poma, 2000).

The evaluation of the interaction degree with other colleagues and clients is based on: i) formal agreements of cooperation and ii) informal linkages that allow firms to increase their technical competencies. From the perspective of informal linkages it is analyzed whether they are oriented to questions such as i) commercialization strategies in external markets, ii) quality, iii) possibility of joint business abroad, iv) partners' search to make agreements, v) development of shared training programs, vi) possibility to make shared developments of products; etc. On the other hand, in the evaluation of the degree of interaction between suppliers and institutional system it is specially pondered the access to technical services (tests, analysis, search of technological and market information, seminars and training courses, research and development projects).

The indicator considers the number of institutions with which the firms are related, the type of institutions (more importance is given to those of higher technical profile) and the frequency of the contacts.

*I. 2. c. The benchmark: the Knowledge Production Network (KPNW)*

Figure 1 shows a stylized representation of our methodology, where the three dimensions proposed are presented for the analysis of a PNW: (i) suppliers' endogenous capabilities, (ii) the linkages between the core-firm and their suppliers and (iii) the linkage of the PNW firms and firms and institutions outside the PNW. As we have discussed above, a PNW is not necessarily a KPNW. From the perspective we present a PNW may be considered a KPNW when it presents the following features: (i) high endogenous capabilities of the firms, (ii) a high linkage degree between these capabilities, which indicate the existence of high capabilities of systemic nature; (iii) a high degree of interaction between suppliers and the core-firm; (iv) a high degree of linkages with external agents; and (v) a high degree of correspondence between endogenous capabilities and the linkages established within the PNW, which indicates the relevancy of PNW for the development of capabilities or (capability development).



**II. Empirical application to the automotive and iron-and-steel sectors in Argentina.**

*II.1. General characteristics of the networks*

The proposed methodology has been applied to a group of 70 suppliers of the iron-and-steel industry and 85 suppliers of the automotive industry, interviewed during 2001 and 2002, respectively. In both cases, most of the firms produce highly specialized goods and services, which frequently require the development of a close

interaction with the core firm. Both PNW are very different as regards their regulatory frame, their competitive structure, their orientation in the market and their strategic objectives. All issues conditioning the process of knowledge generation.

The empirical base of the APNW corresponds to Toyota Argentina, (from now on referred to as TASA) and Volkswagen Argentina (from now on VWA); both established during the nineties as part of a strategy associated to a global-regional phase<sup>4</sup> of automotive companies within the Mercosur (Novick and Yoguel, 1998). Although the headquarters used different paths and models of production, the hybridization process activated to settle in the local environment, has created two networks with similar characteristics as it has been explained by Novick et al. (2002). Thus, we will assimilate them in the same APNW.

In connection to the APNW example, 85 firms have been studied, which represent an important share of the total number of suppliers (40%) of the core firms included in this research. More than half of them are foreign companies covering 70% of the terminals' purchases. This high proportion of ET is the result of a strong process of industrial restructuring that occurred during the nineties. These ET consist mainly of big and medium-sized companies whereas small companies prevail among local ET. Almost two thirds of the ET have been established through the purchase of previous existing companies<sup>5</sup>-in the case of national companies the proportion of new acquisitions is only 9%. These companies sell an average of 23 million dollars annually and employ an average of 200 workers per factory. Sales directed to automotive terminals exceed 70% of their total sales, implying that networks are strongly dependent from the APNW core firm. In general, the profitability of these firms is substantially higher than the one of the industrial average. However, as a whole they have represented a reduced exporting ratio (4%) and a negative dynamics in the market since 1995<sup>6</sup>.

As an example for the iron-and-steel productive network (SPNW), we have studied the network constituted by the Techint Organization (TO), a local group with various interests in steel production, engineering, energy and telecommunications industries among others. In particular, we have considered Siderca (a world leader in the market of seamless tubes) and Siderar (the main local producer of rolled plots) as a single core firm and both of them together with their respective networks of local suppliers a sole productive network (from now on, SPNW). The SPNW is globally recognized (almost 40% of its production is traded abroad) and involves a complex network of supply and marketing relationships.

The SPNW core employs around 9,000 workers and its added sales reached 1,9 billion dollars in 2001. During the last five years, sales have dropped by 1% and employment by 10%. The recession in Asian countries and the drop of the oil price (the main final buyer of the chain) have been important factors with influence on this reduction. These companies have a strong productive and commercial interchange with other

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<sup>4</sup> This phase is characterized by the reestablishment of some companies, which had left the Argentine market earlier. Toyota is the only new incoming company.

<sup>5</sup> This shows the predominant character of foreign investments in automotive industry, which was focused on the purchase and restructuring of previously existing companies.

<sup>6</sup> The proportion of firms showing sales drops is substantially higher in SMEs (small and medium-sized companies) (61%) than in ET (8%).

companies abroad. On the other hand, exports have increased in the last five years. The relationship between exports and sales has evolved from 38% in 1995 to 68% in 2000. Furthermore, added imports of both companies represent 40% of total purchases. This increasing global insertion coincides with the effort both companies have carried out to improve their productive processes.

