

Dynamics of knowledge flows: geographical proximity, vertical relations and learning by interaction

Dinâmica dos fluxos de conhecimento: proximidade geográfica, relações verticais e aprendizado por interação

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Resumo

O objetivo do artigo é compreender as fontes de conhecimento e os processos de aprendizagem que sustentam as inovações das firmas localizadas em Sistemas Locais de Produção (SLP). A principal contribuição é empírica. Foram pesquisados dois SLP do segmento de máquinas para calçados no final dos anos 2000, período em que já era observado o processo de mudança concorrencial com a entrada de empresas chinesas como concorrentes diretas das firmas analisadas. Adotou-se a lógica de que a geração da inovação é influenciada pelo aprendizado e pela interação da firma. A pesquisa de campo foi realizada com questionário estruturado e com entrevistas *in loco*, tanto na Itália quanto no Brasil. Em termos de resultados, destacou-se que: as relações verticais são mais frequentes quando comparadas às horizontais; o aprendizado por interação explica a geração de inovação; e a proximidade geográfica é importante para explicar as redes de conhecimento. Os resultados são consistentes com o padrão setorial identificado como fornecedor especializado.

Palavras-chave: inovação tecnológica das empresas; sistemas de produção local; relações verticais; fluxos de conhecimento

Abstract

This paper aims to understand the sources of knowledge and the learning processes that support the innovations of firms located in Local Production Systems (SLPs). The main contribution is empirical. Two LPS of the shoe machine segment were surveyed in the late 2000s, a period in which the process of competitive change was already observed with the entry of Chinese firms as direct competitors of the firms analyzed. The logic adopted was that firm's learning and interaction centrally influence the generation of innovation. Field research was conducted with a structured questionnaire and on-site interviews in both Italy and Brazil. In terms of results, we highlight that: vertical relationships are more frequent when compared to horizontal ones; interaction learning explains the dynamics of innovation generation; and geographic proximity is essential for explaining knowledge networks. The results are consistent with the characteristics of the industry standard identified as a specialized supplier.

Keywords: technological innovation of firms; local production systems; vertical relations; knowledge flows.

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1 INTRODUCTION

The main objective of this article is to understand the sources of knowledge and the learning processes that support the innovations of firms located in Local Production Systems (SLPs), based on the analysis of the relationships they establish with the other actors in these systems. This study seeks to contribute to the literature by analyzing a particular case, the footwear machinery sector, providing empirical evidence, and highlighting the types of relationships and sources of knowledge that support the innovative processes of firms in LPSs. Although there are empirical studies that emphasize the importance of different types and sources of knowledge for the innovative performance of firms, especially for those located in LPS (PLECHERO; GRILLITSCH, 2021), gaps still remain as pointed out by Asheim, Grillitsch and Trippel (2017). According to these authors, “the knowledge dynamics underlying such processes and their geographic patterns remain largely unexplored” (p. 430).

Innovation generation is understood as an interactive process that attributes importance to learning elements that are internal and external to the firm. Internal
⁴ - Vale do Rio dos Sinos in Brazil and Vigevano in Italy - which ensures that these firms have the characteristic of geographical proximity between actors. A survey of all the firms belonging to the mentioned LPSs was carried out. This segment, in addition to being little studied, plays an important role in footwear production. Garcia, Oliveira and Madeira (2010) underline that innovations generated in this machinery and equipment industry have historically brought technological advances in the footwear industry. In a similar way, Villamil Ramírez (2019), when studying the cases of local footwear systems in Brazil and Colombia, highlight precisely how important footwear machinery companies are sources of knowledge for those that produce footwear.

elements are the structure, routines, and dynamics that characterize learning within the company; while external elements are processes influenced by the sectorial and spatial environments in which the firm is inserted. Thus, sectorial characteristics help to explain more frequent routines performed by a group of firms in an industry, assigning logic to the form and intensity of their search for, use and generation of knowledge and innovation. Regarding local idiosyncrasies, we assumed that geographical proximity has an influence by promoting important face-to-face contacts and stimulating knowledge flows. Hence, the physical location of agents interacting with the surveyed firms is a relevant element for reflecting on such aspects. Thus, this work assumes that the innovation process is interactive and explainable by sectorial and local contexts.

Based on these considerations, a fertile scenario to analyze the mentioned elements is one that would combine sectorial characteristics and geographical proximity of the same group of firms. Hence, we chose to investigate two groups of firms from the same production segment – footwear machinery – belonging to two footwear LPS

As a theoretical and analytical referential, we used neo-Schumpeterian literature, which explains that innovation entails ongoing and progressive changes introduced during diffusion through different processes of learning and interaction. Knowledge creation and dissemination by a firm entail individual and collective moments of tacit and codified knowledge exchanges. Hence, learning processes are also diversified to take into account those characteristics. The literature describes different types of learning processes, which can be united in two large categories: internal and external learning.

Among these processes, it is worth mentioning the one designated learning by interaction. This process is relevant both because of its importance for

⁴ Although aware that the literature uses different concepts – industrial districts, clusters, local production systems, among others, this work does not intend to discuss the conceptual differences among those terms.

relations and exchanges among different agents, which is consistent with the proposed investigation based on the analysis of localized production systems, and because it involves a specific relation, the one between producers and clients, a key relation in the footwear machinery industry herein analyzed. We also should note the peculiarity of the productive segment chosen – specialized suppliers – where close relations with clients are a fundamental practice in the routine of firms. The survey results of this study were also explored in another work. It indicated rarefied horizontal relations for knowledge exchanges among the firms investigated in both LPSs surveyed. That understanding reinforced the analysis of the vertical relations among companies as the key factor to explain the innovative dynamics of these systems. Thus, it is our intention to answer questions such as “are the networks established with customers and suppliers denser than those that characterize horizontal relations?” and “are the prevailing relations those established between actors that are actually geographically close?”

In methodological terms, it is noted that the firms in the two LPSs were surveyed by face-to-face interviews carried out with a structured questionnaire. Most footwear machinery manufacturers in the two agglomerates participated in the survey. It is important to note that Vigevano is the Italian region considered as a key reference in the production and introduction of technological innovations in footwear machinery for the European market. Likewise, the Vale do Rio dos Sinos is the Brazilian region regarded as the reference for the Latin American market. Data treatment was enhanced by a software (UCINET) that enabled the charting of the network of relations with their structural and dynamic characteristics.

