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Domestic and foreign knowledge sources for innovation in internationalized Production Networks: the automotive and the iron and steel cases*

*Hernán Alejandro Morero***

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ABSTRACT

This paper studies the relative relevance of domestic knowledge sources for innovation in internationalized production activities in an emerging economy. Two Production Networks from Argentina with a different kind of internationalization were considered: organized around subsidiaries of multinational companies (the automotive case) and organized around local headquarters (the iron and steel case). A multiple factor analysis was carried out and cluster techniques were applied using a specific innovation survey done to 163 automotive and iron and steel firms from Argentina from the period of 2001 to2005, to evaluate the relative importance of domestic and foreign knowledge sources. The main finding is that in a production network organized around domestic headquarters the best innovative performance underrates the importance of international linkages, in comparison with networks organized around foreign subsidiaries.

KEYWORDS | Internationalization; Production Networks; Automotive Production Network; Iron and Steel Production Network; Argentina

JEL-CODES | B52; L62; L61

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Fontes de conhecimento domésticas e estrangeiras para a inovação em redes de produção internacionalizadas: os casos das indústrias automotiva e siderúrgica

Resumo

Este artigo estuda a importância relativa de fontes de conhecimento domésticas para a inovação nas atividades de produção internacionalizadas em uma economia emergente. Duas redes de produção da Argentina, com diferentes formas de internacionalização, foram consideradas: uma delas organizada pela presença de filiais de empresas multinacionais nos núcleos da rede (indústria automotiva); e outra caracterizada pela existência de empresas locais nos núcleos da rede (caso da indústria siderúrgica). Foram utilizadas técnicas de análise fatorial múltipla e de agrupamento (*clusters*), aplicadas a dados de um levantamento de inovação junto a 163 empresas automotivas e siderúrgicas da Argentina, para o período 2001-2005, com o intuito de avaliar a importância relativa das fontes de conhecimento domésticas e internacionais. A principal constatação é que o melhor desempenho inovador das redes de produção organizadas em torno de empresas domésticas subestima a importância dos vínculos internacionais, em comparação com as redes organizadas em torno de subsidiárias estrangeiras.

Palavras-chave | Internacionalização; Redes de Produção; Cadeia Automotiva; Cadeia de Produção Siderúrgica; Argentina

Códigos JEL | B52; L62; L61

1. Introduction

In recent decades, the main characteristics of the economic and techno-productive context involve an increasing degree of internationalization of production and a dispersion of the innovative activities and knowledge sources to innovate. The question on how this phenomenon constrains or encourages local competences building has occupied an important place in the debate of the role of Multinational Companies (MNCs) and Foreign Direct Investment (CANTWELL, 1994; CANTWELL; MUDAMBI, 2005; CANTWELL; PISCITELLO, 2000; DUNNING; LUNDAN, 2008; ERNST, 2002).

Moreover as competence building is systemic in nature and it is shaped by Systems of Innovation (SI), a recurrent concern in the National System of Innovation (NSI) literature has been the way in which the *national dimension* of the SI is affected by the phenomenon of internationalization of production. The relative relevance of domestic sources of knowledge for innovation (BALZAT; HANUSCH, 2004; JOHNSON, 1992; LUNDVALL, 2007, 1992), namely the *national side* of NSI, is within this problem as well. Therefore, the paper studies the relevance of the domestic sources of knowledge for the innovative performance of firms that operate in internationalized production activities in an emerging economy, taking into account that the literature that has studied the SI's internationalization has been mainly focused on developed countries (CARLSSON, 2006).

We have adopted a NSI approach from a Production Network perspective to deal with this issue(ALBORNOZ; YOGUEL, 2004; MORERO, 2010). The main idea that guides the research is that the national dimension of the NSI is relevant to the processes of accumulation and generation of knowledge even in internationalized Production Networks. For this reason, the importance of the NSI and domestic knowledge sources for innovation in two internationalized Production Networks in Argentina will be studied: the Automotive and the Iron and Steel Production Networks. Although both are internationalized Production Networks, their internationalization differs. While the Automotive network in Argentina organizes its production around firms that are subsidiaries of MNCs with headquarters in other countries –which means that they have cores of the global chain outside the national economy–, the Iron and Steel network organizes its production around local headquarters of MNC –that is, they have a global core inside the country.

In order to evaluate the relative importance of the domestic and foreign knowledge sources to innovation in this two different internationalized Production

Networks, a multiple factor analysis was carried out and cluster techniques were applied applied using a specific innovation survey done to 163 automotive and iron and steel firms from Argentina for the period from 2001 to 2005. The paper is structured as follows: in the next section, we present the theoretical framework, the problem and the hypotheses; next, we present the methodology, with the description of the data source, the construction of indicators and the statistical methods used; and, finally, section 4 summarizes the main results of the quantitative analysis and section 5 presents some final remarks.

2. Theoretical framework, problem and hypothesis

The NSI approach began in the late 1980s as a framework to study the economic performance of countries from a historical, institutional and an holistic perspective (FREEMAN, 1987, 1995; LUNDVALL, 2007, 1992; LUNDVALL et al., 2009; NELSON, 1993). The rate and direction of innovation, on which ultimately the economic performance of a nation depends, arises from the co-evolution between the different aspects of the institutional set up and the national economic structure (LUNDVALL, 1992). As long as innovation reflects the learning processes and relies on the routine activities of firms, innovation is rooted in the *National Structure of Production*, because it limits the direction and scope of the production routines. Secondly, the *National Institutional Set Up* enables innovative activities to take place in an essentially uncertain environment, as long as also institutions shape human habits, affect the characteristics of the productive routines and create the stability needed to support economic activities in a context of ubiquitous change (JOHNSON, 1992).