Around 70 suppliers of the SPNW have been under research. According to their size, the firms in the group have a medium-sized profile: around 60 employees and an annual sales volume representing 7 million dollars (15% of which correspond to TC, 17% to local groups, and 68% to small and medium firms). The above-mentioned shows the minor scale characterizing the suppliers of SPNW compared to those of the APNW. Finally, most of the suppliers are companies with a long productive background: around 60% of the network companies have been founded before 1980.

Contrary to APNW, the studied firms have maintained a high dynamic level of activities even during a recessive period of the national industry (a growth higher than 20%). Said behavior can be explained by (i) greater exporting success (while sales in international markets have tripled during the period between 1995-2000, the industrial Argentine exports have grown 50%); and (ii) a dynamic demand of “core” companies which have increased 30% during the same period.

These firms have achieved a diversified market structure, enabling them to maintain a low degree of dependence from the core firms, establishing an important difference between both networks. Thus, for a high number of suppliers, sales to the core represent only a fifth of their total sales volume. During the nineties, almost half of these companies experienced an increase in the number of employees. Therefore, the work productivity was incremented about 8% in the period between 1995-2000, being the increase higher in companies belonging to economic groups and in the TC branches (15% and 17%), and substantially lower in the case of Small and Medium Firms (4%). The added value resulting from the proportion between intermediate products and sales (60%) is, in turn, higher than the average of the industry.

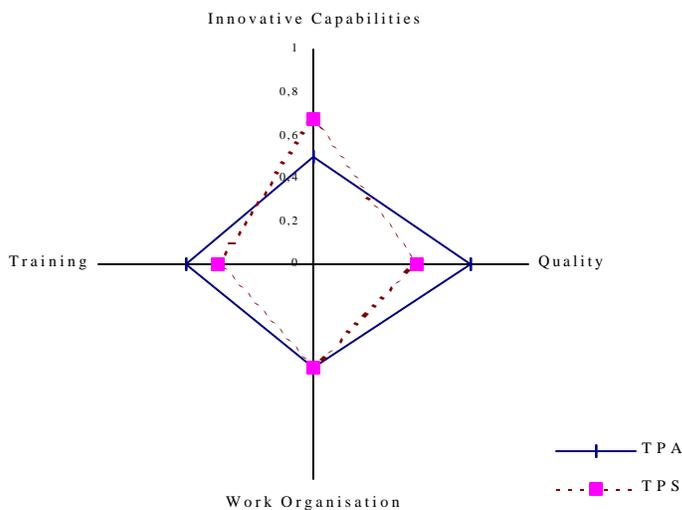
To sum up and as a comparison, we can say that the APNW is characterized by: (APNW,i) the major presence of transnational companies (TC), whether in the core firm or in the group of suppliers, (APNW,ii) a strong regulation (protection) allowing them to obtain advantages in the regional market (Mercosur) in connection with sales and purchases; (APNW,iii) reduced export rates outside the Mercosur, (APNW,iv) very negative dynamics during the last seven years (the added value dropped by 40%). On the other hand, the SPNW is constituted by (SPNW,i) a local core firm, which is a world leader in the market area in which it operates, (SPNW,ii) a prevailing importance of small and medium suppliers, and commercial results showing (SPNW,iii) a high export rate (18%, according to Yoguel et. al., 2003), (SPNW,iv) very positive dynamics of its suppliers, not only in the internal but also in the external market, including during the crisis phase beginning in 1995 and becoming deeper since 1998, and (SPNW,v) an increase of around 7% of its added value during the same period. Therefore, the SPNW reveals itself more oriented to compete in more demanding markets, with less desirable regulatory conditions and, at the same time, with better technological and competitive performance during the analyzed period.

## II.2 Importance of knowledge in the APNW and SPNW

### II.2.a. Endogenous competencies

If we consider the development of techno-productive competencies of firms as the average of all the stages that constitute them (innovative capacity, quality, work organization and training), it can be noticed that both networks reach medium values<sup>7</sup>. The difference between them is based on which are the stages of greater development (see Figure 2). In the APNW, the indicator evaluating quality (0.73)<sup>8</sup> reaches a higher value than the others, which are located at predominantly medium levels: training (0.59), innovative capacity (0.50) and work organization (0.48). This shows that inside this network the effort to certify quality is a necessary condition to become a supplier (see Alborno and Yoguel, 2003). Most of the companies of the APNW establish written internal procedures of quality control (85%) and have control points, where a group of statistics are estimated (72%). Furthermore, external certification processes of quality are quite extended (70% of these firms have ISO 9000/9002 certification and 75% of them adhere to other regulations). The importance of both procedures of quality control (internal and external) explains the levels of the added indicator of quality in the SPNW (0.73). In the SPNW, the quality control dimension is less important. The added indicator is 0.48 and reflects a minor diffusion of external certification (only 60% has ISO 9000/9002 certification) and of the internal effort to regulate quality control (63% of the cases).

