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THE INNOVATIVE PROCESS IN THE AUTOMOTIVE INDUSTRY: AN ANALYSIS OF THE GREAT ABC REGION AUTOMOTIVE CLUSTER

O PROCESSO INOVATIVO NA INDÚSTRIA AUTOMOTIVA: UMA ANÁLISE DO CLUSTER AUTOMOTIVO DA REGIÃO DO GRANDE ABC

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ABSTRACT

This working paper describes the innovative process in the Brazilian automotive industry, taking the Great ABC region as a research object. As a reference for the contemporary industrial organization, the automotive industry stands out as a driving force behind a diversified and complex global production chain. Thus, the industry innovation process mobilizes a strategic set of agents within the industry, with repercussions on the other sectors such as the embedded technology, mobile, among others. This paper results from a qualitative approach supported by a descriptive type of research, outlined by a multiple case study and semi-structured interviews, preceded by a documentary analysis in secondary sources. Locally developed innovations involving agents from the productive chain and in partnership with competitors were identified. Results suggest the practice of open innovation, which was confirmed in field research.

Keywords: Automotive industry. Productive chain. Relational Capital. Open Innovation

RESUMO

Este artigo descreve o processo de inovação na indústria automobilística brasileira, tendo como recorte de análise a região do Grande ABC. Além de ser uma referência da organização industrial contemporânea, a indústria automobilística se destaca como uma força motriz de uma diversificada e complexa cadeia produtiva global. Assim, o processo de inovação da indústria mobiliza um conjunto estratégico de agentes da indústria, com repercussões para outros setores como é o caso dos sofisticados sistemas de tecnologia embarcada , mobile, entre outros. Este trabalho resulta de uma pesquisa de natureza qualitativa, descritiva, delineada por um estudo de caso múltiplo, pautado por entrevistas semiestruturadas, precedida por uma análise documental em fontes secundárias. Foram identificadas inovações desenvolvidas localmente com envolvimento de agentes da cadeia produtiva e em parceria com competidores. Os resultados sugerem a prática da inovação aberta, o que foi confirmado na pesquisa de campo.

Palavras-chave: Indústria Automobilística. Cadeia Produtiva. Capital Relacional. Inovação Aberta.

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1 INTRODUCTION

The automotive industry has been considered one of the most intriguing productive chains since its birth. Its experience with production optimization has developed a cluster of referential models for industrial and management organization for the whole industrial area.

Historically, the search for efficiency was a big driver for the automotive industry development and, at first, gave birth to the mass production concept obtained with the verticalization in the automotive process (WOMACK, JONES & ROSS, 1992), adding some customization degree as a product value to the Toyota System of Production and, more recently, the concept of flexible production. The introduction of quality practices, which resulted in a more efficient production, along with the lean manufacturing philosophy, were, in fact, some of the important outputs of innovation in the processes and products with repercussion on manufacturers all over the industrialized world.

Inserted in a sector of recognized demand for technical and technological capacities, the Brazilian automotive industry was notable for its creative capacity and absorption of new knowledge ,mostly due to the interaction that takes place internally and externally on a solid basis of primary knowledge (GONZALEZ & MARTINS, 2014). Developing innovative competence, hiring talented people and establishing valuable relationships within the industry make the difference. The Brazilian subsidiaries of some of the biggest worldwide manufacturers have adapted vehicles and parts, previously manufactured only abroad, to the economy, geography and climate of South America conditions , making them become global projects, inserted in global structures of manufacturing and assembling. (CONSONI & CARVALHO; 2006; IBUSUKI, 2011).

There was a great development in the suppliers linked to the multinationals which had already worked with the automakers. The biggest suppliers also started with R&D activities in partnership or under their overseas head office coordination (VASCONCELOS, 2012). In those cases, other suppliers that have joined to the R&D efforts such as Bosch, Magneti Marelli and Mahle Metal Leve.

The Technological Development models implemented by automotive industry had a great influence over important agents in the industry's network, like workers' and employers' syndicates which brought upgrades for work, decisions for improvement and changes in processes and products in factories located in the ABC region and in São José dos Campos, bringing together the automotive agents in Brazil, Europe, United States and Japan, setting a new posture for systemic interaction (CONSONI, 2004; QUEIROZ & CARVALHO, 2005; CONCEIÇÃO, 2008; BRESCIANI, 2001).

