Building capabilities through global innovation networks: the case of the automotive industry in Minas Gerais

Ana Valéria Carneiro Dias

Universidade Federal de Minas Gerais

Av. Antonio Carlos, 6627, Belo Horizonte, MG, 31270-901, Brazil

anaval@ufmg.br

Maria Cecília Pereira

Universidade Federal de Minas Gerais

Av. Antonio Carlos, 6627, Belo Horizonte, MG, 31270-901, Brazil

cecilia@ufmg.br

Gustavo Britto

Universidade Federal de Minas Gerais

Av. Antonio Carlos, 6627, Belo Horizonte, MG, 31270-901, Brazil

gustavo@cedeplar.ufmg.br

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Abstract

Internationalisation of R&D towards developing countries has created innovation networks configurations that are truly global. These global innovation networks (GINs) are set up in developing countries for technological or market reasons. Sometimes firms in a country are integrated due to market reasons, and are responsible only for the adaptation of products for local conditions, but overtime the very fact of being part of a GIN increases their technological capabilities and they start conducting more significant innovations. In order to examine how this local innovation capability may happen and what new capabilities are built in this process, we investigated the automotive industry, and conducted case studies in one large European automotive OEM and four automotive systems suppliers in the state of Minas Gerais. Results confirmed that due to some aspects of the technological learning process to be part of a GIN has contributed to enhance local innovation capabilities.

Introduction

The internationalization of R&D activities has been a topic widely investigated recently (UNCTAD, 2005; Dunning, 1993: Cantwell, 1989). From the perspective of developing countries, the internationalisation of innovation activities may be seen as a way to accelerate the building of local technological capabilities, by their integration into global innovation networks (GINs). Such networks may be composed by local companies, headquarters or local branches of multinational corporations (MNCs), universities and research centres located in different countries. Within these networks the transfer of explicit and especially tacit knowledge between the actors is believed to be significantly enhanced.

Explanations of why R&D is internationalised and therefore why a GIN is established frequently mention two main drivers. The first is linked to technological sourcing, i.e. companies would search for a technology, a competence or a skill that is not available in their home country. The second driver is market proximity, given that local innovation activities facilitate the process of adaptation centrally (externally) developed products to local conditions. In some cases a company inserted in a GIN experiences an upgrade in its innovation structure: once set up for adaptation activities, local engineering eventually becomes a source of new technology within the GIN. This indicates that a learning process has taken place and that local innovation capabilities have been increased at a faster pace within a GIN than otherwise.

The aim of this paper is to investigate how developing countries can take advantage of their engagement in GINs to enhance their innovation capabilities. In order to do so, we have carried out case studies to examine the trajectory on the innovation capabilities of OEMs and suppliers, which are subsidiaries of MNCs, in the automotive industry in the state of Minas Gerais, Brazil. The Brazilian automotive industry has been trailing a trajectory of technological capability building from adaptation of products to local conditions to the development of new-to-the-world technologies. The investigation then focused on which factors have been present in the process of learning and developing new skills in the industry as well as on what new competences and skills are currently being developed within the companies.

The paper is structured as follows. In the next section the theoretical framework is briefly presented, focusing on concepts such as GINs, factors that motivate internationalisation of R&D, and aspects that influence technological learning by firms in developing countries. The next section presents the methodology and describes the case studies. Finally we argue that recent trends of the automotive industry in Brazil may be used to illustrate how firms in developing countries can profit from GINs participation by enhancing their technological capabilities.

Theoretical framework

In this paper we examine the internationalisation of R&D using the concept of global innovation networks. GINs are defined as networks of firms and other organisations in which innovative activities are accomplished by pulling resources from parners and different regions and countries, including developing ones (Gastrow et al, 2011; Barnard and Chaminade, 2011). Global corporations that once established global production networks (GPNs) are one of the main drivers of GINs as they expand their activities overseas, adding engineering, development and research activities to the production ones (Ernst, 2006; Ernst and Kim, 2002). In this sense GINs may be considered as an evolution, under certain conditions, of GPNs. Hence, MNCs play a key role in the development of GINs.

The process of internationalisation of MNCs' innovation activities toward subsidiaries is explained in general by two fundamental reasons (von Zedtwitz and Gassmann, 2002; Chiesa, 2000; Gassmann and von Zedtwitz, 1999; Patel and Vega, 1999; Florida, 1997; Reddy, 1997; Dunning, 1993). The first one is market-related: including subsidiaries in innovation networks should make it easier to reflect local preferences, enabling higher product penetration in these markets. The second reason is technology-related: to gain access to technologies that the main development centre is not aware of. Other reasons, such as lower labour cost outside the most deeveloped countries, and even time zone differences, which could turn product development into an around the clock process, thus accelerating time to market, have also been mentioned in the literature (Miotti and Sachwald, 2001; Chiesa, 2000; Reddy, 1997; Florida, 1997). Concerning the role of human capital in the internationalisation of R&D, Gastrow et al (2011) consider that it is possible to conceptualise them in terms of pull and push factors. Pull factors relate to the phenomenon of attraction of R&D by the host country, due to a specific local asset. Push factors are present when some deficiency on human capital availability in the home country drives innovative activities to a different location.