**Figure 2. Endogenous competence of suppliers: APNW vs. SPNW**



On the other hand, the advantage of the SPNW is based on its high capacity of accumulated innovation. (While this indicator reaches 0.68 for the SPNW it is 0.5 for the APNW). In the APNW, the level reached by

<sup>7</sup> In all cases, the maximum possible value is 1 (see methodological appendix)

<sup>8</sup> This value indicates not only the presence of certifications ISO (72%) but also more complex and specific standards required by the terminals.

innovative capacity (0.5) is mainly explained by the presence of new products (0.7), proxy indicator of innovative *output*, activity that is increasingly being handled to suppliers<sup>9</sup>. Substantially minor values are registered in regards to inputs, such as I+D teams. Only 35% of the studied companies possess a formal I+D structure. In connection to the innovative capacities of the SPNW, most of the companies (70%) have stable “formal and informal” development teams, which involve an average of 7% of the staff. Although only 31% of the observed companies have formal laboratories, informal innovation activities are very important. Almost all the human resources involved in I+D are qualified staff (91%). Therefore, these teams have a high level of technical specialization. As to the effort dedicated to I+D, 87% of the companies have developed and/or reinforced products and output processes, 72% focused on the new development of the product and 53% on distribution and commercialization. As a result, the level of innovative capacities reaches 68% of the maximum level, which is considerably higher than the one reached by APNW (see figure 2).

In relation to work organization, the medium level of APNW and SPNW is similar (0.48). In the APNW, this is explained because of a high proportion (about 70%) of workers organized in cells, but having, at the same time, a relatively reduced autonomy when taking operative decisions and being under a more disciplinary than technical model of supervision. As regards work organization in the SPNW, during the last years, most of the companies have incorporated new machinery and, to a lesser extent, they have introduced organizational changes related to strategic direction and organizational structure of the company. These changes are reflected in the organization of the output process. Even when work organization in cells can be noticed in a scarce number of companies, workers show a high degree of autonomy. In connection to salaries, these companies use the traditional type of incentives, although some of them introduce several aspects connecting incentives to quality and/or competence.

However, in the APNW, the effort devoted to training activities is relatively high (0.59): approximately two thirds of the companies, regardless of their size, have structures specially destined these activities. In the SPNW, most of the companies carry out training activities. These include practically all professional levels and cover 70% of their human resources. Approximately half of the firms of the SPNW have their own structure in order to carry out these activities. Even though during the last five years, there has been an increase of 64% in training funds, the indicator reaches a medium level (44% of an ideal maximum).

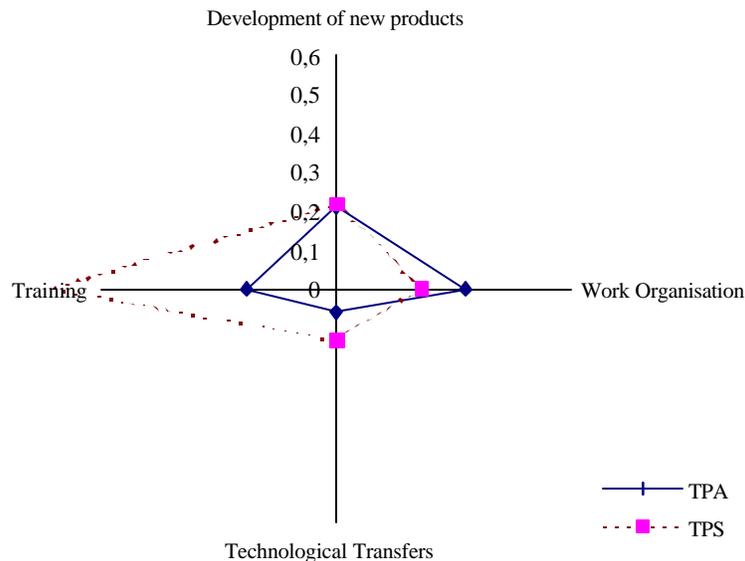
### *II.2.b. Linkages inside the networks*

As shown in Figure 3, the stage of interactions created between suppliers and the core firm constitute an even weaker dimension in the APNW. The level of the added indicator of associations inside the network is only 0.21, which shows a scarce development of non-price relationships and informal interactions between agents. With the exception of the lever of the indicator of assistance for quality and work organization (0.33), which is not extremely low, the remaining indicators show considerably reduced levels (between 0.06 and 0.23).

### **Figure 3. Technical assistance provided by the core: APNW vs. SPNW**

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<sup>9</sup> Due to the continuous changes of models, almost half of the firms sell products less than five years old.



In addition, even if the prevailing relationship is mainly commercial the existence of contracts is very scarce and there is a continuous reprogramming of requests (which makes the associations between core and suppliers become weaker<sup>10</sup>).

In this frame then, it can be noticed that the flows of knowledge and experiences between terminals and their suppliers are not very relevant, indicating that the potential synergies and external aspects seem not to be strategic elements in the current configuration of the APNW.