Therefore, firms from different nations will experience learning processes that differ because, even when they are immersed in an economic system similar to other countries, the environment in which companies operate (and learn) has particular idiosyncrasies, ideological, cultural, economic and historical characteristics (JOHNSON, 1992). There emerges the importance of the *national dimension* to evaluate the processes of learning, as well as the innovative and economic performances. Unless there are in the literature some complementary lines (EDQUIST, 2001) of SI according to the level of analysis, the national level of analysis has been largely dominant.

A recurrent concern in the NSI literature is how the national dimension of the SIs is affected by the internationalization of production and, in particular, on the relevance of the domestic sources of knowledge for the innovative performan-

ce in a globalization context (BALZAT; HANUSCH, 2004; JOHNSON, 1992; LUNDVALL, 2007, 1992; NELSON, 1993). Moreover, a branch of the literature claims that the international dimension is neglected in the NSI theory and proposes a Global Production Network approach (ERNST, 2002). In fact, a series of studies on Global Innovation Networks has risen recently (BRITTO et al., 2013; DIAS; PEREIRA; BRITTO, 2012; LORENTZEN; GASTROW, 2012) towards a Global Innovation System perspective.

Then, the general objective of this research is to study how the globalization of production affects the national dimension of SIs and, more precisely, their ability *as national* to affect the innovative activity in highly internationalized activities in an emerging economy like Argentina. International linkages are not neglected *per se* by a national perspective, but they could erode the importance of the domestic knowledge sources for innovation (created by local actors, within their organizations and by interaction with other national actors) and the relevance of the national dimension could be diminishing progressively.

On the other hand, the empirical studies on the Argentinean NSI have been focused on its characterization (ANLLÓ; PEIRANO, 2005; SUAREZ; DE ANGELIS, 2010), its link with the economic development of the country (KATZ; BERCOVICH, 1993; LÓPEZ, 2007), and on the analysis of the technological policy (CHUDNOVSKY, 1999; FANELLI; ESTÉBANEZ, 2007). Therefore, there are no systematic studies on the issue of the effect of internationalization upon the Argentinean NSI, or on the relative importance of domestic knowledge sources for innovation in internationalized economic activities. The relative significance of the domestic and foreign sources of knowledge for innovation in these activities must be studied. This paper contributes to this issue, addressing the problem through a NSI approach from a Production Network perspective (ALBORNOZ; MILESI; YOGUEL, 2005; ALBORNOZ; YOGUEL, 2004; MORERO, 2010, 2013b).

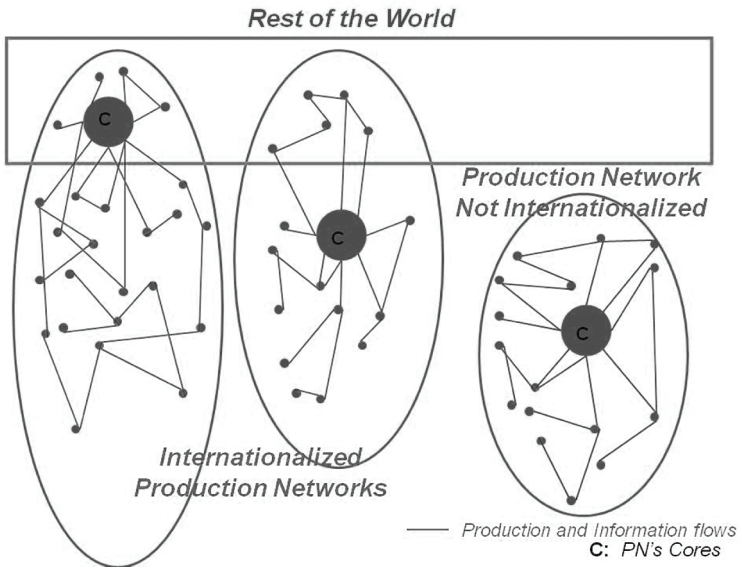
A Production Network is an economic space of technological capabilities building. It is composed by one or more organizing firms (the cores) and all their suppliers and customers, and, on the other hand, by the interrelationships between those elements, derived from purchases and sales, information flow, commercial and productive knowledge flow, through formal and informal channels (ALBORNOZ ET AL., 2005; ALBORNOZ; YOGUEL, 2004). It is an epistemic community (COWAN; DAVID; FORAY, 2000) that shares a codified and disarticulated language, and the knowledge involved is hardly understood by agents that do not belong to the network.

In a Production Network the learning processes and the development of technological capabilities depend on: a) the endogenous competences, product of internal interactive learning; and b) the flow of knowledge through interaction with other actors, which includes linkages within the network (between suppliers and customers with the core, and between firms from the network), as linkages outside of the network.

Thus, within this conceptual framework, a Production Network is defined, in line with the concept of SIs, as *elements* (actors) and their *interrelationships*. However, it is also a concept that focuses on more definite relationships, in the sense that it focuses on the relations around actors who share a specific language and, therefore, a common base of knowledge.