As Garcia (2021) points out, there is a wide debate in the literature about the ways in which local knowledge spillovers are manifested, but gaps remain, even today, in understanding what conditions

and what processes lead to the best taking advantage of local knowledge spillovers into productive structures located. Therefore, we believe that, although the survey took place at the end of the first decade of the 2000s, its results provide information that helps to fill these gaps. Furthermore, it is also worth noting that the footwear value chain is a labor-intensive productive activity that is important for the economy of peripheral countries and, thus, characteristics of its economic dynamics remain relevant for academic studies, as observed in Álvarez-Castañón (2020).

This paper is organized in four more sections. The next one presents a literature discussion. The third section presents the survey methodology used. In the fourth section, findings are analyzed. Finally, the fifth section presents final remarks.

1 KNOWLEDGE, LEARNING, AND SECTORIAL AND LOCAL CONTEXTS

Within the scope of neo-Schumpeterian literature, there is consensus that knowledge is essential to establish competitive advantages both for firms and regions, as it is related to the generation of innovative capacities and the skills needed to be on the cutting edge of technological advantage. In this direction, several empirical studies corroborate this understanding. Such studies provide evidence “[...] that the combination of different types of knowledge is positively related to firms’ performance and the transformation of regional paths” (PLECHERO; GRILLITSCH, 2021, p. 3).

In this context, knowledge is viewed as a key asset, and learning as a fundamental element. In other words, while knowledge is viewed as the main resource, learning is seen as the most relevant process (LUNDVALL, 1992). This happens because it is this learning

process that generates and integrates specialized knowledge, making it possible to innovate.

The literature describes different types of learning processes, which can be united in two large categories: internal and external learning (MALERBA, 1992). Privileging one or more internal or external learning sources will depend on the firm's type and size, but in any case it will involve an ongoing and interactive process influenced by the environment in which the company is inserted (FREEMAN, 1996).

Internal learning is connected to the firm's main functions – R&D, production, marketing and organization. Although external learning cannot replace⁵. In the analysis of LPSs, this type of learning is relevant both because of its importance for relations and exchanges among different agents, which is consistent with the proposed investigation based on the analysis of localized production systems, and because it involves a specific relation, the one between producers and clients, a key relation in the footwear machinery industry herein analyzed.

The neo-Schumpeterian literature makes it clear that the processes of innovation and diffusion of new technologies are not independent; on the contrary, they are part of the same process. Thus, innovation involves ongoing and progressive changes, introduced during diffusion, through different learning processes. Hence, the advances during the diffusion process are also the result of clients' contributions and experiences. The literature acknowledges the importance of both producers and users in the development of technological capacities, and demonstrates that the nature and intensity of those interactions, as well as the synergy between producer and customer are indispensable for a successful innovation process (LUNDVALL, 1988; FREEMAN, 1996).

the internal process, it can speed it up or change its direction. The different types of internal learning are the following: learning by using (ROSENBERG, 1982), learning by doing (ARROW, 1962) and learning by searching. External learning comprises the following types: learning by imitating, learning by interacting (LUNDVALL, 1988), and learning by cooperating. Firms are characterized by the different combinations of internal and external learning they implement.

Among these processes, learning by interaction is worth highlighting (LUNDVALL, 1988). This involves forward and backward interactions with sources of knowledge such as suppliers and clients

We can also state that those interactions are defined in an economic space, i.e., they include agents that are closer or farther apart in geographical and cultural terms. The importance of this distance depends on the type of innovation activity. The more complex and prone to change the technology, the more important is the proximity between customers and manufacturers. The more complex the information codes, also more relevant is a common cultural background to establish implicit codes and facilitate comprehension of the information exchanged (LUNDVALL, 1988; LUNDVALL et al., 2002).

In addition, taking into account the sectorial specificity of the machinery manufacturers we are discussing, it is important to underline the process of learning by using, as stressed by Rosenberg (1982) in the literature. For this author, this type of learning is especially relevant in the case of capital goods, as their performance can only be measured after a long period of experience; as well, their characteristics can only be understood after prolonged and intense use.

Because of this understanding, several authors, such as Pavitt (1984);

⁵ Another term commonly used in the literature to describe this agent is "user." In this paper, we chose "client."

Dosi (1988); Klevorick et al. (1995); Archibugi (2001); Malerba (2005; 2007; 2011); Malerba and Nelson (2011); and Castellacci (2008; 2009) discuss those sectorial differences.

Pavitt (1984), in his classical sectorial taxonomy, identified four main groups of sectors: supplier-dominated, specialized suppliers, scale-intensive, and science-based. To build this classification, he analyzed a set of factors for each sector: dominant technological regime, structural characteristics, origin of the innovation, types of results, forms of appropriation, and possibilities of technological diversification. Pavitt (1984) considers that firms tend to behave in a similar way when they are in the same sector, as productive determinants are similar. Hence, observed intrasectorial routines are similar and allow us to project analyses for a firm to the sector as a whole.

Among the groups proposed by this author, we highlight specialized suppliers, whose attributes help the discussion in this paper. In general, this group includes capital goods and especially machines and equipment. It is characterized by high economies of scope, high supply diversification generally concentrated in medium-sized firms with capacity for product innovation. For the most part, these are enterprises that develop close relations with customers (other firms), have high internal capabilities, and specifically master design and engineering technologies.

In line with discussing the role of sectoral patterns with a view to local systems, Gertler and Wolfe (2010) emphasize that the geography of knowledge flows will also exhibit characteristic patterns by sector. According to them, in those industries where innovation to be driven by need to solve specific problems arising in the interaction with customers and suppliers (such as the development of specialized machinery), tacit knowledge tends to be more important. As a result, given the central role of tacit knowledge and face-

to-face interactions with customers and suppliers, they argue that learning and localized knowledge flows are very relevant. Also for Asheim, Grillitsch and Tripl (2017), the knowledge acquired through the application or combination of existing knowledge, typically in interactive learning processes with customers or suppliers, has a strong tacit and context-specific dimension.