On the other hand, in the SPNW, linkages between suppliers and the core company are more dense, fluid and stable than in the APNW. However, the results show contradictory aspects, which place this network in an intermediate level between a PNW and the ideal CPNW. Firstly, linkages are ruled by rarely reprogrammed contracts, what represents a positive aspect. The presence of a contract relationship, which is a non-frequent feature of the automotive industry, reduces the strategic uncertainties of the suppliers and allows stable planning that favors the development of competencies. Secondly, the presence of less formal but still significant relationships concerning the circulation of knowledge can be noticed. These include technical meetings, visits to factories and other ways of informing and communicating, which involve an important proportion of the providing companies' staff (approximately 10%). Such personal interactions tend to be more intimate in the case of very specific products, whose technical performance is related to aspects of use. However, formal assistance provided by core companies in relation to technical and technological problems, work organization and supplier's competitiveness, seems to be a weaker aspect (see chart 2 of the statistical appendix). A high

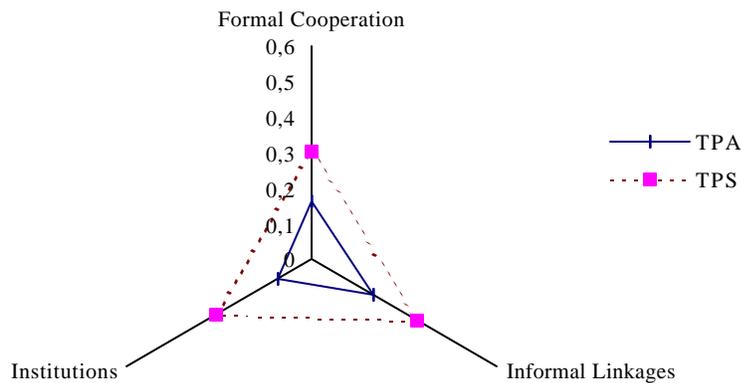
<sup>10</sup> There are other issues related to the strategy of automotive terminals which are also an obstacle to the possibility of generating closer links with the suppliers. An example of this is the direct migration of JIT as a basic component of the Argentine model, even when in this case great part of the supplies are imported. This creates contradictions in the strategy of suppliers of the terminals working with JIT because of the 40% corresponding to the domestic purchase of parts and pieces, while they accumulate important instock in the remaining portion coming from abroad.

proportion of companies have reported not to be receiving technical assistance. The same situation was noticed in APNW (see comparison in figure 3).

### II.2.c. Linkages inside the networks

In the APNW, the associations outside the network (with institutions and other agents) are very weak (0.16). All the indicators score very low values, revealing that firms suffer an important degree of isolation. Relationships with other firms are scarce, not only from the point of view of formal cooperation (0.16) but also in connection with the informal linkages (0.20) that tend to increase the competence of companies and their technological values. However, the indicator of linkages with domestic technically-oriented institutions shows the lowest value (0.11), which is possibly explained by the high quantity of trans-national companies<sup>11</sup>

**Figure 4. Linkages outside the network: APNW vs. SPNW**



On the other hand, firms belonging to SPNW operate at medium levels of interaction with other firms and institutions not belonging to the network, levels that are, however, higher than the ones found in APNW (see Figure 4). This aspect represents an additional source of information and knowledge to the network. As regards the relationship between these suppliers and institutions, 40% have a regular contact with governmental agencies and organizations belonging to the technological and scientific system (Universities and/ or

<sup>11</sup> The pattern of behaviour of the multinational companies of the APN (terminals and suppliers) is not different from the average strategy of localisation of TC in developing countries: critical products and processes with high technological content are maintained in central locations (headquarters and subsidiaries in industrialized countries) and only less complex products and processes are decentralized to developing countries. Being these products and processes the ones that generate less synergies and technological external aspects. This also influences the insufficient links with local institutions as the most important technical assistance is provided by the headquarters. However, the mentioned strategy answers to the evaluation carried out *ex-ante* by TCs on the available capacities in the location of destination: “TCs only transfer technologies which are appropriate to the existing capacities of the receiving country.”

technological and scientific institutions); 25% are connected to industrial chambers and 15% to governmental agencies carrying out programs focused on the modernization of technology.

Finally, almost one third of the SPNW' suppliers has entered into formal cooperation agreements with other agents, which are oriented to the purchase of technology, training activities and marketing. Moreover, most firms of the group (70%) maintain informal linkages with other colleagues -customers and suppliers-, which were considered by the firms to be a contribution to the improvement of their technological and organizational capacities in connection with their productive and commercial issues.

### Summary

The application of the methodology to the APNW shows significant weaknesses in each of the stages proposed for the evaluation of the PNW: (i) endogenous competencies are not high and are less systemic, (ii) the association between suppliers and the core is weak and (iii) relationships with other firms and institutions are practically non-existent.