On the other hand, this framework is related to the sectoral system of innovation approach (MALERBA, 2004), in the sense that in the analysis it takes into account actors, networks and institutions around a common knowledge shared. It differs due to the adding of an organizational hierarchical distinction between firms inside the networks (the cores on the one hand, and their suppliers and customers on the other), and focusing on the relationships and linkages around the cores of the networks.

FIGURE 1
Internationalized Production Networks

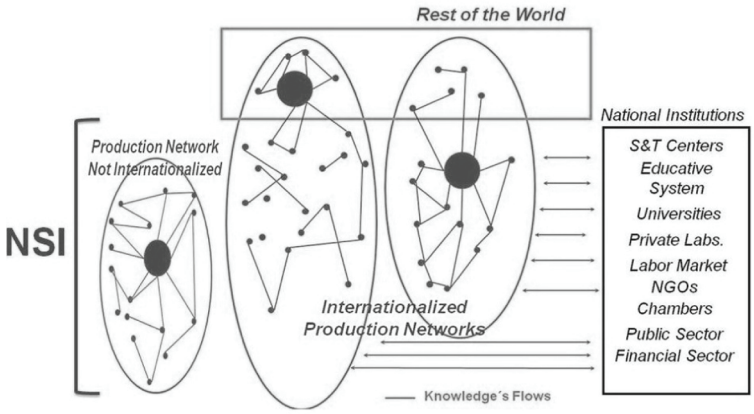


Source: Own elaboration.

Since we are interested in the effect of internationalization on the knowledge sourcing of the firms, it is necessary to distinguish between internationalized and not internationalized Production Networks. Thus, as it is shown in Figure 1, internationalized Production Networks are those that have significant interactions with the rest of the world at both the production and knowledge and information flows. In turn, a Production Network that is not internationalized in a country keeps little or no productive linkages, and shares little or no information and / or knowledge with the rest of the world.

Figure 2 presents a simplified representation of an NSI from a Production Networks perspective. Following the definition of Lundvall (1992), it is composed by **elements** and their **interrelationships**. The elements are, first, the firms (core, its suppliers and customers) taking into account the internal processes of interactive learning and the accumulated competences and skills, and other institutions such as S&T Centers, Universities, private labs, the organization of labor markets, industry and commerce chambers, and the characteristics of the public and financial sectors. Finally, the system it is composed by the interrelationships, which are flows of knowledge between the elements, as technological and commercial linkages relevant to the innovative activity and learning processes of firms.

FIGURE 2
A NSI from a Production Network perspective



Source: Own elaboration.

Then, within this framework of the NSI from a Production Network perspective, the specific aim of this research is to analyze the importance that the NSI has to local firms that operate in highly internationalized Production Networks in

a developing country, such as Argentina. The main idea that guides the research is that the national dimension of the NSI is relevant to processes of accumulation and generation of knowledge, even in internationalized Production Networks. It follows the first hypothesis (*H1*)*: it is expected that, even in internationalized Production Networks, the firms that complement their external knowledge with domestic knowledge (internal learning and national linkages) will have a better innovative performance than those firms with sources of knowledge that remain mainly external*.

In this paper we will deal with two facets of the process of the global dispersion of the innovative activities (MUDAMBI, 2008) in developing economies. Firstly, we will take into account domestic networks where their internationalization process is led by the establishment of foreign MNCs as cores. For this case, we will consider the automotive case from Argentina, which is organized by foreign subsidiaries of MNCs. That means, the cores of the global chain are outside the national economy and the internationalization of the network is driven by the installation of automakers that respond to the global strategies of large foreign enterprises. Secondly, we will take into account domestic Production Networks where the internationalization process is defined by the internationalization of domestic cores that constitute MNCs from developing countries. In this case, we will consider the iron and steel case from Argentina, which organizes its production around domestic-based MNCs (with headquarters in the national economy) and constitutes cores of the global chain. That is, the internationalization in this local network was driven by the internationalization of national cores, which are MNCs.[1]

There is no reason to consider that this difference between the networks will have neutral effects upon the effect of the internationalization of production on the knowledge sourcing origin. Therefore, the importance of NSI could vary with the particular characteristics of the type of internationalization of each network. In particular, by the importance of the tacit components of knowledge rooted in the nation, *in the internationalized Production Networks whose cores are local, the importance of the NSI for the generation and accumulation of knowledge of the firms will be higher, in relation to the internationalized Production Networks whose cores are outside the country*; which is the second hypothesis (*H2*) of the paper.

1 Both cases are emblematic of the internationalization in the Argentinean industry. Together they represented between 39% and 44% of industrial exports, and between 11% and 14% of total exports in the 2004-2006 period (DNCI, Ministerio de Economía, Argentina). Thus, the consideration of these cases is relevant in regard to the internationalization of the Argentinean economy.

3. Methodology and data source

3.1. Indicators and method

To carry out this type of analysis we constructed a series of indicators representative of the learning processes of the firms that stylize the diverse sources of knowledge to innovate. Following past research in the field (ALBORNOZ; YOGUEL, 2004; MORERO, 2010, 2013a; MOTTA; MORERO; LLINÁS, 2007), we constructed Interactive Internal Learning indicators, an External Purchase of Technology indicator, Linkages indicators and Innovative Performance indicators (MORERO, 2010, 2013b)[2]. All these indicators are ordinal variables with three categories (low, medium and high).