Ernst and Kim (2002) drew attention to the fact that GPNs can be seen as organizational configurations that favours knowledge transfer; therefore, developing countries could take advantage of their integration into global networks in order to increase their technological capabilities. Given that integration of local firms into such networks requires a minimum level of capabilities, the participation in GINs would boost knowledge transfer because. Therefore global firms that integrate (or even coordinate) the networks are compelled to transfer technical and managerial knowledge to local firms. GPNs also act are mediators of local capability building by promoting many forms forms of tacit and explicit knowledge conversion processes – socialisation, combination, externalization and internalization (Nonaka and Takeuchi, 1995).

Lall (2001) examined some features of technological learning that should be taken into account by research policy makers in developing countries. For instance, the learning curve for a given technology is not uniform or predictable; there are differences in learning that arises from different levels of development between the countries. Neither it is possible to determine exactly how a firm should learn, as there are differences among firms due to characteristics of the technology (modern x traditional, speed of changing of the technology, similarity to the firm's base of knowledge); thus learning has to be learned, and firms learn by developing organisational routines.

Indeed, learning is path and context dependent. The learning process is also technology specific as some technologies are more explicit-knowledge based while others are much more tacit. Automotive technologies are mentioned by Lall (2001) as examples of “engineering technologies”, considered to be more dependent on tacit than on codified elements.

Another feature of technological learning is the dependence of some technologies on external sources of knowledge or information such as other firms, technology institutions, capital goods suppliers. This dependence might lead to the establishment of networks in order to get access to knowledge which is disperse by nature. In addition, even if the R&D function may be one of the most important ones to increase capabilities, as innovation is in itself a process of learning, it is not the unique place where learning occurs within the firm. In fact learning and capability building takes place at any organisational levels such as the shop-floor, quality management, maintenance, procurement, logistics, as well as relations with external partners such as other firms (Lall, 2001). Finally, there may be different levels depths of technological development. While know-how or operational capability must be present in order to perform any activity, know-why is representative of a deeper form of capability, which leads workers to understand the principles of the technology and thus may enhance more autonomous innovative capabilities.

To sum up, in order to profit from networks to increase local capabilities, firms and countries should first present technology or market reasons to be integrated in the networks (pull factors). Once being part of a GPN, they should analyse the aspects related to technological learning and create routines, strategies or policies which take these aspects into account in order to foster learning and eventually become part of a GIN.

What is important to note, is that the process described above could be conceived with an explicit aim at capability building. For instance, developing countries or local firms can deploy a specific set of policies to develop local skills aiming at fulfilling perceived deficiency in skills elsewhere, thus building a combination of pull (local skills) plus push (lack of skills in central countries) factors. To investigate if such model o development is feasible, we will present and discuss the case of the automotive industry within a GIN.

Methodology

In order to examine the process of capability building mentioned in the previous section, we conducted in-depth case studies. In total, five companies were chosen, one OEM and four autoparts makers. The OEM is a subsidiary of an European MNC. It is ranked amongst the ten largest OEMs of the world and the five largest of Europe, and it is one of the market leaders in Brazil. The autoparts companies are all direct suppliers of this manufacturer, and are also subsidiaries of MNCs. In other words, they are part of a GPN and, in some aspects (as will be discussed later) of a GIN. Three of the autopart makers have headquarters in the same country of the manufacturer. Table 1 summarizes the characteristics of the selected companies.

Table 1: Case studies

Company	Main product	Capital origin	Time in Brazil	Notes
OEM	Cars	Europe	More than 30 years	
Supplier 1	Powertrain systems	Europe (same as OEM)	10 years as an independent company	It is a spin-off from the OEM
Supplier 2	Stamped parts and bodies	Europe (same as OEM)	11 years	
Supplier 3	Suspension systems	Europe (same as OEM)	More than 50 years	Once a local company, it was acquired by an MNC in the 1990s
Supplier 4	Transmissions/ engine parts	USA	More than 50 years	

Source: Author's elaboration

In each company at least one semi-structured interview was accomplished; the interviewees were product engineers and human relations managers or directors. In one case an Innovation Manager was interviewed. The interviews were guided by a script with questions related to the technological and skills trajectory of the unit, considering different actors who takes part in knowledge intensive activities – shop floor workers, supervisors, technicians, engineers, as well as marketing and innovation managers. Questions also referred to the existence of linkages with training institutions, universities and research centres, in Brazil or abroad.