This research seeks to understand and describe the innovation process within the automotive production chain and the related agents such as the local suppliers, workers, syndicates, sales force and others. To attend this purpose, three automakers located in the ABC Region and members of its production chain, one Consultancy Company, three suppliers and two syndicates were interviewed and analyzed, besides documentary search, in order to answer the main question of this study: what are the features for the innovation process in the automotive production system?

This paper is structured in five sections. First section refers to this introduction. In the second, the theoretical review is debated seeking to build the field research guidelines. The third section presents the method applied in the data collection. Obtained data is analyzed and the results are presented in the fourth section. And, finally, in the fifth section, some considerations are formulated regarding the innovative processes in automotive industry, contributions and research's limitations are indicated as well as the opportunities for future studies.

2 THEORETICAL REVIEW

The rapid movement of technological frontiers poses challenges both for the driving companies and for the companies that are part of the production chain . Time and investment are necessary elements to accompany the changes, whose availability requires, more and more, the interaction between the actors around a common object. Thus, relationship capacity and trust building are intangible artifacts typical of the innovation process in a productive chain. Trust and commitment are the essential condition to change the patterns of business transactions simply oriented by market targets up to a new platform of business guided by knowledge, resources, capacities, creativity which are exchanged among members of a productive chain (BLONSKA et al, 2013).

The value of relational capital has been debated since the 1950s, initially focused on the value of the relationship networks, passing through aspects of interest of groups, finding in Bordieu, in the early 1970s, the exploitation of relational capital in contrast to cultural, economic and symbolic capital.

The relational capital is inherent to the cooperative strategy which enhances common standards among partners, mutual expectations in the potential of cooperation, and, beyond that, relational capital involves "mutual trust, openness, transparence, social bonds and common values of the entities" (LENART-GANSINIEC. 2016, p. 2009).

Specifically, in industrialized and knowledge-based societies, relational capital gains evidence because of the information exchange . Relational capital is based on personnel capacity to establish relationship among customer and suppliers, brands, internal processes and user, being an important resource for the formation of intellectual capital and the acceleration of the cycles of the development of new products and services expanding the organizational capabilities and resources with which the organization operates (GARCÍA-MERINO et al, 2014)

In order to exploit the study´s object, we conducted a research in the automotive industry located in the ABC Region aiming to find out the relational factors regarding innovation within the industry and its value chain. So, we considered the role of the government, research agencies, universities, companies, suppliers and workers, and their influence as innovation agents, through the Innovation Management. We present the main results along this article.

Schumpeter (1939) stands still as most influential author in innovation studies, as stated by the Oslo Manual (OCDE, 2006). Nevertheless, other contemporary authors revisited Schumpeter´s concepts and offered a new view on the innovation categorization which includes original concepts. The organizational innovation is nurtured by the new

business models and also reflects the relational capability to attend new markets and to stablish innovative organizational arrangement, such as Modular Consortium, installed by Volkswagen, near Rio de Janeiro, focused on productivity and production cycles reduction. The second category, i.e., technological innovation refers to the technological change waves that hits product, new materials, services and operational processes.

Tidd, Bessant and Pavitt (2008) define innovation process as a process essentially guided to renew what companies offer to the market (their products and/or services) and how they are made and sold, which includes searching/identifying threats and opportunities to change the in the internal and external ambiences. In this case, it is essential to develop people to scan environment in search of novelty, even in the regulation environment. Opportunities to provide product and process under the green philosophy is a social recognized necessity, nowadays. The present challenge is to ensure knowledge accumulation to support the innovation efforts, and, reaching this challenge implies taking advantage advantage of the intellectual capital of the companies Each employee´s intelligence counts.

The differences among the nature of the companies and the resources applied towards the innovation can define the innovation strategy. For example, medical laboratories tend to create solutions focused on R&D, which calls a long term of R&D effort; companies that focus on product may worry on speeding the development of new products, due to its variations; large engineering companies tend to concentrate in design and managing projects and implementation steps (TIDD, BESSANT & PAVITT, 2008).