First, we designed an overall indicator of Internal Interactive Learning that seeks to capture the virtuosity degree of circulation of knowledge within the firm. Two equally weighted sub-indicators compose this indicator: an indicator of internal Structure of Circulation of Knowledge (SCK) and an indicator of the Intensity of Circulation of Knowledge (ICK). The first sub-indicator tries to capture aspects related to the structure of the firms conditioning the internal learning processes and the circulation of knowledge inside the organization. The SCK indicator summarizes various aspects related to work process organization (teamwork, supervisory roles and the degree of autonomy given to workers, as well as their rotation), the structure of R&D and training structure. The second sub-indicator, the ICK indicator, attempts to capture aspects of learning within the firms related to innovation and learning activities. It includes the internal development of technology efforts (R&D expenditures, product development, organizational change, etc.), quality and continuous improvement activities. A more profound and detailed exposition of the components of the indicators can be found in Morero (2010).

Firms also make efforts in External Purchase of Technology. In order to capture this phenomenon, an indicator that measures the intensity of the external buy of technology was constructed, taking into account if the firm has purchased capital goods and/or acquired licenses. In addition, Linkages indicators have been constructed, trying to distinguish between linkages with national and with international actors. The intensity of the linkages is considered through three factors: the number of objectives of the linkage, the frequency of interactions, and the number of agents

2 A full detail of the construction of each one could be consulted on Morero (2010, 2013b).

involved taking into account domestic linkages (cores, other plants, domestic suppliers or customers, chambers, technology centers and universities) and international ones (other plants, international customers and suppliers, headquarters).

We want to see the relative importance of the innovation of these types of knowledge sources. Here, we can distinguish the national and foreign kinds, as well as the external and internal sources, as it is shown in Chart 1.

CHART 1
Sources of knowledge for innovation

	External	Internal	National	Foreign
Internal Learning		X	X	
External Puchase of Technology	X		X	X
National Linkages	X		X	
International Linkages	X			X

Source: Own elaboration.

Finally, as we want to relate the different balances of these knowledge sources to innovative performance, we have developed a global indicator of the innovative performance of the firms. This indicator takes into account the areas or types of innovations (product, process, commercial or marketing and organizational innovations), the importance of the innovations introduced and their results (improvements in efficiency of human resources, in the internal JIT, in the development and improvement of products, product adaptation, development and process improvement, development of new forms of distribution and production organization). An overall indicator of innovative performance of firms was also developed taking into account the number of areas where the firm obtained results from innovation and the global importance of innovation.

All of those are qualitative variables, and for their quantitative analysis, it is convenient to apply techniques from multivariate data analysis. Multivariate Analysis is a powerful set of methods when the problem that arises implies multiple dependent or interdependent variables. One particular multivariate analysis technique is the Multiple Factor Analysis. It is a data reduction technique that allows us to summarize a large number of heterogeneous variables (called the active variables) in a new space, drawing (in fact, projecting) the observations (in this case, the firms) into a new set of variables called the factors. The factors are new variables that maximize the variability of the active variables selected. That is, the factors are a smaller number

of variables, more manageable than the original variables, but are also homogeneous and continuous variables composed by a combination of the originals. In the case of a series of ordinal variables or categorical multidimensional variables, the factors are combinations of the categories of all the active variables involved in the analysis. The technique constructs factors until all the variability (also called the inertia) of the active variables is summarized by the factors, which implies that all the factors together explain the same information that the original variables.

Therefore, to characterize the learning process and identify the main sources of knowledge for the firms of each network, we will apply a Factor Analysis as a way to reduce dimensions between diverse categories of qualitative variables. This analysis will enable us to use a new set of variables for each firm (the factors) that summarizes the knowledge sources recurrence in a homogeneous way to compare all the cases.

In this paper, we will apply the Multiple Factor Analysis to reduce dimensions of two indicators: the overall Internal Learning indicator and the overall Linkages indicator, which are the Factor Analysis active variables. Thus, a set of factors will be generated in terms of the active variables (in fact, in terms of all their categories), and we will project the cases (the firms) on those new dimensions. This projection of each observation in new 'homogeneous' dimensions (made of heterogeneous qualitative variables) allows us to calculate distances between the cases, specifically in these terms.

The final goal of this analysis is to build relatively homogeneous groups of firms, related to the main aspects of their learning processes (that is, the relative importance of the innovative performance of the external and internal components of knowledge, as well as the national and foreign sources), and then evaluate the innovative performance associated, in homogeneous dimensions. The Factors calculation could be used to perform a Cluster Hierarchical Analysis, grouping the firms in such a way that the cases in the same group are more similar (in relation to the factors) to each other than to those in other groups.

Moreover, it is also possible to project in the new dimensions not only the observations, but also their other characteristics not involved in the Factor construction, as supplementary variables. Thereby, the groups could also be characterized by the level of the other variables not involved in the Factor Analysis nor Cluster Analysis through a proportion 'Valeur Test' (MORINEAU, 1984) for each category of variables. In that sense, we will be particularly interested in the variables of innovation, to characterize the innovation performance of the groups.