A secondary source of data was desk research, which focused on information about foreign direct investment in the automotive industry, the local education system and local training systems. This contributed to build a general panorama of competence and skill building and availability to companies in the automotive industry.

Case studies

Established in Brazil during the second half of the 1950s, the automotive industry experienced continuous growth until the late 1970s. During the 1980s, the sector suffered a strong contraction. In the 1990s, following the process of trade liberalization and monetary stabilization, the production of vehicles experienced a marked recovery. Pushed by competition from foreign markets and by the growth of the local market, a strong investment cycle took place. From 1991 to 2001, OEMs invested over U$ 17 billion, while the autoparts companies invested close to U$ 12 billion (ANFAVEA, 2009). By the early 2000s six OEMs that were not operating in Brazil at that time had announced or inaugurated new plants in the country. At the same time all OEMs that already operated Brazilian plants had announced new investments to increase production capacity. These investments brought along innovations in the production process. The new plants followed lean production flexibility criteria, adopting multi-tier or hierarchical supply chains for components and parts (Salerno et al, 2009).

In relation to the autoparts industry, the investments, although high, were smaller than those observed for manufacturers. This difference is due to the high growth of autoparts imports during the whole period. Another characteristic of the investments in these activities was the intense process of mergers and acquisitions (M&A). This process led to the denationalisation and concentration of the Brazilian autoparts industry, as shown in Table 2, in tandem with the movement of capital concentration and centralisation the industry experienced internationally.

Table 2 - Capital ownership, auto-parts sales, and investments, Brazil (1994, 2001)

	1994		2001	
	Local capital	Foreign capital	Local capital	Foreign capital
Capital ownership	51,9%	48,1%	22,8%	77,2%
Autoparts sales	52,4%	47,6%	26,7%	73,3%
Investments	52,0%	48,0%	15,6%	84,4%

Source: Anfavea (2009).

After the financial crisis in Asia, in 1998, the Brazilian automotive industry experienced a period of instability and uncertainty that lasted until 2003. From this year onwards its production and sales once more presented a strong trend of growth, with the production capacity nearly reaching its limit. During this time, a recovery of investments could also be observed (from 2006/2007), having been only momentarily slowed down by the international financial crisis. The current perspectives, however, point to an increase of the production and to new investments. The projections indicate that the production capacity, which went from 2.0 to 3.5 million vehicles with the investments of the 1995/2001 period, will reach 6 million in 2013 (ANFAVEA, 2010). It is, therefore, a mature and important industry, with the OEMs responding, by themselves, for almost a fifth of the country's industrial GDP (ANFAVEA, 2010). There is a striking presence of MNCs in the sector, including in local competence-building.

During the 1990s, it is important to notice that the process of production restructuring experienced by the entire sector. MNCs subsidiaries and local suppliers replicated practices based on the Toyota Production System, which had been adopted at their headquarters. This process modified the profile of the workforce, especially of the operational, technical and supervisory workers. From the 2000s onwards, the headquarters shifted strategies of local subsidiaries, leading to the configuration of new Global Production Networks (Fleury, 1999).

In tandem with the deep process of productive restructuring observed in the past fifteen years – ownership changes, strategies shifts, capacity modernization and increase – innovation, as well as engineering activities in general, has evolved following a distinctive path. It begins with the adaptation of products developed abroad to the conditions of the local market after the installation of the MNCs. The next step is the development of local products broadly based on those produced at the headquarters. Finally, in some cases, the possibility of developing products for other markets (other developing countries, or, more rarely, developed countries) arises.

However, for companies operating in Brazil, this evolution suffered a major setback during the 1990s. As part of a process of generalized restructuring of production under fierce competition, caused by both tariff reduction and the overvalued currency, companies reduced the installed capacity of engineering activities (following the initial concepts of what a 'global product' should be). This trend was reverted during the 2000s, with the reintegration of the Brazilian subsidiaries into the global strategies of the MNCs (Fleury, 1999).

The new strategies of the MNCs included the possibility of a new international division of knowledge-intensive activities. In this division, the Brazilian subsidiaries would be responsible for the development of certain products or technologies, directed to local, regional or, in some exceptional cases, global markets. Alternative fuel engines, robust suspension systems and light, low cost vehicles, are examples of technologies which led to a selective decentralisation of engineering activities towards Brazil (Dias and Salerno, 2004).

As a consequence, GINs have emerged, albeit incipiently. Nevertheless, it is important to highlight that the Brazilian subsidiaries are usually responsible for the development of technologies related to specificities of the local market (such as alternative fuels for internal combustion motors or more robust suspension systems). Significant innovation activities related to more advanced technologies (e.g., electrical motors or new materials), have not been observed. Hence, it can be argued that, in the Brazilian automotive sector, basic research is almost inexistent – applied research and product development are the norm.