Based on a large study of clusters in different regions of Canada, Gertler and Wolfe (2010) propose a typology on the "geography of knowledge flows". From there, they confirm the understanding that in the industrial sectors of capital goods "intra-cluster relations promote the local circulation of knowledge, underpinning the learning process that enable firms to succeed at innovation"

Thus, geographical proximity gains importance as a relevant element in the process of creating and disseminating innovation because when we take into account that the processes of knowledge generation and innovation are interactive and localized, we understand that exchanges among agents in the local space favor and maximize those processes. Furthermore, it is inferred that the specific local institutional framework, through particular learning mechanisms, generates qualitatively different innovation processes (CASSIOLATO; LASTRES, 1999; MORGAN, 2004; MATOS et al., 2017).

This idea is corroborated by the understanding that economic processes are socially rooted, and that most knowledge is created and reproduced through various forms of social interaction (MASKELL; MALMBERG, 1999, p. 171; MASKELL, 2001). Thus, knowledge is socially embedded and the learning process is predominantly interactive (LAM, 1998, p. 4). For this reason, in the framework of evolutionary thinking, innovation should be understood as resulting from this interactive learning process between firms and their environment. Hence, the environment in

which the agents are immersed, with its cultural, socioeconomic and political characteristics, interferes with and influences the form in which knowledge is generated and circulated among different actors, in the same way that the possibility of this exchange and knowledge sharing is maximized and stimulated by the physical proximity of those agents.

Therefore, local systems are adequate as units of analysis, as they are considered interactive learning spaces (AROCENA; SUTZ, 2000; LASTRES; CASSIOLATO; MACIEL, 2003; LASTRES et al., 2020). To this extent, we can affirm that local communication channels facilitate knowledge diffusion, making it possible for local enterprises to obtain advantages in innovation performance, as informal networks have an important role in the emergence of production agglomerates and in interactive learning and, as a consequence, in local development (DAHL; PEDERSEN, 2003, p. 2). Likewise, when local potentialities and noncommercial interdependence are emphasized, it is demonstrated that the socio-institutional framework, intercompany communication, and the local learning process play a decisive role in the innovation and growth process (BATHELT; MALMBERG; MASKELL, 2002, p. 10)⁶.

2 METHOD

A descriptive and qualitative research was carried out based on the collection of primary data, through two surveys that were carried out in each set of firms in two local systems of manufacturers of footwear production machines. We chose to do a comparative survey, taking into account the economic relevance of the two LPS, both for the productive sector investigated and for the

regions where they are located. The first LPS surveyed was Vigevano (Italy) between November 2007 and February 2008; and the second was Vale do Rio dos Sinos (Brazil) between August and November 2008.

The starting point to investigate the Vigevano firms was setting up a databank of footwear machine producers located in that region, based on the register kept by the National Association of Italian Manufacturers of Footwear, Leathergoods, Tannery Machines and Accessories (ASSOMAC). A population of 35 firms was identified and we were able to survey 28 of the firms (80%). The remaining seven did not want to participate in the survey.

Likewise, the starting point to survey the Vale do Rio dos Sinos producers was setting up a databank of footwear machine manufacturers located in that area. We used two information sources: the register of companies affiliated to the Brazilian Association of Machinery and Equipment Industries for Leather, Footwear and Allied Trades (ABRAMEQ) and the catalog of the participants in the main fair in this sector, the “International Fair of Leathergoods, Chemical Products, Components and Accessories, Equipment and Machines for Footwear and Tanneries” (FIMEC) in 2007 and 2008. Twenty-four firms were identified. Respondents totaled 19 firms, i.e., 79% of the population was surveyed.

A structured questionnaire was applied in face-to-face interviews in all investigated firms. The questionnaire was organized in three parts: a) firm’s general informations; b) informations about the performance of R&D activities and the technicians who perform these activities; and c) information about the flows of information and knowledge. The validation of the questionnaire was done in two stages: a) an evaluation by industry

⁶ In addition to geographical proximity, there are other “proximities”. Boschma (2005) defined four other types of proximity in addition to the geographical one: cognitive, related to knowledge accumulated by firms; organizational, linked to the firms’ coordination; social, connected to the social context; and institutional, resulting from the sharing of values and norms.

experts and academics specialized in the research's field of knowledge; and b) face-to-face application in three firms of each LPS investigated in the exploratory stage of the field research.

The structured questionnaire was designed based on previous studies that had already applied the Social Network Analysis (SNA) method in the investigation of LPS, as Giuliani (2005); and Morrison and Rabellotti (2005). It is important notice that it was used in the questionnaire the *roster-recall*⁷ tool which comprises the provision of a list of all network members to each network actor (survey respondent), so that the respondent mentions with whom he or she has a relationship. This tool was applied in the third part of the structured questionnaire and with this it was possible to structure the networks that represent the horizontal relations, analyzed in the next section.

In terms of indicators used in network analysis, the most relevant for this study are density (the amount of ties among actors, as the ratio between existing linkages and possible ones) and reciprocity of ties between actors, which were calculated for the analysis of horizontal relationships.

For each interview, the researcher went to the firm's facilities - both in Brazil and Italy

- and, in most cases, as a complement to the interview, a visit was made to the factory facilities. Interviews were done with the person responsible for the product development and improvement process in each firm. The interviews lasted an average of 1h30minutes.

After the interviews conducted, the data were tabulated and relevant characteristics of the two groups of firms

analyzed were described, such as the frequency of firms by size, by localization, by product specialization, and general characteristics of the R&D activities that the firms carry out. In the case of data regarding information and knowledge flows, the data were tabulated using UCINET software, with which it was possible to generate the networks' representation (figures) and calculate two indicators (density and reciprocity) for the horizontal relations.

3 KNOWLEDGE FLOWS AND THE PROCESS FOR GENERATING TECHNOLOGICAL INNOVATIONS

The data collected in the field research concerning the characteristics of the firms investigated, their R&D activities, and the horizontal relations they establish to seek knowledge are reported in subsection 4.1. The results concerning the vertical relations established by the firms to obtain knowledge and generate innovations are reported in section 4.2. This last section presents, mainly, the results obtained from the use of UCINET to represent the networks.