Then, applying Cluster Techniques upon the Factor Analysis, we will elaborate typologies of firms according to knowledge sourcing, and we will constitute homogeneous groups of firms taking into account their main ways of learning. In addition, the innovation indicators will be projected as supplementary variables, and it could be seen if the different typologies of firms have a differential innovative performance associated with them. This analysis will allow us to reach an approximation to the importance of the NSI in the knowledge sourcing in each network, differentiating the relative importance of the firms' external and internal sources of knowledge, as well as the domestic and foreign sources, for their innovative performance.

3.2. Characteristics of the sample

The data source is a technological survey specifically designed under a production network perspective, carried out during 2006, among 89 car parts producers, suppliers of automakers, and 74 firms from the iron and steel network; located in the provinces of Buenos Aires, Córdoba and Santa Fe, in Argentina.[3] The survey collected data about general structural issues of the firms, the sales-purchasing structure of the network, linkages and relationships between their actors, innovative activities (types of innovations introduced, results of the innovations, importance of each type of innovation introduced, expenditure on innovative activities, personal distribution, quality activities, etc.), human resource management (organization of the work process, etc.) and training activities for the 2001-2005 period.

The automotive sample includes 89 producers of different types of auto parts, located in the provinces of Buenos Aires, Córdoba and Santa Fe.[4] Two-thirds of the firms surveyed are national owned firms, and those with over $ 5 million annual sales and more than 50 employees predominate. In the sample, the direct and indirect suppliers of automakers represent 79%, which implies that the sample includes around 25% of manufacturers of original parts and components for the automotive industry with plants in Argentina. On the other hand, the firms that sell almost exclusively to the replacement market account for 21% of the sample and less than 5% of this kind of auto parts producers of Argentina. For illustrative purposes, Table 1 summarizes the sample values of the key indicators.

3 This survey was carried out as part of the research project "Production networks, innovation and employment", PAV 057/03 (SECyT, Republic of Argentina).

4 For a review of the characteristics and historic evolution of the APN in Argentina, consult Morero (2013a).

TABLE 1
Key indicators: sample values

Percentage

Variables	Automotive			Iron and steel		
	Low	Medium	High	Low	Medium	High
Internal Learning	17.98	25.84	56.18	28.38	25.68	45.95
External Purchase of Technology	20.22	43.82	33.71	17.57	50.00	28.38
Linkages	38.20	25.84	35.96	37.84	44.59	17.57
National Linkages	21.35	34.83	43.82	12.16	43.24	44.59
International Linkages	47.19	33.71	19.10	62.16	21.62	14.86
Indicator of Innovation	37.08	22.47	39.33	45.95	35.14	18.92

Source: Survey of the project "Production Networks, Innovation and Employment". Own elaboration.

The iron and steel sample includes 74 firms from the city of Buenos Aires, Buenos Aires province and Santa Fe.[5] Following Castillo, Rojo, and Rotondo (2008) the sample covers around 24% of the firms of the Argentinean network. Almost 78% of the sample are national firms, predominantly companies with up to 30 employees (48% of the sample), while firms with more than 100 employees represent 23% of the total. Approximately one third of the firms in the sample have sales below $ 5 million a year. Just over a third of the sample is composed by firms that do not export, a third of it by those that export up to 20% of their sales, and less than a third by firms whose exports represent more than 20% of their sales.

Since this is a network that has both backward and forward linkages from the core, the sample includes suppliers as clients of the core. The suppliers represent almost 60% of the sample and include the production of metallic and chemical inputs, machinery and instruments, electrical inputs, specific and nonspecific services, and mining supplies. On the other hand, the users or customers represent 40%, and include service centers (such as sheet folding, cutting, etc.), producers of metallic and chemical inputs, and final users in various sectors such as construction and metallurgical industry.

5 For a review of the characteristics and historic evolution of the APN in Argentina, consult Borello et al. (2007)

4. Results

4.1. Quantitative analysis: the automotive and the iron and steel Production Networks

The factor analysis reduced dimensions of two variables (Internal Learning and Linkages) with three categories each (Low, Medium, High), which are the active variables. The analysis gave four factors in both networks that collect 100% of the inertia, as Figure 3 illustrates. That is, for example, in the automotive case, Factor 1 captures the 31.97% of the variability (inertia) of the active variables, and together with Factor 2, they accumulate the 60.10% of the inertia. When we utilize the four factors, it implies using the same information as the active original variables, as they accumulate their whole variability. These new dimensions allow us to calculate distances between the firms in these terms (their knowledge sourcing for innovation), and to apply cluster techniques to build relatively homogeneous groups of firms on the main features of their learning processes. Then, additional variables can be projected into these new dimensions, to characterize the groups.

FIGURE 3
Multiple factor analysis

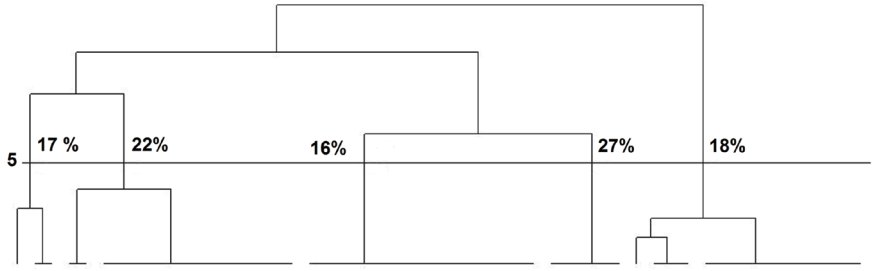
Number	Eigenvalue	%	% Accumulated
Automotive Production Network			
1	0,6394	31,97	31,97 ††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡
2	0,5627	28,13	60,10 ††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡
3	0,4373	21,87	81,97 ††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡
4	0,3606	18,03	100,00 ††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡
Iron and Steel Production Network			
1	0,6763	33,82	33,82 ††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡
2	0,6066	30,33	64,15 ††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡
3	0,3934	19,67	83,82 ††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡
4	0,3237	16,18	100,00 ††‡‡††‡‡††‡‡††‡‡††‡‡††‡‡

Source: Survey of the project "Production Networks, Innovation and Employment".Own elaboration.