Considering the specifications of the productive chain, the automotive industry seems to fit in several options of the firm`s nature described before, despite some authors claiming the basic pattern for the innovation steps remain the same in automotive industry no matter the nature of the firm. Different trajectories experienced by the industry combine both scientific knowledge and market demand, and more recently from customer´s insight as seen in the design of the Mio automobile, promoted by Fiat, as an open , collaborative and innovative process. Trajectories leaded led by the Demand Pull Model, nurtured by the consumer insights combined with the Science Push Model can outline new patterns for technological change (MOWERY & ROSENBERG, 1979; PAVITT, 1984; SANTOS, 2012).

The theoretical set presented suggests that innovative process in the regional automotive industry combines different trajectories related to scientific knowledge and market needs understanding, and involves different agents of the production chain, and outside it, in a quasi-open innovation process, such as R&D Institutes, Dealers and Syndicates.

2.1 INNOVATION TYPOLOGY

There are different conceptions about the term "innovation" and sometimes there are contradictory ways of using it. Innovation, in essence, is the concrete result of diverse knowledges - tacit and explicit - that can create advantages for the organizations that achieve them. And it will be all the more shocking the more intense the change that innovation promotes. Thus, an innovation can be

defined from the degree of novelty that it translates. From one end to the other, it can be a source of novelty-filled artifacts or an improvement that brings incremental benefits when an opportunity is explored (CHRISTENSEN; RAYNOR, 2003).

Kohler and Begega (2014) have identified three sociological currents that attempt to explain innovation from the post-schumpeterian innovation paradigm: innovation as a process of value creation in the Marxian sense; innovation is a construct that supports the theoretical understanding of institutional diversity and social change; and innovation as an essential foundation for organizational dynamics.

Chesbrough, Wanderverbeke and West (2006) studied innovation degrees and a company strategy to implement them. He went beyond the innovation traditional mode on searching for, selecting and applying innovation. He divided innovation modes in two: Closed innovation, when companies invest heavily in their own structure and R&D departments; and Open Innovation, when companies forge strategic alliances or acquire technology from other companies, institutes or universities, even though the company already has a R&D area.

Chesbrough claims that even large companies with big R&D departments and high budget for innovation have their creativeness and development limits. When they affiliate to other companies, sometimes a lot smaller, they get a greater speed and a lower cost on creating and implementing innovation. Still on Open Innovation, a company may hire institutes, universities and other companies (CHESBROUGH, 2008).

Some authors detached that clients may collaborate in creation of new products or services, as previously mentioned in Fiat Mio case study; therefore, organizational or marketing innovations (LENART-GANSINIEC, 2016). For this purpose, we commonly see universities, research centers, laboratories, technological incubators and scientific parks working collaboratively. Cooperation may come in different levels, intensity or types of innovation.

Based on the different perceptions about innovation, the typology related to the application of innovation as follows in Figure 1:

Figure 1 - Types of innovation

Schumpeter (1934)	OECD (2005)	Tidd, Bessant, Pavitt (2008)	Forum FGV (2005)	
New products introduction	Product Innovation	Product Innovation	New asset introduction	Technological Innovation
New production methods introduction	Process Innovation	Process Innovation	New production method introduction	
New market openings				
Developing new sources of raw material and other inputs	Organizational Innovation	Position Innovation	Organizational Innovation	Organizational Innovation
Creating new market structures in an industry	Marketing Innovation	Paradigm Innovation	Business Innovation	

Source: The Organization for Economic Co-operation and Development (OECD, 2005), Tidd, Bessant and Pavitt (2008) and Forum FGV (2004)

According to Figure 1, and in the case of an industry of medium-high technological intensity, it can be observed that the innovations occurring in the auto industry tend to focus, more frequently, on the category of technological innovation than in postmodernity, from the combustion engine that consolidated the concept of self-propelled vehicle, or automobile, lived consecrated experiences as the innovation in products and services, as the pickup trucks, vans and SUVs; and process innovation, such as Lean Manufacturing or the Toyota Production System - TPS.

The automotive industry experimented two types of innovation: one regarding new markets development, to install industrial plants in Africa and Asia. The second , is related to find new businesses models in order to reach sustainable advantages such as the creation of "holographic structures" that integrate the Department of Business, Support Department and Local Departments of companies such as 3M, Dupont, Electronic Data Systems - EDS purchased by Hewlett-Packard – HP.