3.1 INTERNAL STRUCTURE AND HORIZONTAL RELATIONS

Beginning with the group of firms in Vigevano, we note that footwear machinery manufacturers are mostly small-scale⁸⁵ producers: 82% of the 28 firms interviewed have up to 35 employees. The three largest firms have 200, 93, and 87 employees, respectively.

The size of the firms surveyed in the Vale do Rio dos Sinos region

⁷ This tool can be used when all the actors in a network are known, as is the case in the study conducted.

⁸ Considering the typology used to classify Italian companies, we have the following: "small" up to 49 employees, "medium-sized" from 50 to 249 employees, and "large" starting at 250 employees (ISTAT, 2001). While the Brazilian firms were ranked as follows: "small" up to 99 employees, "medium-sized" from 100 to 499 employees, and "large" starting at 500 employees (IBGE, 2005). We chose to utilize the typologies adopted by the research institutes of the firms' home countries. For our survey, the main difference was the upper limit established by the IBGE for small-scale firms. Because of this limit, Vale do Rio dos Sinos has more small companies than medium-sized ones. However, we noticed that this did not have a significant impact on survey results.

reinforces the characteristic of the footwear machinery manufacturing sector as being mainly formed by small-scale and medium-sized firms. Out of 19 companies, 16 are small-scale and three medium-sized. There is no record of a large company in any of the surveyed areas.

In geographical terms, all the Italian firms surveyed originated in the city of Vigevano where they still remain. Most (22) have productive activities just in Vigevano. Six companies also produce in other places – mainly China and India. The situation is similar for the group of firms in the Vale do Rio dos Sinos region, where all of them originated, developed and are still operating. Unlike their Italian counterparts, the Brazilian companies surveyed produce exclusively in Vale do Rio dos Sinos.

Regarding the firms' productive activity, we highlight as a characteristic the specialization in producing certain classes of machines, organized according to the stage of the shoe production process, such as: modeling and cutting, preparing and stitching the upper, assembling and making the sole, among others. In the case of the Italian firms, ASSOMAC has a typology with eight classes of machines and classifies their firms accordingly. The machines produced are standard or customized. The group of 28 firms in Vigevano includes manufacturers of different classes of machines. The majority of the firms are specialized in producing more than one class.

We highlight three factors that characterize the two groups of firms investigated: 1) they are essentially formed by small-scale firms; 2) both groups of firms are rooted in their original localities, in the sense that the majority still produce exclusively where they were born, despite important moves by foreign competition, such as the entrance of China into the market (as will be discussed later, we assumed that this characteristic is directly related to the importance of specialized technical labor for

manufacturing those machines, and that this specialization was mainly developed based on local tacit knowledge); and finally 3) they are firms specialized in producing classes of machines; this means complementarity of products among firms in the same local system, indicating a priori low intragroup competition.

Concerning the process of generating technological innovations, the vast majority of Vigevano firms stated that they have adequate internal structures to carry out their own research and development activities (R&D). Few firms share this activity or seek structure and knowledge (equipment or technical personnel) from other firms or institutions related to the sector, through formal or informal relations. The vast majority of these structures are informal and are made up of a relatively small number of technicians specialized in the improvement and innovation of machinery – 24 firms reported to have up to five technicians. This is an interesting characteristic of this sector, together with the fact that those technicians do not have university degrees and the majority have been working in the same firm for over ten years.

Most of the Vale do Rio dos Sinos firms stated that they carry out R&D without a formal department. They think their actual structures are adequate to ensure innovation. These characteristics are consistent with the small size of those firms, as well as with the pattern for the group of specialized suppliers, who often explore opportunities to innovate through informal activities of project improvement, usually with little R&D activity.

An important element in the process of generating innovations is the level of formal education of technicians dedicated to R&D. These actors play a central role in identifying clients' needs and translating them into an improved or new product. They are employed for quite some time by the same firm; in general, they have a fair amount of experience, but

not necessarily formal qualifications. Important notice that there is little mobility among local and extra-local firms.

In Vigevano, we identified a total of 105 technicians working in the 28 companies surveyed. Seventy-six percent of them have no university degree. A similar situation was found in Vale do Rio dos Sinos, where 12 firms stated they had technicians with university degrees and 18 worked with technical personnel without such a degree. In this latter LPS, the group of technicians is made up of 89 professionals, 74% without a university degree.

This is certainly an indication that tacit knowledge is very important for the development of new products, as knowledge acquisition takes place more through experience in the execution of activities and solution of technological problems (learning by doing) – often in the same firm – than through formal knowledge (university education, for example)⁹.

Concerning the types of innovations, it was identified mostly the introduction of incremental product innovations, resulting mainly from demands from the major customers: footwear manufacturers, who have a central role in the production chains in which these productive segments are inserted. Product innovation introduced by the Brazilian firms is focused on facilitating the use of the machine by its operator, instead of automation. On the other hand, product innovation in Vigevano firms generally emphasizes the issue of quality in the shoemaking process, equipment automation to favor greater standardization in the final product, and thus the possibility of production in small batches (typical of this industry in Italy). Italian firms introduced earlier safety items in their machinery.

Before going further in the analysis, it is important to examine that there are four elements that synthesize the generation of innovation by the firms investigated: 1) there are more similarities than differences between the two groups of firms, although they are in localities with distinct characteristics in terms of the quality of the footwear industry final product; the prevailing explanation for this item is the pattern of firm size and sector to which the firms belong; 2) informal internal structure, in terms of departmentalization and budgetary planning, and a streamlined structure; 3) the central role played by technicians in the process of generating innovations, through their tacit knowledge and experience; and 4) incremental product innovations; but it is important to register that the Vigevano group of firms more frequently develops products with greater aggregate value than the Vale do Rio dos Sinos group.

Finally, concerning the external elements related to knowledge exchange through horizontal relations, i.e., with firms of the same segment, it was observed that in both groups of

firms surveyed the networks formed had low density. The characteristics of these relations could be summarized as follows¹⁰:

- In the case of the group of firms operating in Vigevano and Vale do Rio dos Sinos, knowledge flow densities were identical and, coincidentally, very low (4%); which means that only 4% of the possible linkages were present in the network;
- Both networks showed null reciprocity in the linkages among actors;
- Only a small group of firms participated in the networks. In the case of Vigevano, this group was made up of 13 firms, out of a total of 28; in the case of Vale do Rio dos Sinos, the group had

⁹ This becomes even more evident when the majority of Italian and Brazilian firms state that their technicians dedicated to R&D do not attend formal courses, seminars or workshops.