Case 1: OEM

The OEM is a subsidiary of a European TNC which has been operating in Brazil for more than a decade. It is one of the largest subsidiary outside its home country (in terms of production volumes and sales), and it is considered a strategic branch inside the corporation. The building of local competences is a consequence of the trajectory of the subsidiary, which is typical of the Brazilian automotive industry: innovation related activities have evolved from adaptation, or "tropicalisation", to product development. No significant basic research activities exist in this subsidiary, only applied research – more specifically, product and process development. The local unit is formally responsible for adapting products which were developed in the headquarters to emergent markets, in particular Brazil, as well as for developing new products on centrally designed platforms.

As a whole, it is possible to say that workers' formal qualification has been increasing at OEM over the years for all organisational levels. For instance, 12% of shop floor workers have college degrees or are enrolled in college – in Brazil 36% of the population of tertiary age are in tertiary education (UNESCO, 2011). Currently, the lowest admission requirement is a high school degree. The workers who fail to meet the standard are stimulated to qualify themselves, either through partnerships the company has established with local educational institutions, or by means of an internal incentive for minimal qualification (e.g., general education development courses).

The company has established partnerships with educational institutions, consultancies and training institutes associated with the manufacturer. Partnerships with public institutions for operational level qualification were not mentioned. The company stressed the importance of training in management tools, especially tools from the Toyota Production System (TPS). It is worth mentioning that this is a corporate policy and all firms of the group (OEM, Supplier 1 among others) must implement it. The company also trains its workers to allow for a broader comprehension of how the production processes work. There are training programmes aiming at developing competences related to continuous improvement (kaizen) and to methods of analysing and solving problems. The OEM also has a programme which gives financial incentives to workers who propose innovative ideas to improve products or processes, including for operational level workers. The programme can foster the search of new knowledge by the workers and by the company as a whole.

The case studies demonstrated, in all companies investigated, a growth trend for the local engineering sectors and their workers' competences. At OEM there is no on-going local basic research projects, only applied research. Basic research occurs fundamentally at the headquarters, and collaboration is more intense with the latter's laboratories. Nevertheless, in the last seven years the company has set up new local laboratories that made local development projects possible.

It is important to note that this trend became stronger with tax incentives provided by nationwide policies to foster innovation. However, the fact that the OEM presents important capabilities related to the development of products aiming at emerging countries – low cost, medium performance products – also helped to reposition the local branch within the broader network. These capabilities were built along the trajectory of the company, from local adaptation to local development. For instance, in the 1980s, when the Brazilian federal government consolidated its research program on ethanol as a biofuel (the *Pro-Álcool* program), the company developed and launched the first ethanol engine in the Brazilian market. In the 1990s it was the first company to introduce a vehicle equipped with a 1000 cc engine to comply with the public policy of decreasing federal taxes on small sized vehicles (locally known as popular vehicles), in order to stimulate sales. In the end of the 1990s the Brazilian unit was part of the global team which developed a car destined to emerging markets (Dias and Salerno, 2004).

The engineering department grew from 400 employees in 2005 to approximately 850 in 2010. The sector of product development is structured as in the headquarters; this makes the relationship with the headquarters easier, as each Brazilian engineer has a counterpart within the European engineering. Whenever a technical matter emerges, they are able to meet in order to discuss it, thus enhancing an international network. According to the company, engineers still lack background in technical areas. Once in the company, they must undergo training programmes in product development management (amongst others, quality and reliability), as well as technical training (in automotive engineering). The company also has formal incentive programs for specialisation, Master's and PhD courses. Training programmes in a research centre at the headquarters are also frequent.

Following sector standards, OEM's interaction with research institutes and local laboratories is not very intense. On the other hand the relationships between the OEM and suppliers are of extreme relevance in the Brazilian automotive industry – which is also a pattern observed worldwide. Co-design i.e. joint development of products or processes by the manufacturer and the suppliers is a common practise in the industry and differences between companies regard the level and strength of the partnerships established for the development of the project. The OEM is in charge of directing co-design activities in the studied network. It is important to remark that this type of interaction is part of the company’s history. There are four types of suppliers: suppliers that co-develop the products; suppliers that develop the product given the specifications from the client; suppliers that only manufacture the product according to the specifications; and the more simple "commodities" suppliers.

Case 2: Supplier 1

Supplier 1, which was previously a powertrain department inside the organizational structure of a European car assembler, was created in the beginning of the 2000s. Its headquarters are located in the same European country as the car assembler. At the moment of our investigation the company was carrying out an internal program in order to promote innovation in its products and processes.