Figures 4 and 5 present the results of the hierarchical cluster analysis in the automotive and in the iron and steel case, respectively, and the cut considered. The graphic (the hierarchical cluster tree) shows alternative groups formation according to the "similarities" of the firms regarding the active variables, and the best cut is

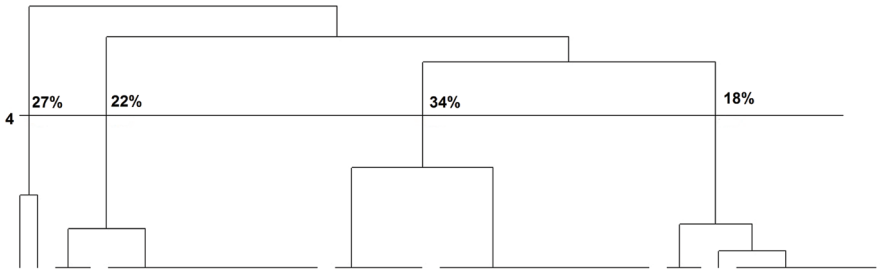
the one that shows the major height in the tree for each group. Following this criterion, the cluster analysis in the automotive case provided five groups and in the iron and steel case, four groups.

FIGURE 4
Automotive cluster analysis



Source: Survey of the project "Production Networks, Innovation and Employment".Own elaboration.

Figure 5
Iron and steel cluster analysis



Source: Survey of the project "Production Networks, Innovation and Employment".Own elaboration.

Table 2 below presents the over and underrepresented categories of the key indicators of the cluster analysis. On the one hand, the groups could be stylized by their main learning modes (namely, their knowledge sourcing), and the innovative performance implied could also be seen on the other. In that sense, in both cases the groups of the analysis could be ranked according to their innovation level.

In the automotive case, groups 1, 2 and 3 are relatively the more innovative. Group 1 covers 27% of the sample and is characterized by a high internal Interactive Learning and high Linkages. Moreover, the firms that have medium External Purchase of Technology are overrepresented. Regarding the linkages, the firms that have high linkages with national actors are overrepresented; similarly, firms with

TABLE 2

Cluster analysis: over and underrepresented variables

Variables	Internal Learning			Ext. Buy of Technology			Linkages			National Linkages			International Linkages			Innovation		
	Categ.	% in the group	Sign. (1)	Categ.	% in the group	Sign. (1)	Categ.	% in the group	Sign. (1)	Categ.	% in the group	Sign. (1)	Categ.	% in the group	Sign. (1)	Categ.	% in the group	Sign. (1)
Automotive Production Network																		
Group 1 (27%)																		
Overrepresented categories	High	100,00	***	Medium	58,33	*	High	100,00	***	High	87,50	***	Medium	50,00	**	High	66,67	***
Underrepresented categories				*Low*	*4,17*	**				*Medium*	*12,50*	***				*Low*	*12,50*	***
										Low	*0,00*	***						
Group 2 (16%)																		
Overrepresented categories	High	100,00	***	High	57,14	**	Low	100,00	***	Low	57,14	***	Low	71,43	**			
Underrepresented categories										*High*	*7,14*	***						
Group 3 (23%)																		
Overrepresented categories	Medium	40,00	*				Medium	100,00	***	Medium	70,00	***						
Underrepresented categories	*Low*	*0,00*	**							*Low*	*0,00*	***						
Group 4 (17%)																		
Overrepresented Categories	Medium	100,00	***															
Underrepresented Categories							*Medium*	*0,00*	***				*Medium*	*13,33*	*	*High*	*20,00*	*
Group 5 (18%)																		
Overrepresented categories	Low	100,00	***	Low	43,75	**	Low	62,50	**	Low	43,75	**				Low		***
Underrepresented categories				*High*	*12,50*	**	*High*	*18,75*	*	*High*	*25,00*	*				*High*	*6,25*	*
Iron and Steel Production Network																		
Group 1 (34%)																		
Overrepresented categories	High	100,00	***	High	48,00	***							Low	76,00	*	Medium	48,00	*
Underrepresented categories				*Low*	*0,00*	***	*High*	*0,00*	***							*Low*	*28,00*	**
Group 2 (18%)																		
Overrepresented categories	High	69,23	*	Low	38,46	**	High	100,00	***	High	100,00	***	High	53,85	***			
Underrepresented categories	*Low*	*7,69*	*										*Low*	*15,38*	***			
Group 3 (27%)																		
Overrepresented Categories	Low	100,00	***				Low	65,00	***	Medium	70,00	***	Low	90,00	***			
Underrepresented Categories							*High*	*0,00*	**	*High*	*15,00*	***	*High*	*0,00*	**			
Group 4 (22%)																		
Overrepresented categories	Medium	100,00	***				Medium	81,25	***				Medium	43,75	**	Low	68,75	**
Underrepresented categories							*Low*	*18,75*	*				*Low*	*43,75*	*			
							High	*0,00*	**									

Source: Survey of the project "Production Networks, Innovation and Employment". Own elaboration.