¹⁰ The described horizontal relations were identified with the use of the tool called *roster recall*, as mentioned in the section 3.

seven firms, out of a total of 19. The explanations for this reality are the following: a) little competition among firms of the production system does not ensure low market opportunism because of low private knowledge appropriability by those firms. This makes it possible to copy products, even by firms that are not direct competitors at the time, as commented before. In general, firms consider that the risk of this occurring is very high. Hence, locally there is a “potential competition” that inhibits firms from meeting to exchange technological knowledge (although this has been observed in the two groups, it was more evident in the Vale do Rio dos Sinos); b) it was also reported as an explanation for this situation the fact that the firms’ productive specialty has diverse knowledge requirements to solve technological problems; although in the same vicinity they are specialized in different products and knowledge; hence, they would unlikely find the needed technological solutions. Thus, we inferred that geographical proximity among firms was not sufficient to stimulate a dense knowledge flow in horizontal relations (as mentioned by Giuliani, 2005; and Morrison and Rabellotti, 2005; and lastly c) an explanation for this situation can also be found in the sectorial logic for generating innovations, as firms reported that the knowledge needed to solve technological problems is found through relations with their clients and suppliers, as described in the next section. This finding also corroborates what is pointed by the literature (Lundvall, 1988, Lundvall et al., 2002; and Asheim, Grillitsch and Trippel, 2017) by contributing to the reinforcement of important regularities that helps to explain the firm’s innovation generation process.

In general, the results herein described highlight the fact that knowledge needed for the R&D process is

quite specific to the firms, and obtaining technological knowledge through horizontal relations among firms, either formally or informally, is a limited process because relations are essentially established only by a small group of companies. Hence, we intend in the next section to examine answers to the following two questions (already mentioned above): “are the networks established with customers and suppliers denser than those that characterize horizontal relations?” and “are the prevailing relations those established between actors that are actually geographically close?”

3.2 VERTICAL RELATIONS AND THE GENERATING INNOVATIONS

In both agglomerates, the firms highlighted that the main information needed to further product development or improvement processes come directly from their clients, footwear producers, or from resellers, who communicate with footwear manufacturers. Hence, it is the identification of users’ technological needs – the footwear producers – that drives forward the technological innovation process. Information obtained from specialized suppliers is also relevant and refers especially to the technical characteristics of equipment and materials for the machines.

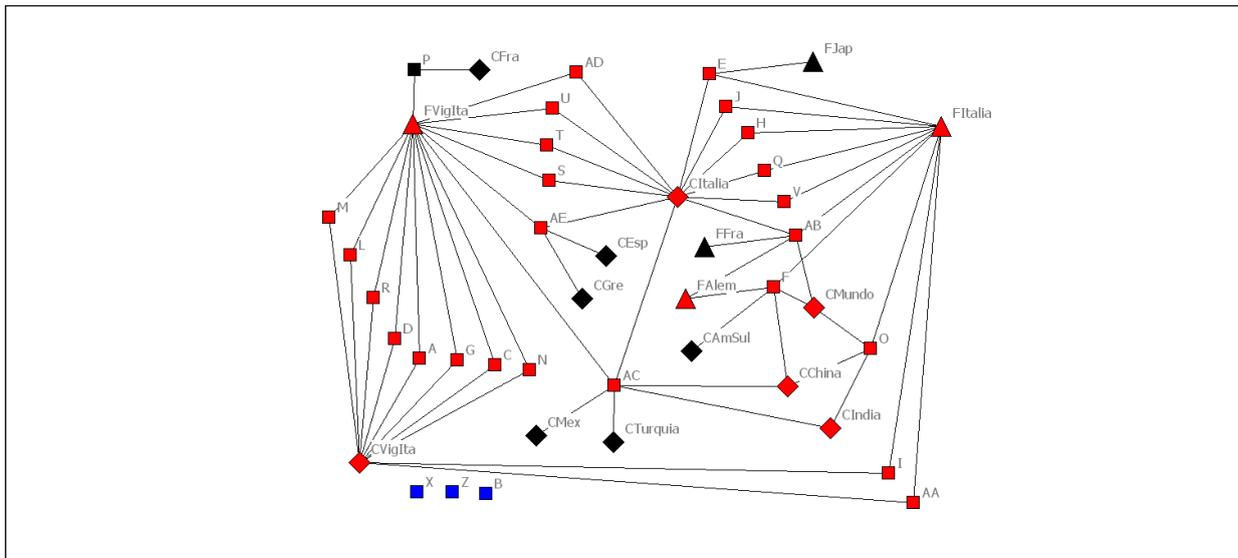
So, survey results emphasized the importance of vertical relations, as compared to horizontal relations. Knowledge flows based on vertical relations have proved to be an important element in the firms’ external knowledge process, corroborating the sectorial pattern for specialized suppliers (Pavitt, 1984; Malerba, 2005; 2011). The latter are quite dependent on relations with clients and other suppliers, even when there is strong influence of the “geographical proximity” element for firms in the same production segment. These findings corroborate the

literature. As highlighted earlier, both Gertler and Wolfe (2010) and Asheim, Grillitsch and Trippel (2017) emphasize that knowledge arising from interactive learning processes with customers or suppliers has a strong tacit dimension resulting from local characteristics.

To examine vertical relations, the footwear machinery manufacturers were questioned about their main clients

(footwear producers) and suppliers (mechanical and electronic components, and software) with whom they exchange important information and knowledge for the footwear machinery innovation process. Clients and suppliers were classified according to the regions where they are located. Figure 1 presents the vertical relations established by firms in Vigevano.

Figure 1 - Knowledge flows established by Vigevano firms with their clients and suppliers



Source: Field survey data processed by UCINET 6.