Due to its trajectory, even if it has existed as an independent company for less than 10 years, it profited from the 30-year Brazilian experience of the car assembler from which it has split. This means that many of its workers have previously been workers of the car assembler; its organizational structure and procedures are still very similar to the car assembler ones. Some of its workers were responsible for the development of important local innovations such as the small engines and the ethanol fuelled engines that were mentioned in the previous sub-section. These competences, which arose from the path followed by the Manufacturer, are being consolidating at present, for instance, with the development of flex fuel technologies. Indeed, the company faces ongoing changes, towards greater local technological competence regarding new local and global products (alternative fuels), as well as competences related to large production, due to TPS. It is thus necessary for the employees – operators, technicians and engineers as well – to be constantly upgrading their skills. As an example Supplier 1 requires a minimum of secondary education for shop floor workers, who have also been trained in TPS tools – especially quality control, problem solving methods, autonomous maintenance and continuous improvement. Supplier 1 recognises the importance of the worker '*having a notion of innovation*', according to one HR manager. This is related to the company's current context, marked by the development of an innovation programme. Besides this, like the OEM, Supplier 1 has got benefit programs for workers who propose innovation and improvement ideas.

The impact of being inserted in a global network is evident in the case of development of competences in the engineering and innovation levels. In particular the relationship with the headquarters is very important, as can be seen in Supplier 1's slogan '*one product, one engineering'*. The practice of sending Brazilian engineers to the headquarters for them to do specific training programmes is quite common in Supplier 1. In this company, the subsidiary also hosts engineers from abroad, for them to, for example, familiarise themselves with the flex-fuel engine technology – a case of local developed technology that may be exported to other markets. The company is studying the implementation of a prize for engineers who publish academic papers on innovation ideas. The company's engineers possess specialised knowledge, but they develop flexible abilities in multidisciplinary teams. In the Supplier 1 engineering department there are about 300 employees, 56% of which are engineers. In this sector, ten employees possess Master's degrees and only one is a PhD.

Co-design is also present in Supplier 1. Besides carrying out the development of its product with the OEM, some of the main locally developed products involved a decisive participation of the suppliers. For example, recently a new device aimed at enhancing the performance of flex fuel and ethanol engines was developed in Supplier 1 together with a company which belongs to the same group as Supplier 3. This device was granted in 2010 a Brazilian and a European patent. The development of this device is strongly related to the competences already possessed by the engineers of Supplier 1, which were developed for over 20 years, due to the ethanol Brazilian programme (therefore these competences at first were not developed because of GINs, albeit they might be enhanced within a GIN at present).

Another example concerns an important local innovation introduced in a transmission system which was developed along with Supplier 4. This new transmission system was developed due to a demand of the OEM, which asked Supplier 1 for a system that could improve the performance of its small off-road vehicle (developed in Brazil). Supplier 1 started a conceptual research on technologies available on traction, presented by the headquarters as well as by other suppliers. Since final product price could not be increased, given the characteristics of the Brazilian emerging market, it was necessary to think up a low cost solution. Finally an idea concerning a device which could enhance the performance of the small vehicle in low adherence road conditions was borrowed from agricultural machinery market and seemed to present the best cost-benefit-viability scenario. However, a specialist supplier which could implement this in a first prototype was needed, as integrating the new mechanism in a small front transversal transmission represented a new-to-the-world challenge. So, after dealing with some potential suppliers in a more focused stage of definitions, Supplier 4, which presented the application of an electro-mechanical locker differential system, was finally chosen. A product development team was created with manufacturing engineers, production engineers, purchasing engineers, testing engineers and technicians as well as engineers from Supplier 4, in Brazil and in the USA. The new product called for new productive processes, because the new transmission would aggregate fragile electric components (Bagno et al., 2008) – something challenging for a traditional gearbox assembly line. Shop floor workers were trained in the new process.

This case illustrates how engineering worked through transversal processes with other departments as process and manufacturing engineering, service, legislative council, client and others. Concerning the external relation, it is important to emphasize the managing of complementary capabilities among Supplier 1 internal teams, OEM and Supplier 4. It can thus be said that an innovation network emerged, and that the overall competence level of the network (or, of the actors involved in the network) was increased. Since some of the competences needed to develop the new device were not present in the Brazilian subsidiary of Supplier 4, engineers from the USA development centre were integrated in the team.

Case 3: Supplier 2

Supplier 2 is a subsidiary of a European TNC company which has been operating in Brazil for less than 10 years, following a demand posed by its main client, the OEM.

Therefore, its very presence in Brazil is a consequence of being inserted in a global network which operates with follow sourcing policies, since Supplier 2 is a main supplier of the OEM in Europe. It produces stamped parts and car bodies and its whole production is destined to the OEM.