On the contrary, in the SPNW, the different stages that determine the endogenous competence are strongly connected, constituting a main difference when compared to the APNW. The creation of codified and tacit knowledge arising from the innovative capacities is mediated by the development of quality-assurance systems and by the nature of work processes, where the cell-based organization tends to be predominant. In turn, training strengthens the competencies created at these levels. Thus, from the point of view of endogenous competencies of suppliers, the SPNW is closer to be a knowledge network than the APNW.

Taking into consideration all the characteristics, the SPNW achieves a substantially high level of generation and dissemination of knowledge in the important stages of the endogenous capacities of companies. Weaknesses are noticed in the scarce technical assistance of the core firm, although the relationship with the rest of the network is characterized by stable contracts and it includes other (informal and tacit) forms of interaction. This is verified in the case of the interactions with firms not belonging to the network and with institutions.

### ***II.3. Comparative analysis: competence, linkage styles and autonomy of the core firm.***

As described before, both PNW are not a KPNW as the generation of knowledge and its dissemination within the PNW seems to be unimportant. The descriptive analysis shows the weakness of the association levels (linkage style) between the dimensions constituting endogenous competencies (innovation capacities, quality, work organization and training). However, some differences in both sectors can be pointed out: (i) the innovation capacity is relatively higher in the SPNW than in the APNW; (ii) in the SPNW, linkage styles are characterized by a higher intensity of the relationships; and (iii) the proportion of branches of trans-national firms is higher in the APNW than in the SPNW.

To evaluate this aspect arising from the descriptive analysis, we propose an econometric analysis, which will in turn clarify some of the differences between APNW and SPNW. As a matter of familiarity we present only

OLS estimations, though we have also estimated median regressions in order to avoid the problems of outliers and the results remained the same<sup>12</sup>.

For this purpose, we have defined the linkage style ( $LS \in [0,1]$ ) as the following function:

$$(1) \quad LS_i = f(X_i, TP_i)$$

$X_i$  is a group of variables related to the characteristics of the firms  $i$  (their sales and type of property), and  $PS_i$  is a “dummy” variable, which differentiates both PNW. Thus, the econometric model to be estimated is:

$$(1.a.) \quad LS_i = \alpha_1 sales_i + \alpha_2 FDI_i + \gamma PNW_i + \mu_1$$

The results of the estimation (table 3) confirm the fact that belonging to the SPNW is significant and positive for the quality of the linkages (see statistical appendix). Besides, the ratio associated to the belonging or not to multinational companies (FDI) and sales is a non-significant variable.

Now, we will focus on the explanations of the accumulated capacity of innovation ( $IC \in [0,1]$ ). For this purpose, we consider:

$$(2) \quad IC_i = f(X_i, Z_i, EMI_i, EV_i)$$

Once again,  $X_i$  is the controlling variable representing the stable characteristics (origin of property and sales),  $Z_i$  is a group of variables associated to the rest of the dimensions of CPNW (quality, training and work organization),  $EMI_i$  the money investment or non-investment in innovation and  $EV_i$  the linkage style. The equation to be estimated is:

$$(2.a.) \quad IC_i = c + \alpha_1 sales_i + \alpha_2 FDI_i + \beta_1 wkorg_i + \beta_2 training_i + \beta_3 quality_i + \beta_4 EMI_i + \phi EV_i + \mu_2$$

The OLS estimation shows: (i)  $EV$  is a positive and significant variable, (ii) the fact of belonging to a multinational corporation is also positive and significant and (iii) the rest of the dimensions defining a PNW are not important (see Table 4).

The repetition of this exercise for each of the dimensions has not revealed any significant connection with the rest of them. This might reinforce the idea that the PNW in both sectors is partially integrated and has been based on incomplete interactions, and that the synergies within the PNW were concentrated on the linkages style and the accumulated capacity of innovation.

To sum up, after analyzing the characteristics of the firms (the quality and property) and the rest of the dimensions that determine the KPNW, we notice that the association pattern appears as a significant channel

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<sup>12</sup> Median regressions are available upon request.

through which the accumulated capacity of innovation of companies improves itself. As belonging to SPNW widens the association pattern established between suppliers and the core company, we have identified a possible candidate to explain the higher capacity of added innovation in the SPNW. On the other hand, multinational companies develop weaker levels of connection, but they seem to be innovating more. This fact shows the presence of other channels, apart from the linkage styles, that are relevant for the accumulation of innovative capacities<sup>13</sup>.

The differences between both PNW can be explained by the characteristics of the core companies and above all by its autonomy and its market scope. In the automotive case, not only the core company but also its suppliers are multinational companies' branches, subject to a strict hierarchy system and playing, in general, a marginal role inside their multinational corporation<sup>14</sup>. That is why local or even regional orientation of activities and market scope coincides with very low levels of autonomy involving strategic and technological options. This could be one of the reasons for high dependence on the economy cycle and the intrinsic volatility, which characterize the local and regional market.