Briefly, new scientific and technological knowledge are usually the basis for innovations. The intensity of the new knowledge as well as new technology applied in new products, processes and services can vary from low to high intensity. Between the extremes of this conception are the identified radical innovations, when introducing (the) highest degrees of novelties and incremental ones, which offer important improvements to existing artifacts, processes, and services. Another kind of innovation considers the impact of how new technologies, specifically in radical innovation type, hits the society way of life living, which is defined as Technological Revolution (TIDD, BESSANT & PAVITT, 2008)

Aiming to illustrate, in an automotive industry electronic suspension can be seen as an incremental innovation, such as radial tires and microprocessors; radical innovation is represented by the case of the creation of *multiflex* cars (using ethanol and/or gasoline) and electric cars (WRIGHT, KROLL & PARNELL, 2000). As a technological revolution example, we have the Fordism, which revolutionized the productive system for over 60 years, and led to the Lean Manufacturing and Volvism, a broader change on production management, relationship and behavior on workers, suppliers, customers, syndicates and others, besides the government and institutes (CONCEIÇÃO, 2008).

Given the involvement of the productive chain in the actions related to technological innovation, this research has defined technological innovation as its object of analysis the technological innovation, locally developed for products, services and processes in the Brazilian automotive subsidiaries in the ABC region. It seems that the process of innovation in the local automobile industry involves companies of different degrees of technological intensity, in different degrees of participation in innovative process.

2.2 THE AUTOMOTIVE INDUSTRY

The automotive industry begun began in the second phase of the Industrial Revolution, along with the third wave of technological revolution (FREEMAN & SOETE, 2008; PEREZ, 2011), as shown on Figure 2, alongside the six big innovation waves, according to Kondratiev.

Figure 2 – Technological Revolution phases

	Wave	Science & Technology and Education	Transport and Communications	Industrial Energy
I	1st Industrial Revolution Phase (1780-1790)	Learning through scientific societies	Channels, cart roads	Water mill
II	2nd Industrial Revolution Phase (1830-1880)	Mechanic and civil engineers	Iron roads and telegraph	Steam
III	3rd Industrial Revolution Phase (1830-1880)	Chemical and Industrial R&D, National Laboratories	Steel rainways, telephone, planes and cars	Electricity
IV	Mass Production Era Fordism (1930-1980)	Broad Industrial R&D, Mass Education	Highways and Ratio	Oil
V	Microelectronic Era (from 1980 on)	Data Networks, Global R&D Networks, Continuous Training	Telecom Networks, in Multimedia	Oil and gas
VI	Health and Environmental Technology	Biotechnology, Genetics and Nanotechnology	Telemathics and Telework	Renewable energy

Source: Freeman and Soete (2002, apud Santos, 2012).

Mowery and Rosenberg (2005) and Drucker (2010) comment that Germany, France, Italy and England invested heavily in creating technical schools and universities to face the second wave of the Industrial Revolution, when one may notice the rise of technicians, entrepreneurs, engineers, such as Daimler, Benz, Siemens, Peugeot, Renault and others in the automotive area. Those authors also state that credit agents started to support some companies and institutes in Europe and, after that, the United States, investing in technical schools and universities and amplifying credit to companies.

Mowery and Rosenberg (2005) also state that investment in education in the XIX and XX centuries, the protection of intellectual propriety and trademark and the conditions created by investments on education/specialization created the right ambience for developing and consolidating entrepreneurship in chemical, electrical, electronic and mechanical industries, including the automotive industry in the United States and, before that, Europe.

Liker (2005) points to joint ventures, like NUMMI - New United Motor Manufacturing Inc, in the city of Freemont, California, in 1984, made by GM and Toyota, or the Ann Arbor University, from Michigan, also stated by Liker (2006), supported by the US Air Force Office of Scientific Research (AFOSR), that sent researchers and American students to Japan for over a decade to acquire and comprehend Japanese companies organizational models, especially from the automotive area.

The Toyota Production System - TPS, or Lean Production, had spread over Japan in the 1960s, according to Liker (2005). And from the TPS, came Lean Manufacturing and Lean Production. And, after that, came Lean Thinking (Liker, 2006), which was a great influence for service and business management. After that, the Lean Production model went to the construction area, as Lean Construc-

tion (PERETTI, 2013). All those authors state that there is a great importance on entrepreneurship and human capital on the innovation trajectory in the United States, Europe and Japan, and even on the emergent economies, such as South Korea, China and Brazil (FLEURY & FLEURY, 1995).