The node format represents the different types of actors: squares are the firms that responded the survey, and are listed from A to AE, triangles represent the suppliers, and diamonds the clients. To understand correctly Figure 1, it is important to keep in mind that the representation of clients and suppliers is not necessarily of individual actors, as in the case of respondent firms, but also of a category of information and knowledge source relevant to the generation of innovation in the surveyed companies. The latter is also characterized by its geographical location, as explained later on. Colors in the charts represent the intensity of the linkages of each node with the others¹¹:⁸ red nodes have the largest number of linkages, and most of the

respondent firms belong to this group; followed by black nodes, where there is only one surveyed firm (P); and finally the blue nodes, representing the firms X, Z and B that did not report on their relations with clients and suppliers and, thus, are not connected to the network.

Concerning the categories of clients and suppliers and their intensity of linkages in the knowledge flow, we note that the largest number of relations is established among clients and suppliers geographically close, as follows: suppliers and clients from Vigevano and other Italian regions (FVigIta and CVigIta), as well as suppliers and clients from other Italian regions (FTalia and CItalia). This highlights the relevance of locality and the country where the agglomerate of firms is

¹¹ Nodes were classified according to the k-core tool of the UCINET software; k-core is a group of nodes that are more linked among themselves than with other network nodes.

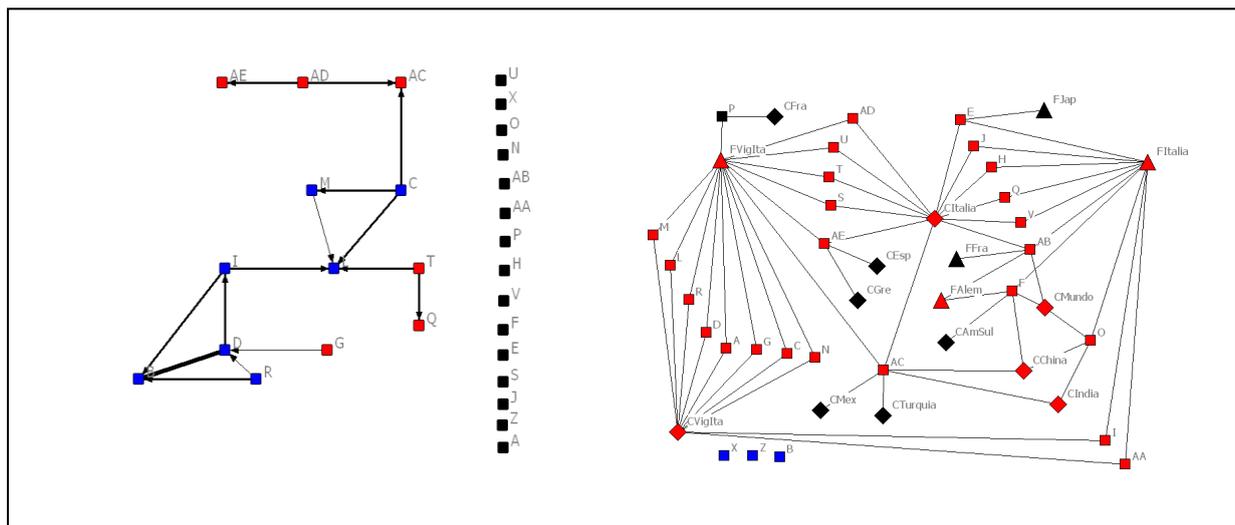
located, corroborating that the localized knowledge flows are very relevant, as analysed by Gertler and Wolfe (2010). Another fact seen from Fig. 1 also corroborates this statement: agents farther located from surveyed firms in geographical terms are the least consulted in the network¹².

It is important to take into account in our analysis information from firms in the agglomerate that are producing footwear machinery in other places in addition to Vigevano because they bring forth elements that help to explain behaviors. The five firms producing machines abroad are the following: A, AB, O, D, and AC – O manufactures in

India and all others in China. Out of these five, three (AB, O, and AC) reported they have as important sources of knowledge clients and suppliers from several parts of the world; out of a total 17 linkages (lines) connecting surveyed firms to clients and suppliers outside Italy, nine connected the three above-mentioned firms.

It is important to compare the network of vertical knowledge flows with the network representing horizontal knowledge flows. Figure 2 presents the two networks identified for Vigevano in the field survey, allowing for that comparison.

Figure 2 - Knowledge flows established by Vigevano firms in networks of horizontal and vertical relations



Source: Field survey data processed by UCINET 6.

The representation of the network of horizontal is drawn on the left side of Figure 2. We note that the network is quite rarefied because only a minority of firms participated in it and linkages among companies are scarce. Blue nodes refer to firms with more linkages in the network, red nodes represent firms with fewer linkages, and black nodes are the companies that do not consult and are not

consulted for exchange of technological knowledge. This does not occur in the network of vertical relations, as all firms have relations in this network, except for three that did not respond to the questions on this topic (X, Z and B).

Comparing the two networks, we note:

- 1) Firms have more relations with clients and suppliers (vertical

¹² These are clients represented by nodes in the format of black diamonds, generically located in other countries of the world (CMundo), or else in South America (CAmSul), China (CChina), India (CIndia), Spain (CEsp), Greece (CGre), Turkey (CTurquia), Mexico (CMex), and France (CFran); and suppliers (black triangles) from Germany (FAlem), France (FFra), and Japan (FJap).

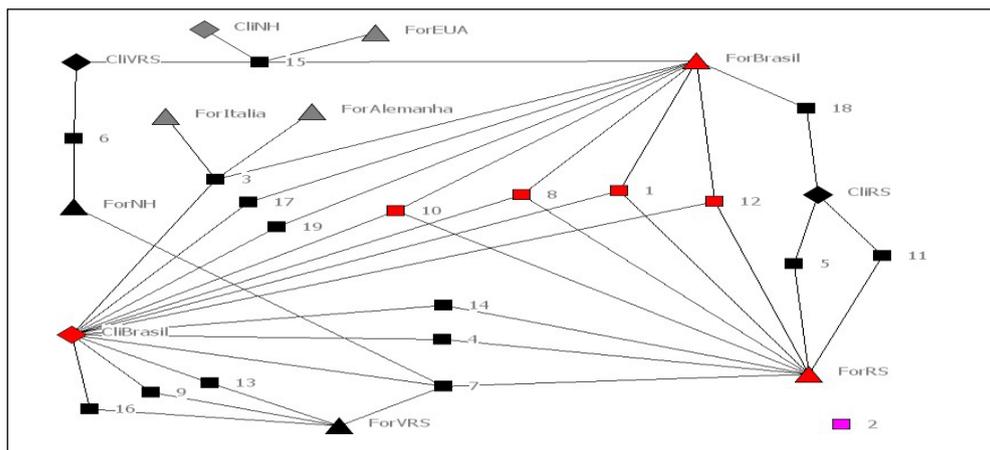
relations) than among themselves (horizontal relations). This finding from the research reported here is relevant because it allows us to make a comparison and conclude that the knowledge flows from horizontal relationships are less used by the firms investigated than the knowledge flows from vertical relationships.