(1) *** Significative at 1%; ** Significative at 5%; * Significative at 10%.

medium linkages with international actors are also overrepresented. In short, this is a group that balances its sources of knowledge, with a high Internal Learning, complemented by External Purchase of Technology and high Linkages, mainly with national actors, but also with foreign agents. This group is dominated by firms that have a high and important introduction of innovations, with two-thirds of the group reaching a high modality for the global indicator of Innovation. Meanwhile, Group 2 represents 16% of the sample and states, like the previous group, a high Internal Learning, but low Linkages with other actors. In this group, the firms that resort to high External Purchasing of Technology (high at 57%), strongly complement this source with Internal Learning efforts, but neglect the external flows of knowledge and learning processes through interactions with other social actors. Accordingly, the innovative performance of these firms is lower than in the previous group. The Innovation indicator remains at levels not significantly different from the sample average, as is it in Group 3, where the firms with a medium level of Internal Learning and Linkages are overrepresented.

Groups 4 and 5 are the two relatively least innovative groups. Group 4 includes 17% of the sample and is composed of firms with a medium Internal Learning (100%), and maintain average levels of linkages. The innovative performance of the firms from this group is between medium and low, as the firms with high Innovation are underrepresented (50% of the group)[6]. Finally, in group 5, which accounts for 18% of the sample, the firms with a low level of Internal Learning and Linkages predominate. In addition, the firms with a low external buy of technology are overrepresented. In regard to Linkages, low domestic linkages (43.75%) are overrepresented, while the firms in this group maintain linkages with foreign agents at average levels of the sample. Here the firms that have not introduced innovations of any kind are overrepresented (not shown in the table). Taking into account the results and the importance of innovations, the firms with a low overall indicator of Innovation are overrepresented: they account for almost 70% of the group.

In the iron and steel case, the four groups could also be ranked according to their innovation level. First, groups 1 and 2 account for a superior innovative performance than the others. Group 1 is characterized by a high Internal Learning and Linkages at average level. Furthermore, the firms that have a high External

6 Additionally (not shown in the table), the firms that have introduced organizational innovations are underrepresented, as in the sample they represent about 48%, and in this group only reached 26%.

Purchase of Technology indicator are overrepresented. Regarding linkages, the levels of National Linkages are average, which is high (see Table 1), while the firms with a low International Linkages indicator are overrepresented. As a result, the overall Linkages indicator is at an average level, which tends to be between medium and low. In short, this is a group that maintains a particular balance of knowledge sources: a high Internal Learning and External Purchases of Technology, and National Linkages that tend to be high, while the International Linkages have minor relevance. Statistically, in this group, the firms with a medium overall Innovation indicator are overrepresented (48%) and those with a low level (28%) are underrepresented, stating a group with an innovative performance between medium and high. Group 2 is characterized by a high Internal Learning and high Linkages. The linkages in this group are high: all the firms of the group have a high overall Linkages indicator and a high level of national linkages. Also, International Linkages are high; firms with a high indicator of International Linkages are overrepresented. However, the firms that performed a low External Purchase of Technology are overrepresented. In global terms, the innovative performance in this group is average, which tends to be low. Thus, although this group shows a good complementation of knowledge sources between internal learning and linkages, both domestic and international, it does not accompany it with external buy of technology. In that sense, it has a particularly different combination from the previous group, and a relatively minor innovation performance.

Groups 3 and 4 are the least innovative groups from the iron and steel network. Group 3 is characterized by a low Internal Learning and an overall low level of Linkages. The External Purchase of Technology remains at average levels. In global terms, the innovative performance is average, which tends to be low[7]. Lastly, group 4 represents 22% of the firms in the sample and is characterized by a medium level of Interactive Learning and Linkages. On the other hand, the External Purchase of Technology remains at levels not statistically different from the sample values. The global indicator of Linkages becomes a medium level for just over 81% of the firms in the group. The firms with a medium level of the International Linkages indicator are overrepresented, and the linkages with national actors remain in proportions that do not differ significantly from the values of the sample (which tends to be high). However, this group has the worst innovative performance of the iron and

7 Slightly lower, however, than the previous group, taking into account the type of innovations not introduced (not shown in the table): firms that have not introduced process innovations (55%) are overrepresented.

steel sample. The firms with a low global indicator of Innovation are overrepresented (about 69% of the group). This indicates that relative medium levels of acquisition of knowledge are not necessarily associated with a relative good innovative performance, not even in medium levels.

4.2. Comparative analysis and discussion

From the quantitative analysis in the automotive network we can appreciate (see Chart 2) that most innovative firms (group 1) are those which resort to high domestic sources of knowledge and combine this knowledge with high external sources, such as the external buy of technology and international linkages. This shows that the best innovative performance of auto parts producers depends on an interaction between high domestic sources of knowledge (internal learning and national linkages) and high external or foreign (external purchasing of technology and international links), despite operating in an internationalized network. This can also be seen in the intermediate groups (groups 2, 3 and 4), where the innovative performance tends to reach medium or average levels, and is associated with different kinds of balances between external and internal sources of knowledge.