The company is also adopting TPS techniques in its production lines. This is so due to an exigency of the OEM. Indeed, in the automotive industry, the car assemblers drive the value chain and it is not uncommon that they compel their suppliers to adopt specific production methods and techniques. In Supplier 2, with the introduction of TPS, the company realised that it was necessary to require an elementary school degree for shop floor workers – it is paramount that they understand the production process, have a better control over the production and know how to use TPS management tools (e.g., interpreting simple graphs). An increase in the qualifications of the technical and supervisory positions can be noticed as well. For supervisory levels, a high school degree is required, preferably in technical courses, and a college degree is desired. For the technical level, a high school degree in a technical course is demanded. Supplier 2, as the OEM and Supplier 1, also presents a kaizen program, in order to enhance continuous improvement.

The engineering department of Supplier 2 presents a significantly higher proportion of technicians in relation to engineers. The area comprises approximately 120 persons, 30% of them engineers and 70% technicians (basically CAD operators). The engineering works are arranged according to the automobile parts being projected, in a functional structure very similar to the OEM, which is its main client. When a project involves more than one area, a multidisciplinary team is formed including engineers and technicians of all relevant areas. There are few members of the staff with post-graduation (one with a Master's degree, one of the area's managers is doing a Master's in Engineering and another is doing an MBA). Most CAD operators are taking engineering courses.

The company has got no partnerships with research institutes or local universities. The respondent from the engineering department said the company is not engaged in many market driven innovations, as most of their products and project services are the property of the client. It is also important to mention the relationship between the company and its European headquarters – the latter has got the engineering competences the Brazilian branch relies on, especially regarding projects of vehicle bodies. On the other hand, the headquarters does not possess the structural calculation competence, carried out only by the Brazilian branch, which supports the company worldwide. Innovation projects in the company tend to be internal and process-related, but even in these cases Supplier 2 does not use research results or research institutes for the improvement of its processes.

The interaction of Supplier 2 with its subcontracted staff is expressive, as some of the CAD operators are subcontracted. Such interaction does not lead to innovations for the company. On the other hand, the company has been pursuing partnerships with suppliers to start innovation projects for the company (not the client). As an example, there is a North-American supplier that performed structural calculations for a bus body, a product for which the studied company did not possess know-how. The contract with the supplier from the USA was signed determining the transfer of structural calculation technologies to the Brazilian company. Regarding physical component suppliers for manufacturing, it is important to clarify that the OEM chooses most of the suppliers of Supplier 2. Some of them participate in the product development, in a co-design involving the Manufacturer and Supplier 2; in these cases, the OEM formally establishes the interaction between Supplier 2 and its suppliers by contract.

Case 4: Supplier 3

Supplier 3 is a case of a former Brazilian company which was acquired by a multinational group in the 1990s, during the period of restructuring of the Brazilian automotive industry that followed the opening of the market (as discussed in the introduction of this section). This company was one of the largest Brazilian autoparts firms and, before being incorporated by the European group, it had followed a path of technological development in Brazil. When the acquisition occurred, many questions were raised concerning the risk of reduction of engineering and innovation activities in the company. Indeed, to a certain extent some of the engineering activities the firm carried out in Brazil were centralised in the European headquarters, but others, more related to local products, were kept in the country. It was the case of technologies related to suspension systems, since, due to local conditions (bad road conditions), vehicle suspensions in Brazil must be much more robust than European ones. Competences linked to the development and testing of these robust, low cost suspensions were developed in the company since it was a Brazilian-capital firm.

The company demands a minimum of secondary education for shop floor workers. Currently, the lowest admission requirement is a high school degree. There is increasing demand in terms of education and labor skills. The workers who do not meet the standard are stimulated to qualify themselves, either through partnerships the company establishes or by means of an internal incentive for minimal qualification (e.g., general education development courses). The company has incentive programs for the minimum qualification and development (encouraging technical courses). They also offer training for understanding how the production processes work.

Increasing the minimum requirement for qualification for production workers (high school) is related to the trajectory of technology and innovation of the company, as well as the characteristic transformation of the company's history over the past year. In 1990, when the acquisition by the multinational group was accomplished, it began to incorporate more complex technologies and new ways of managing processes such as quality and cost reduction programmes. The profile of the shop floor workers was also changed. Production workers must be prepared for the correct interpretation and use of quality tools in place, as the TPS ones, for example. Besides this, there is also constant incentive to promote the application of better practices, through a programme of suggesting innovation and improvement ideas. With this programme, any worker can give a suggestion and should direct its application together with a team defined by the company.

Concerning innovation activities, after the acquisition in the 1990s, the MNC made use of the local competences the national company had developed, basically concerning low cost solutions for more robust suspension systems. Nowadays, there are engineers with specialised knowledge, as well as the organisation of multidisciplinary teams conjugating flexible abilities related to product and process design, quality management, reliability engineering and cost engineering. These teams are mainly in the product development centre, located in its own premises, which are equipped with laboratories for testing new products. As presented by the other investigated firms, engineers of Supplier 3 directly interact with the suppliers and subcontracted companies, in co-design activities as well as in qualification and training programmes.