A possible explanation of the weakness of the linkage pattern within the APNW might be as follows: A limited autonomy of the core influences the network articulated by it<sup>15</sup>. One of the expressions of such instability of the core firm is the instability of contractual associations. At the same time, the suppliers' companies depend on their own headquarters. The consequence of such hierarchy is (i) a limited interaction and weak information and circulation of knowledge within the APNW and (ii) a learning process based on the linkages established within the multinational corporation. This fact may also explain why the accumulated capacity of innovation in the APNW is lower than in the SPNW, considering the fact that the importance of TNCs is higher in the APNW than in the SPNW.

In the case of the SPNW, the core company is a national corporation, which has become multinational through acquisitions or mergers of companies in Latin America or Europe. As a result, its strategy has a high level of autonomy, reflected to suppliers' companies. This autonomy and scope not only gave shape to the core company but also to the network articulated around it, allowing the SPNW a flexibility to face regional fluctuations of prices and demand.

Furthermore, as noticed before, inside the SPNW, there exist higher levels of relationships indicating not only more stable contractual relationships but also higher importance of informal interchanges in the interior of the PNW.

Finally, a complementary expression of the differing weight of local influence in the process of generation and circulation of knowledge in both PNW is the intensity of the linkages established with agents external to the PNW and with the institutional system. As a matter of fact, 80% of the companies of SPNW have established a permanent connection with other private or public institutions, 70% have established informal contacts with

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<sup>13</sup> The size of the firm seems to be significant for the innovation capacity only for firms constituting the APN.

<sup>14</sup> Some Argentine branches are under control of their corresponding Brazilian branches.

<sup>15</sup> Similar evidence is found in Humphrey (2000) for Brazil, India and South Africa.

companies outside the SPNW and 30% have entered into formal agreements with other companies. However, for the automotive sector, the bilateral connection with the headquarters is in all cases the most relevant one.

#### **IV. CONCLUSIONS**

This article proposes a methodological design, which makes possible the identification of the level of development of the productive network from the point of view of the generation of learning processes. Identifying these processes is vital to capture the way in which the new economy spreads into the old sectors studied in the article: the automotive and iron-and-steel complexes. This methodology is based on the idea that the emergence of new sectors (producers of information and communication technologies) is not the only way in which the “new economy” is revealed. There are several signs of the presence of elements associated with the new economy in traditional sectors, such as the growing importance of tacit and codified knowledge in the development of competitive edges. This issue is also reflected in the new configurations adopted by productive activities, which confer growing relevance to productive networks, innovation systems and global value chains controlled by buyers and/or producers.

When applying the methodology to the analysis of the automotive and iron-and-steel complexes, weaknesses and differences of both industries can be noticed in connection with the generation of endogenous competencies, linkages with their corresponding core companies and network synergies. To such extent, both networks under study do not constitute productive networks with an intensive knowledge (KPNW). However, generation and circulation of knowledge in the iron-and-steel network are considerably higher than in the automotive one. This coincides with a more noticeable presence of a “new economy” in the first network.

In the case of the automotive network, the weakness in the generation and circulation of knowledge is reflected by (i) the absence of linkages between the three dimensions determining the endogenous competencies of the individual companies and (ii) the absence of linkages between the endogenous competencies of the suppliers, and the linkages with the core inside the network. On the contrary, in the iron-and-steel network, there is a stronger association between the factors determining the endogenous competencies of suppliers. Furthermore, a positive connection could be found between the degree of development of the endogenous competencies of the suppliers and the informal linkages with the core company. Our econometric study confirmed these results.

The differences in the importance reached by the learning processes in both networks may be explained by the fact that, even if both networks are global, the iron-and-steel one is the international center of a global network, while the automotive one is a regional network controlled by a global chain. A strong connection can exist between the development of learning processes and the strategic character or not of the local network. In sum, if the local component of a global network mainly benefits from static competitive advantages (the closeness and access to the regional market, the great quantity of natural resources, cheap and relatively productive labor), the generation of learning processes can be less relevant and, therefore, the evolution path of the local network can be blocked. Consequently, in cases where the local productive network does not have a strategic function within the global chain the importance of the learning processes is less significant, concentrating the critical learning on the international core of the network. As a consequence less competitive

local networks are generated that are scarcely complex and strongly vulnerable to context changes. This case is evidenced by the automotive network operating in Argentina, with an exclusively regional market scope and an exploitation of the network's closeness and access to Mercosur.

Consequently, the development of local learning processes and the achievement of competitive advantages based on knowledge require, as a necessary but not sufficient condition, a productive network with high local competence or strategically associated to the global network it belongs to.

In the automotive PNW, controlled by subsidiaries of multinational companies, the development of regulations and rules favoring local network from the perspective of the regional market (Mercosur) constitute a necessary condition for the creation of policies. A complementary and more offensive strategy should have to enhance the development of identified local endogenous competencies -beyond localization advantages- that might be used by multinational companies as key resources.

From the point of view of networks with a local core, the policy should be guided basically towards an increase in the internationalization and the importance of local key factors. The development of a policy of this kind would require strong private participation and the emergence of intermediate agents capable of articulating the group of dimensions which determine the individual and global competencies of the network.