- 2) The production of machinery in countries other than Italy (Vigevano) partly explains the vertical relations established with clients and suppliers from other countries; thus, we understand that there is a relationship between manufacturing machinery outside the home country and the search for sources of external knowledge for the innovation process among clients and suppliers abroad.
- 3) Another relevant finding is that there is specialization in the search for external knowledge: a large group of firms considers the vertical relations with clients and suppliers from the agglomerate locality and

its country as the main source of external knowledge; another group of smaller companies exchanges knowledge through both vertical and horizontal relations, privileging local and national firms in the vertical network (Italian clients and suppliers); and lastly, the third group of firms has vertical relations with local and national clients and suppliers, but also from abroad (in general, these companies do not have horizontal relations in the agglomerate). On this topic, we highlight the low degree of openness of the agglomerate firms, given the few linkages with agents from abroad.

The footwear machinery manufacturers in the Vale do Rio dos Sinos agglomerate were also questioned about their main clients (footwear producers) and suppliers (mechanical and electronic components, and software) with whom they exchange important information and knowledge for their product innovation processes. Figure 3 presents the vertical relations established by these firms.

Figure 3 - Knowledge flows established by Vale do Rio dos Sinos firms with their clients and suppliers



Source: Field survey data processed by UCINET 6.

Formats in Fig. 3 represent the different actors: squares are respondent firms and are listed from 1 to 19. Triangles represent suppliers; and diamonds the clients. The same way as in Vigevano,

representations of clients and suppliers do not necessarily refer to individual actors, as in the case of respondent firms, but also can represent a category of information and

knowledge source, which was also¹³. Colors in the drawings represent the intensity of linkages of each node with the others¹⁴: red for those with the largest number of linkages, followed by black nodes, grey, and finally pink (firm 2, which provided no information on its relations with clients and suppliers and hence is disconnected from the network).

Figure 3 also provides interesting information regarding clients and suppliers chosen by the Vale do Rio dos Sinos firms. As found in the research conducted at Vigevano's LPS, we note that there are strong linkages with agents located up to the country's geographical limit where the agglomerate is located: the most consulted clients and suppliers are represented in red; clients are from Brazil (CliBrasil) and suppliers from Rio Grande do Sul state (ForRS) and Brazil (ForBrasil). Reinforcing the importance of geographical proximity, other clients and suppliers located even closer to the agglomerate were also cited, but with less network linkages (black nodes), such as: suppliers from Novo Hamburgo (ForNH), clients and suppliers from Vale do Rio dos

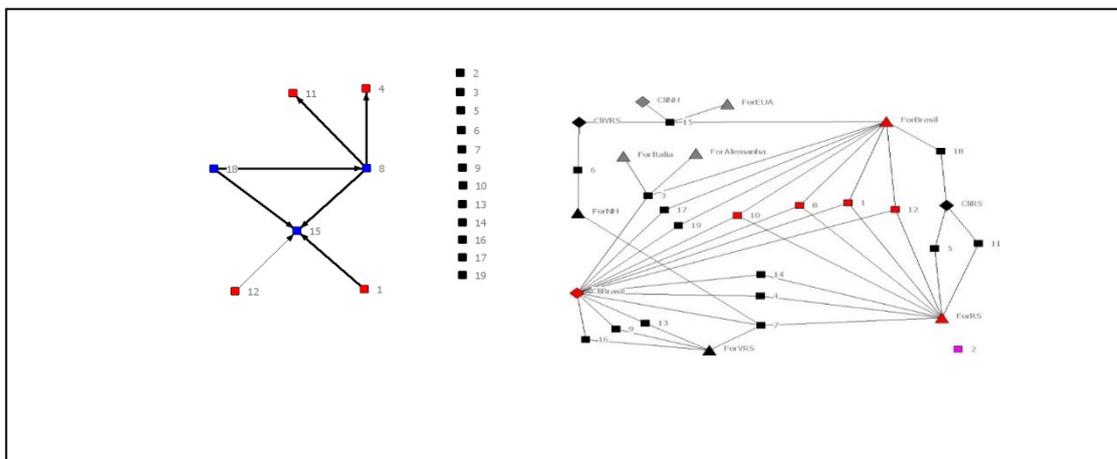
categorized by its geographical location

Sinos (CliVRS and ForVRS); and clients from Rio Grande do Sul state (CliRS). This highlights a pattern of vertical relations whose characteristic element is the geographical proximity to clients and suppliers. Lastly, all network actors outside Brazil are suppliers from Europe or the USA. This raises two issues:

1) The footwear machinery manufacturers in Vale do Rio dos Sinos do not consult with clients outside Brazil; their innovations are basically shaped by needs from local, regional or national clients. Hence, they respond to technological demands characterized by the position of the Brazilian footwear industry in a global chain of value.

2) There are no relations with Chinese firms, although their participation in world footwear production has been rising in the last years. This was different from what we had seen in the Vigevano agglomerate, where clients and suppliers from other countries were consulted, including China. This consultation shaped in a distinct way the innovations generated by that group of companies.

Figure 4 - Knowledge flows established by Vale do Rio dos Sinos firms in networks of horizontal and vertical relations



Source: Field survey data processed by UCINET 6.

¹³ Note that “VRS” is the acronym for Vale do Rio dos Sinos; “NH” is the acronym for Novo Hamburgo, city that is part of the set of municipalities forming the region defined as VRS; “RS” is the acronym for Rio Grande do Sul state, located in southern Brazil and where the VRS is also located, and, likewise, NH; finally, firms’ national dimension was defined by acronyms ending in “Brasil.”