Case 5: Supplier 4

Supplier 4 is a subsidiary of a USA multinational group, which has been operating in Brazil since the 1950s. It produces transmissions and engine parts to cars, trucks and buses manufacturers. Most of its production is sold to manufacturers and around 25% is destined to aftermarket. During the 1970s the company started a policy of local adaptation of its products, which evolved to local development in the 1980s, thus consolidating its local engineering, which is specialised in transmissions and clutches components to small pickup vehicles (a type of vehicle which is not present in USA); other competences are centralised in the headquarters.

Supplier 4 provided further evidence for the tendency of greater qualification and instruction amongst technicians and supervisors. It stated that most of its supervisors currently possess higher education, while its technicians possess secondary education and technical degrees. The interviewee pointed, as the main reason for the increase in the qualification of these levels, the greater scope of abilities demanded of the direct workers, and, consequently, of supervisors and technicians as well. Improvement suggestion systems (kaizen) extensive to all employees were also verified in Supplier 4. In this company, multi-functional groups design the improvement projects. They hold regular meetings in order to accompany the evolution of the project, observing the methodologies of the TPS.

The engineering department makes use of multidisciplinary teams for the development of products for local or world markets (the headquarters consider Supplier 4 a competence centre for certain products). This company has been present in Brazil for more than 50 years, notwithstanding the fact that is has always been a subsidiary of an MNC, and during this period it has accumulated engineering capabilities. The engineers of Supplier 4 are currently presented with goals regarding innovation and submission of patent proposals. There are incentives for innovators, via internal prizes. The company also possesses a centre for the development of new products, equipped with a laboratory for testing materials (chemical, physical and resistance analyses) and for mechanical tests (dynamometers, coupling durability, lubrication, impact...). The tests the company cannot internally perform are carried out at the USA headquarters, at the facilities of the clients, at research institutes or at universities.

Discussion

The evolution of competences, knowledge and skills displayed by the workers of the automotive in Minas Gerais sector is closely related to the industry's trajectory in the past twenty years. Even if all investigated companies had set up their facilities in Brazil in order to gain access to local (plus regional) market and not due to technological reasons, all of them have enhanced their local innovation structures, although in different levels. Competences related to engineering and to technological development have grown in pace with the increase of innovation-related activities, especially the development of local products, which occurred largely during the 2000s.

The relationship between the increase of competences and the greater responsibility of the firms is bidirectional. There is, on the one hand, an effort to increase local competences due to changes in the technological profile of the unit (which leads to offering qualification and training programmes inside the companies, through partnerships with local institutions or by the local governments). At the same time, such an increase enables local subsidiaries to demand from their headquarters the allocation of time to perform activities of greater technological content, configuring a virtuous cycle that combines pull and push factors. The local professionals are actively seeking greater qualification and experience, while the companies are also in a process of acquiring autonomy in R&D.

The product development process in the automotive industry has for some time profited from external sources of knowledge, notably suppliers. There are incipient partnerships being attempted with local universities, aimed at technological development. These initiatives are mostly present in the OEM. On the other hand, co-design is a widespread practice within this industry and the case studies confirmed this as all firms are engaged in co-design; the two new-to-the-world technologies developed by Supplier 1 were created in co-design with two other suppliers, locally and abroad. The transfer of competences and of knowledge for product development activities occurs, between these units, in an informal and contextual manner, and it is related to the "manner of doing things" that is disseminated in the studied companies. This is consistent to the fact that in the automotive industry tacit knowledge is predominant (Lall, 2001).

In this sense, a ‘global network’ or ‘global chain’ configuration can be identified in the competence-building process of local branches of MNCs. This process involves the unit, the headquarters and its suppliers and clients (multinational and local), universities and local training or qualification institutions. Knowledge and technology transfers thus occur locally and globally.

The main force in the internal dynamics of this network is the OEM (the headquarters and the subsidiary company). It is the (bidirectional) relationship between the headquarters and the subsidiary that determines which competences must be locally developed, in the operational as well as in the management and engineering levels. The local development needs of the OEM determine the partnerships with the education institutions and the universities. They also determine the competence development needs of the suppliers, especially those participating in co-design. Co-design practises themselves create an engineering network in which there is a daily exchange of experiences and knowledge, especially tacit knowledge, increasing the competences of the network as a whole, as predicted by Ernst and Kim (2002).

At the global scale, knowledge transfers occur mainly between the headquarters and the subsidiary. In the case studies a distinctive demand for increased autonomy in relation to the headquarters in order to develop technologies and to produce knowledge locally – in other words, creating pull factors. As an example, engineers are frequently trained in specific technologies at the headquarters, but there is an emerging trend transferring certain knowledge from Brazil to the headquarters (flex fuel, for instance). This means that if at present the cases of new-to-the-world local developed technologies are still rare, there is a possibility that in the future the number of local major innovations will be increased.