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## Methodological appendix

This appendix describes how the following indicators are estimated: innovative capabilities, quality, work organization, training associated with the development of internal skills, "linkage styles" that account for the relationships of network firms with external agents and with the core-firm.

### A. Development of endogenous skills

#### A.1 Innovative capabilities

(a) Potential human resource capabilities to carry out developments,

(a1) ratio of workers devoted to R&D over the total number of workers employed: the simple ratio between both aggregates is estimated.

(a2) ratio of workers with a high relative qualification (engineers and technicians): the ratio between this aggregate and the total number of workers formally devoted to R&D is estimated. The indicator is equal to 1 if this ratio is greater than 30%, is equal to 0.5 if this percentage lies between 20 and 30%, is equal to 0.25 if the percentage is greater than 0 and less than 20%, and is equal to zero in the remaining cases.

(a3) ratio of highly skilled workers devoted to R&D ("innovative skilled workers") over total employment. The indicator is equal to 1 if this percentage is greater than 4%, is equal to 0.5 when this percentage is greater than 2% and less than 4%, and equal to 0 otherwise.

(b) Existence of a specific infrastructure (R&D laboratories dedicated to create and/or adapt new developments): The indicator is equal to 1 when a formal infrastructure exists and otherwise is equal to 0.

(c) Development of new products: this indicator is the ratio between the weight of new products introduced from 1995 onwards over the total turnover in 2000 (APNW) and 2001 (SPNW).

(d) Relevance and complexity of development activities: this indicator is defined as the total number of achievements in development activities over the total number of possible cases (product developments and improvements, process developments, process improvements, new distribution and marketing methods, and internal just-in-time)

All these factors are complemented through some indicators of pecuniary efforts dedicated to innovation. It is built up as the average of the following dichotomous factors (0 or 1). Whether or not the firm has made some purchases in a) embedded technologies, b) R&D, c) organizational changes, d) channels, e) product and process adaptation

#### A2 Level of quality assurance

This aggregate indicator of quality assurance is the average of the following factors:

- Sequence (weight = 0.30): it is equal to 1 if the firm uses control worksheets and estimates 75% of the possible statistical parameters (frequency distribution, histograms, cause-effect diagrams, variable control graphs;

statistical control of attributes); it is equal to 0.50 when the firm estimates less than 75% of the statistical parameters; and is equal to 0 when the company does not use control worksheets.

- Quality certification (weight = 0.70): a simple average is estimated to reflect the existence of ISO9000 certification (values 0 or 1) and an indicator is computed to reflect the number of standards considered (number of standards above 3).

### **A.3 Work organization**

This indicator is a simple average of the following factors:

A.2.1. Percentage of workers organized in cells: the simple ratio is estimated.

A.2.2. Relevance of the cell: this indicator is equal to 1 when cell-workers participate totally or partially in determining production rhythms, establishing and controlling quality standards, programming or reprogramming machinery, designing, improving or developing processes or products; the indicator is equal to 0.6 if less than 80% of the workers are involved in such activities and equal to 0.3 when 60% (or less) of the workers are involved.

A.2.3. Cell autonomy: this indicator is equal to 1 when a supervisor and a facilitator are included in the team; it is equal to 0.5 if only one of them exists, and equal to 0 when the cell has neither of these functions.

A.2.4. Relevance of polyvalence: this indicator is equal to 1 if polyvalence is an important skill for the work organization and 0 otherwise.

A.2.5. Extension of polyvalence: this indicator is equal to 1 if polyvalence requires skills from one sector exclusively and 0 otherwise.

### **A.4 Training efforts**

B.1. Type of qualification. The indicator is equal to 1 if the number of professionals and technicians in the firm is greater than 15%; it is equal to 0.5 when their number is greater than 5%, and is equal to 0 in the remaining cases.

B.2. Percentage of training expenses with respect to total sales. This indicator is equal to 1 if this percentage is greater than the average; it is equal to 0.5 when this percentage is in the neighborhood of 10%, and is equal to 0 in the remaining cases.

B.3. Participation of less skilled human resources in training. This indicator is equal to 1 if this percentage is greater than 60%, and is equal to 0 in the remaining cases.

B.4 Existence of a distinct structure within the area of human resources. This indicator is equal to 1 when a separate area exists and otherwise is equal to 0.

## **B Exchange of knowledge with other agents outside the network and with the core-firm**

### **B.1. Agents outside the network**

B.1.1. Formal agreements: This indicator is equal to 0 if the firm has not signed formal cooperation agreements. Its value is 0.5 when the firm has formal cooperation agreements covering at least one of the possible areas (merchandising, input purchase, technology purchase, training, and exports). It is equal to 0.75 when agreements covering two areas exist and equal to 1 when the agreements cover at least three areas.