¹⁴ Also defined by the tool *k-core*.

Horizontal relations are represented on the left of Figure 4. We note a quite rarefied network, the same as in Vigevano. Blue nodes are the firms with the largest number of linkages in the network, red nodes have fewer linkages, and black nodes refer to all companies that do not consult with others and are not consulted for knowledge exchange through horizontal relations. We also have noted that all firms in the network of horizontal relations are also in the network of vertical relations, such as the red nodes (8, 1, and 12) or black nodes (15, 4, 11, and 18), i.e., they are in the two groups with the most intensive relations.

Finally, in terms of vertical relations, Vigevano firms consult mainly with clients and suppliers from Vigevano or Italy in general; while Vale do Rio dos Sinos companies consult with clients and suppliers from Rio Grande do Sul state and Vale do Rio dos Sinos. Thus, we conclude that the two groups of firms obtain external knowledge mainly through interaction with local and regional clients and suppliers, or at the national level at the most.

We also highlight that for the Vale dos Rio dos Sinos network, no other clients beyond the national ones were cited¹⁵. This situation is different from the one observed in the flow of technological knowledge in the Vigevano network, where other clients, besides Vigevano, were mentioned such as Pavia, Italy, and Europe, located in several parts of the world. Those firms in Vigevano play a role in knowledge exchange because they extended the knowledge flow by including foreign actors.

In conclusion, while there is an openness of the firms' internal structures to different sources of knowledge, especially through relations with clients and suppliers, this openness is geographically limited. It is restricted to the main region of the agglomerate

(Vigevano or Vale do Rio dos Sinos) or to areas relatively close to them (Italy, Rio Grande do Sul state, and Brazil). Thus, the surveyed generation of innovations has proved to be fairly specific to the firm, as technical knowledge remains compartmentalized within the company through its own technicians, and external knowledge needed to generate innovation is obtained most intensely from clients and suppliers.

4 FINAL CONSIDERATIONS

We can highlight that in comparison to horizontal relations, vertical relations between footwear machinery manufacturers and their clients and suppliers are more frequent in both production systems studied in Brazil and Italy.

This does not mean that the innovation process is not fairly specific to the firm, tied to its internal structure. The knowledge of professional technicians (who often spend their whole productive life in one single company), increasing their knowledge mainly through experimentation (*vis-à-vis* a process of formal education), has proven to be also important for generating product and process innovations. Among the internal learning mechanisms, the most relevant is learning by doing. Given the size of the companies that characterize these LPSs, mostly small-sized firms, the majority of them do not have formal R&D departments, assigning to technicians the key role in generating innovations. On the whole, it is not part of the firms' routines to share their structures with other companies working in the same machinery segment or with institutions, either through formal or informal relations.

On the contrary, interactions with actors external to the firms were emphasized in the survey. Thus, respondents focused on informal vertical

and Brazil.

¹⁵ Represented by Novo Hamburgo (NH), Vale do Rio dos Sinos (VRS), Rio Grande do Sul state (RS),

relations between footwear machinery producers and their clients and suppliers.

Thus, it was mainly through knowledge flows established with clients and suppliers that we verified the importance of geographical proximity between firms for the process of technological change in the sector – vis-à-vis relations with other machinery manufacturers from the same agglomerate or from others (horizontal relations). So, as observed by the literature, proximate partners, as identified in this study, help firms to exploit their existing knowledge by further deepen their understanding in specialized contexts (Balland; Boschma; Frenken, 2022). From this observation, it can also be concluded that, learning by interaction is a key type of learning in both LPSs studied, and a central element to explain the firm's innovative dynamics, generating a dense knowledge flow.

In both agglomerates, the informal participation of technicians from client and supplier firms is considered fundamental for the generation of innovations, as they favor the acquisition of important information and knowledge to build the technical “knowing how to do” and, thus, defines the firms' innovation capacity. Hence, among external learning processes, learning by interaction was the most emphasized, and also explained the dynamics of generation of innovations in the surveyed firms.

The empirical study carried out, therefore, contributes to show that the two LPS studied use quite traditional knowledge sources for the generation of innovations, corroborating the characteristics highlighted by the literature, either the one that emphasizes the relevance of geographical proximity for knowledge flows in clusters, or the one that emphasizes the sectorial characteristics of proximity with clients and suppliers.

Taking into account these issues, the central contribution of this article is to be found in its empirical results, which demonstrate the following: (i) learning by

interacting is the key form of learning in the two agglomerates, especially for the vertical relations, and (ii) geographical proximity is relevant, understood as the geographical closeness between local firms – producers, clients, and suppliers from Vigevano or Vale do Rio dos Sinos – and between footwear machinery manufacturers from the locality and the country where the agglomerates are located.

Considering these remarks, the two LPS analysed can be considered interactive learning spaces (AROCENA; SUTZ, 2000; LASTRES; CASSIOLATO; MACIEL, 2003; LASTRES et al., 2020). However it is important highlight that firms in these LPS have distinct roles in the knowledge flows, since the vertical relations among them reported that knowledge is transferred among a small and specific group of firms only. So, firms with distinct innovative dynamics and distinct roles in knowledge flows have been identified, countering the understanding that the firms in productive clusters have homogeneous characteristics and roles, as suggested by the traditional literature on Marshallian industrial. This has already been pointed out by others empirical studies as Giuliani (2005) and Morrison and Rabelloti (2005).

It is worth mentioning the extent to which these field survey findings are consistent with the characteristics of the sectorial pattern of the segments producing equipment and machinery, identified as specialized suppliers. The reason is that firms with that sectorial pattern tend to be relatively small and operate in close contact with their users/clients, incorporating specialized and tacit knowledge into equipment design and manufacture. Formal R&D activity tends to be of low intensity. In turn, cumulative capacity building, as well as specific demands from users, tend to be important, as they result in innovation appropriability.

As future studies, it is suggested to update the empirical research in the two

investigated LPs, so that a longitudinal analysis can be done to identify changes and continuities in the knowledge flows established by the firms. In addition, it would be interesting to advance the discussions in the area by conducting empirical research in LPs from different productive sectors. This would make it possible to analyze regularities concerning the establishment of knowledge flows and learning processes of firms in productive clusters.

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