This reasoning is also supported by the fact that the level of formal education has shown an upward trend in all investigated companies, that is, not only know-how but also know-why is being encouraged. As Lall (2001) indicates the presence of know-why competences in general means that deeper capability exists which supports more technological autonomy. Indeed, in the staff departments and in the technical and engineering levels, professionals have consistently shown intention of acquiring competences necessary for a career in innovation in the automotive sector. This movement is still timid in Minas Gerais, and it can be seen by the growth of professionals with technical level qualification (with knowledge of specific software for product development, especially CAD and simulation or laboratorial ones) and higher education (business and engineering courses).

In addition, in engineering areas, there is an important interaction between the companies and local research institutes or universities, both public and private, through the investment in specialisation, Master's or PhD courses – although there are relatively few PhDs in the sector. However, the market still is short of qualified and experienced professionals (specialists), particularly in the technical and engineering areas. This can be explained by the still recent character of the research in the sector, which was intensified only beginning in the 2000s (Dias et al, 2011).

Another equally important way of developing engineering competences is the transference of local engineers to training programmes at the headquarters of MNCs. There are cases in which local subsidiaries send engineers abroad with the explicit purpose of performing training in the headquarters' Research Centres, plants or training centres. Finally, it is of relevance the fact that the OEM trains engineers, technicians and managers of the suppliers.

An attempt to standardise the production management models between the OEM headquarters, the OEM and the suppliers was detected, led by the OEM headquarters. The production management model chosen is based on the TPS, and presents characteristics such as: adoption of quality tools (statistical process control, PDCA, structured problem-solving methods...), continuous improvement (kaizen) performed in a structured manner, multifunctional capabilities and an increase in the demand for holistic knowledge (comprehending the whole production, being able to deal with eventualities, amongst others). Hence, there have been efforts to improve the qualification of shop floor workers (mainly by the manufacturers and systems provider auto parts companies), materialised, fundamentally, in (internal and external) trainings in the management tools adopted by the model. This finding is coherent with the proposition by Lall (2001) that states that technological capabilities are often developed at all organisational levels.

Taking all these factors into consideration, it can be argued that the participation in a global network, albeit an incomplete one, has led to an increase of the local competences in the automotive sector. This occurs via internal development (internal training, knowledge transfer between the headquarters and the branch or between the client and the supplier) as well as via the development of competences through the establishment of partnerships with local supplier, clients and education and research institutions.

However, it is important to notice that, with the exception of the technologies related to ethanol fuelled engines, local capabilities have been developed by local units along the years in an informal way i.e. without formal partnerships with local universities or research centres. These competences are related to local market characteristics, such as conditions of usage and customers' preferences and lower income levels. To the extent that some of these characteristics are also present in similar, important developing markets (such as Latin America, South Africa, Western Europe or India) these competences started being recognised by the headquarters, local engineering infrastructure was enhanced and its procedures and local capability development were formalised in the last decade. This is the case of the OEM, Supplier 1 and Supplier 3, for instance.

Final remarks

This paper investigated how the integration of firms in a global innovation network affects the demand of local skills and eventually lead to an increase in local innovation capabilities. The results showed that demand for higher-level competences, in particular of engineering positions, is closely tied to the configuration of the local GIN. In the case of Minas Gerais, the GIN under investigation is found in the automotive industry, which has been subject to important qualitative changes in terms of innovative activities in the last decade. From mere processes of adaptation of products developed elsewhere to local markets, local branches have gaining increasing degrees of autonomy to develop new products to the local market, which can eventually be selected by the headquarters to serve other countries.

The degree of autonomy is related to a higher degree of integration of the OEM’s local subsidiary to the corporation’s global activities. In this sense it seems that emergence of GINs is associated with improvements in the configuration of a GPN. The position of the local subsidiary in its headquarters’ global division of innovative labour is highly path dependent. Local capabilities have been built progressively during the past two decades, having been accelerated in the past ten years. This acceleration was possible due to policies companies have adopted to foster learning: training programmes, incentives for employees to increase their formal education and thus their know-why, new organisational routines such as kaizen programmes at all organisational levels, teamwork and formal external linkages with universities.

The quality of linkage between firms in the productive network also contributed to build new capabilities and to the emergence of a GIN as it made knowledge transfer inside co-design processes possible. Thus it can be said that firms in developing countries can enhance their technological capabilities when integrating a global innovation network. Finally, it must be stressed that in the current case this has happened in spite of the fact that linkages between firms and universities are very weak and that there are few public policies explicitly aiming at promoting local innovation in the automotive industry, as in the case of Pro-Alcool program. Therefore there is plenty of room for further improvements of local capabilities if the observed initiatives are coupled with sound, sector specific policies which strengthen pull and push factors.

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