B.1.2. Informal connections with other agents: A number of different issues included in possible exchanges with other agents, as well as the frequency of such interactions is considered. Among possible issues, a group of topics

of greater relative complexity is selected among those having a relative weight of 1 when the alternatives of the firms were considered (the possibility of carrying out joint business, possible partnership, shared training programs, shared product and process developments, problems associated with quality management). A weight of 0.5 is assigned to informal talks about business carried out within the framework of Mercosur and about automotive regulations for the year 2000. A weight of 0.25 is assigned to informal talks about carmakers' demands, merchandising strategies for the domestic market, and topics related to the sector's chamber. Finally, a weight of 0 is assigned to the remaining alternatives (economic conditions at the country, financing, labor problems and others). The aggregate obtained for each firm is divided into the maximum possible amount (7.5) so as to parameterize factors. The result thus obtained is then multiplied by the periodicity of connections: the factor is equal to 1 when daily or weekly contacts occur; it is equal to 0.5 when monthly contacts occur, and equal to 0.25 if contacts are merely sporadic.

**B.1.3. Institutions outside the network:** the values of this indicator lie in the interval [0,1]; it is equal to 1 when the firm resorts to other institutions that: (i) perform tests, (ii) provide analysis and methodology, (iii) search for technological and market information and also process and examine it, (iv) provide training seminars and courses, (v) carry out research and development projects. The remaining values are defined as the ratio between effectively realized connections and total possible connections.

## **B.2. Inside the network**

This indicator involves 6 different factors

**B.2.1. Participation of the carmaker in training activities.** This indicator lies in the interval [0,1]. Its maximum value corresponds to a carmaker that has actual influence on decisions about training, thematic areas involved, methodologies selected, target audience, trainers' selection, assessment and other related issues. Its value decreases with the decreasing number of assistance areas.

**B.2.2. Intensity of technical assistance for quality and work organization.** This indicator is equal to 0 if there is no assistance; it is equal to 1 when technical assistance is provided for all the alternatives involved, and is equal to 0.3 for each element involved (quality improvement techniques, product development and design, work and production organization).

**B.2.3. Core-firm support for development activities:** this indicator adopts values in the interval [0,1]. The maximum value (1) is assigned when the carmaker takes part in product development and improvement, product adaptation, development or improvement of new processes, distribution transformations, and internal JIT and client-supplier relationships. Its value decreases with the decreasing number of assistance areas. In this sense, the indicator is a ratio between the alternatives for which the firm receives support and the total number of alternatives considered.

**B.2.4. Use of the core-firm's infrastructure and laboratories.** This indicator is equal to 1 if the provider uses the core-firm's laboratories and is otherwise equal to 0.

**B.2.5. Technology transfer.** This indicator is equal to 0 if there is no transfer from headquarters; it is equal to 0.5 when there is transfer from headquarters, and equal to 1 when there is transference from car-makers and/or technology providers, etc).

## Statistical appendix

### A. Average levels of indicators

Table1: APNW: Average level of factors

Determinants of competencies creation and diffusion in the network <sup>a</sup>	Average
Whole linkages with core-firm	0.21
Training assistance	0.23
Quality and work organization assistance	0.33
Product and process development assistance	0.21
Technology transfer	0.06
Use of coordinating enterprise infrastructure	0.13
Linkages with other agents	0.16
Formal cooperation	0.16
Informal linkages	0.20
Linkages with institutions	0.11
Competencies level in the network firms	0.58
Innovation capacity	0.50
Quality	0.73
Work organization	0.48
Training efforts	0.59

Source: own elaboration

Table 2: SPNW: Average level of factors

Determinants of competencies creation and diffusion in the network <sup>a</sup>	Average
Whole linkages with core-firm	0.35
Training assistance	0.72
Quality and work organization assistance	0.22
Product and process development assistance	0.22
Technology transfer	0.13
Use of coordinating enterprise infrastructure	0.08
Linkages with other agents	0.32
Formal cooperation	0.30
Informal linkages	0.34
Linkages with institutions	0.31
Competencies level in the network firms	0.52
Innovation capacity	0.68
Quality	0.48
Work organization	0.48
Training efforts	0.44

Source: own elaboration

## B. Econometric models

Table 3: Estimation of equation 1.a.

	Linkage Styles
Cons	0,27 (0,06)
Size	-0,0003 (0,0006)
FDI	<b>-0,10*</b> (0,06)
PNW	<b>-0,11*</b> (0,05)
Work Organization	<b>0,20*</b> (0,10)
Training	-0,0006 (0,0007)
Cumulative Innovation Capabilities	0,0002 (0,0001)
Pecuniary effort in Innovation	0,0008 (0,0005)
R- Squared	0,24

Notes:            between brackets standard deviation

\* significant at 5%

Source: own elaboration

Table 4: Estimation of equation 2.a.

	Cumulative Innovation Capabilities
Cons	0,47 (0,15)
Size	-0,000157 (0,00001)
FDI	<b>0,14*</b> (0,007)
PNW	<b>0,36*</b> (0,18)
Work Organization	-0,12 (0,12)
Training	-0,000003 (0,000008)
Pecuniary effort in Innovation	0,05 (0,14)
R- Squared	0,26

Notes:            between brackets standard deviation

\* significant at 5%

Source: own elaboration