CHART 2
Sumary of automotive cluster analysis groups

Variables	Group 1	Group 2	Group 3	Group 4	Group 5
Innovation	High	-	-	Medium / Low	Low
Internal Learning	High	High	Medium	Medium	Low
External Purchase of Technology	Medium	High	-	-	Low
Linkages	High	Low	Medium	Medium	Low
National Linkages	High	Low	Medium	-	Low
International Linkages	Medium	Low	-	-	-

Source: Own elaboration.

On the other hand, the less innovative firms (group 5) have a low level of Internal Learning, External Purchase of Technology and National Linkages. However, the group has an average level of linkages with foreign actors. This suggests that the firms that fail to complement their external knowledge with domestic components, and their sources of knowledge are mainly external and foreign; tend to have a re-

latively lower innovative performance. Even in a deeply internationalized network, foreign sources of knowledge do not appear as a perfect substitute for the domestic sources and the internal processes of learning.

It emerges that the innovative performance of the auto parts producers in Argentina is directly related to a complementation between internal and external knowledge sources for innovation. Thus, despite the fact that the internationalization of production is often associated with an increased access to foreign sources of knowledge, it does not diminish nor extinguish the importance of the domestic knowledge sources. In that sense, the NSI remains of crucial importance to firms established within the national economy, even for those operating in internationalized Production Networks, such as the automotive case in an emerging economy, such as Argentina.

The results in the iron and steel case differ partially (see Chart 3). While there is a certain kind of knowledge sources balance that is associated with the best innovative performance, it is different from the most successful complementation of the automotive case. Here, the group with the best innovative performance is associated with a complementation between a high Internal Learning, a high External Purchase of Technology and a high level of National Linkages, but the linkages with foreign actors appear as less important. Although domestic (internal learning and national links) and external sources of knowledge (such as the acquisition of technology) are essential in the most innovative group, foreign sources, as international linkages, are less important.

CHART 3
Sumary of iron and steel cluster analysis group

Variables	Group 1	Group 2	Group 3	Group 4
Innovation	Medium / High	-	-	Low
Internal Learning	High	High	Low	Medium
External Purchase of Technology	High	Low	-	-
Linkages	Medium / Low	High	Low	Medium
National Linkages	-	High	Medium / Low	-
International Linkages	Low	High	Low	Medium / Low

Source: Own elaboration.

The similarities between the knowledge sourcing balance associated with the best innovative performance in both Production Networks, characterized by a certain complementation between internal and external sources, domestic and foreign knowledge sources (opposed to groups with knowledge balances dominated mainly by external and foreign sources) accompany *H1*. Thus, although the internationalization of production is often associated with a higher access to foreign sources of knowledge, this neither reduces nor extinguishes the importance of national sources of knowledge for innovation. Moreover, in this sense, the importance of the NSI is crucial to the innovative performance of firms established inside the country, even for firms that operate in internationalized networks and in an emerging economy.

From the analysis of the other groups of the Iron and Steel case, we also noticed that diverse balances of knowledge sources are associated with low levels of innovation, which includes groups where firms with high internal learning are overrepresented, and also with low and medium levels. In fact, in the worst innovative group (group 4), which has a particularly low level of innovation; firms with a medium level of Internal Learning are overrepresented. Different kinds of knowledge sources complementation are associated with relatively poor innovative performances. Indeed, groups with minor innovative performance than the best have high levels of international linkages (group 2) or medium levels (group 4). This suggests that, in this network, the best innovative performance is associated with a very particular complementation of knowledge sources, where the replacement of external acquisition of technology with foreign linkages is associated with a worse differential innovative performance than group 1.

In that sense, the best innovative performance of the iron and steel firms in Argentina is related to a certain complementation between knowledge sources that underrates the importance of Linkages with foreign agents for the innovative performance, particularly as in regard to the automotive firms. Thus, despite the fact that the internationalization of production is often associated with an increasing access to foreign sources of knowledge; it appears that in a internationalized Production Network, where the core is inside the country, the best innovative performance is associated with a knowledge sourcing that could diminish the importance of some foreign sources, opposed to a case of a Production Network with foreign cores, as the automotive case in Argentina. Thus, *H2* also finds evidence that supports it and suggests that the NSI importance for the innovative performance of firms, as *national*, will be higher in Production Networks with local cores.

5. Final remarks

This paper analyzed how domestic sources of knowledge for innovation matters, as the *national side* of NSI, in internationalized production activities, in relation to foreign sources. The main idea that guided the research was that the national dimension of the NSI is relevant to the processes of accumulation and generation of knowledge, even in internationalized Production Networks. The analysis added empirical work that suggest that firms which complement their external knowledge with domestic knowledge (internal learning and national linkages) will have a better innovative performance than those firms whose sources of knowledge remain mainly external and foreign, even in internationalized activities. Even more, the *national side* seems to be *relatively* more important in Production Networks organized around domestic headquarters of MNCs, in respect to networks orbiting around foreign subsidiaries.

These results should be cautiously interpreted in their generalization scope given the nature of the methods used, which has a lesser predictive capacity than other typical econometric tools, and the nature of the data (a specific survey, in two specific sectors, in a specific country). However, the analysis provides suggestive insights to be taken into account, on the importance the NSI holds in a global world, highlighting the relevance of the localization of the cores of internationalized Production Networks, upon the domestic dimension of NSI in an emerging economy.

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