Although Brazil already had some multinational industries, like Rhodia and (including the automotive) Ford and GM since 1920, they weren't really industries, but CKD (Completed Knock Down – they would get all the pre-assembled parts and only assembled the final parts). The automotive post-war fordist industry was brought to Brazil by the end of the 1950s through public policies generated by the federal government and by some companies that were already in Brazil, like General Motors, Ford, Mercedes-Benz and, after that, Volkswagen. According to Fleury and Fleury (1995), the fordist model was partially introduced in emergent economies. The mechanical fordist model was well adopted in the ABC Region, which was called "the Brazilian Detroit" (CONCEIÇÃO, 2008), even without the high paychecks and thick syndicates the well developed countries had.

The joint venture between GM and Fiat gave birth to the Flexpower Engine (using both ethanol and/or gasoline), which brought together suppliers like Delphi, Iochpe-Maxion, Bosch, Magneti Marelli and Mahle, besides other great automakers, like Volkswagen and Ford (GATTI JUNIOR, 2010). The same suppliers also worked on designing, engineering and upgrading the "flex electronic ignition".

Gatti Junior (2010) states that the agreements made between suppliers, companies and research institutes and universities, even outside the automotive chain, like Coopersucar and Petrobras, were a great contribution on solving problems like corrosion and integrating components like the electronic ignition and the fuel pump.

The automotive companies in Brazil, besides creating partnerships and joint ventures, created technology and research centers for developing and adapting parts and vehicle projects. According to Gatti Junior (2010), the examples are: Celta, Meriva, Zafira and S10, from GM; Ecosport, from Ford; Brasília and Fox, from Volkswagen; and the electronic management engine, from Mercedes-Benz Brazil, which was completely developed by the engineers in the Technological Development Center (CDT), in São Bernardo do Campo (MERCEDES-BENZ BRAZIL, 2013).

According to Fleury and Fleury (1995), the TPS came to Brazil on the second half of the 1980s, using some of the Japanese management tools, but without Total Quality Management - TQM, Community Management, high productivity levels and highly educated labor, despite the fact that there was an already strong ABC Metallurgical Syndicate.

Santos et al (2013) state that the human factor in the technological area may help the country to achieve a higher innovation level. Consoni (2004) and Queiroz and Carvalho (2005) claim that the Brazilian automotive engineering is growing on knowledge and applying that in R&D activities in the Brazilian subsidiaries, also sharing international projects and helping to manage innovation on the head offices. When talking about the external and internal agents in the innovation process, especially in Latin America and Brazil, it's important to notice Sábato and Botana's work (1975): the triangle of Sábato.

Etzkowitz and Zhou (2006) went further and inserted the environment and society as a whole in the theory, amplifying the model to two "helix twin" groups; one for the traditional structure and the other for the triad University, Government and Social-Public. So, we assume that the triple helix twin may be used to describe the relation between the agents in the innovation process for the subsidiaries and the production chain.

2.3 CONTRIBUTIONS FROM THE THEORETICAL FOUNDATIONS

In order to use the proper instruments and build a solid research, we used basic concepts from Innovation Research – PINTEC - from 2008 up to 2011, and concepts and theoretical constructs based on the studied literature, which appear on Figure 3, as follows:

Figure 3 – Concepts/Theoretical constructs

Keyword	Concept	Autor/Year
Innovation Process	"A new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software".	Oslo Manual (OCDE, 2005, p. 49)
Innovation Conditions	Entrepreneurship and intellectual capital to lead Brazilian companies and people to propose and participate in the innovation process along with the headquarters.	Bresciani (2001), Consoni (2004), Consoni and Quadros (2006), Ibusiki (2011), Tidd, Bessant & Pavitt (2008), Conceição (2008)
Human Resources	High qualified human resources within in a participative decision making process.	Consoni (2004), Consoni & Quadros (2006), Ibusiki (2011), Conceição (2008)
Open and Closed Innovation	Open innovation: partnerships strategically developed or acquired from other companies, scientific and technological institutes (STI), universities and others related to Research and Development (R&D) activites. Closed Innovation: Improvements developed within the Company´s R&D activities by its own investments.	Chesbrough (2006, 2008)
Relational capital	Interactions developed among individuals from different areas, departments, R&D Centers, STI, internally and externally.	Saxenian (1996), Chesbrough (2008); Maximiano (2009), Gatti Jr (2010)
Local Knowledge	Knowledge applied on local products development, but founded in global structures.	Consoni & Quadros (2006); Ibusiki (2011)
Technological innovation	Products, services and process improvements.	Oslo Manual (OCDE, 2005)
Organizational Innovation	Business model improvement, new markets development.	Oslo Manual (OCDE, 2005)
De-industrialization and re-industrialization	A specific crisis that made automotive plants leave ABC Region in 1980s up to the beginning of 1990´s towards other cities in the countryside. And the local production recovery and growth in 1990s and on.	Conceição (2008), Bonelli & Pessoa (2010), Oreiro & Feijó (2010)

Source: The Authors

The main input from this study is stating the relatively open innovation practiced on the studied subsidiaries. We assumed the open innovation in such industry can be explained by adapting theoretical models from Pavitt's innovation process (1984, apud Santos, 2012) and the triple helix twin from Etzkowitz and Zhou (2006), to reflect on managing local innovation built by the local suppliers or partners,

for the development, design and implementation of locally conceived models in global structures.

3 METHODOLOGY

This is a descriptive research, based on a multiple case study involving three great automakers located at the Great ABC region, specifically in the city of São Bernardo do Campo, and also one supplier. The syndicate representative of the automakers employers was part of the interviewees. As requested, the obtained information was adapted and the interviewee's names were not disclosed. For the analysis effects, those companies are named as Alpha, Beta, Gama and Delta. The interviews transcripts and observations were delivered to the University for scientific proof of data collection.

A case study, single or multiple, can be considered a research guide in which several methods for data collection are used, such as observation, interview and documental analysis (GIL, 2009). This research was conducted accordingly.

During the visits it was possible to observe the workplace for getting knowledge of the organizational chart and some practices of R&D.

For the documentary research, it was analyzed reports issued by official agencies such as Innovation Research (PINTEC), developed by Brazilian Institute for Geography and Economics (IBGE), Organization for Economic Co-operation and Development (OECD), World Economic Report and others. Theoretical review enabled the authors to prepare three different semi structured interview guides: one for the automakers, one for the suppliers and other for the syndicates. The interviews took place from September 2012 up to May 2014.

The interviews were made with representatives of Human Resources, Research & Development, Engineers, Production and Sales in the three automakers in the Great ABC region. And also included three suppliers from the automotive chain, two related syndicates and one consultancy agency specialized in the automotive area, in accordance with the necessity of including internal and external processes as well as agents or contributors from several areas of the involved companies (GIL, 2009). All the interviewees have a long-term of experience in automotive industry and related activities.

The scripts were validated and used as grounds for the interviews, visits and observations made in the field research. Interviews were made with suppliers, automakers, professional societies and associates in a formal request by letter. For the automakers and suppliers, the areas of HR, R&D, Engineers (Product and Production), Production and Sales were involved. The data was analyzed, compared and summarized according to the question category.

4 RESEARCH FINDINGS

The information from the automakers and the consultancy agency were grouped according to a script question. The same thing occurred with the information from the syndicates and the suppliers. The interviews were made with 26 high qualified professionals from the automotive industry, as described below:

- Study case subject: 5 representatives of each automaker company (Engineering, P&D; Human Resources, Sales, Production); Main Supplier: 3 representatives (P&D; Engineering, Focal Point with Industry): 18 participants

- Syndicates: 2 high positioned representatives: one for São Caetano do Sul (Public Relations); one for the Great ABC region (director).
- Suppliers: 2 second line suppliers: 2 representatives for each one (P&D and Production)

4.1 CONSOLIDATED DATA FROM THE INTERVIEWS WITH THE AUTOMAKERS

For this article, we present the information received from interviews with the companies Alpha, Beta, Gama and with a consultancy firm, which were consolidated for the areas of R&D, Engineers, Production, Sales and HR.

The interviews were made with Eugênio Pinheiro Consultancy Agency. Due to a secrecy request by the automakers, answers were adapted and consolidated by category, without altering its content, and summarized as follows in categories:

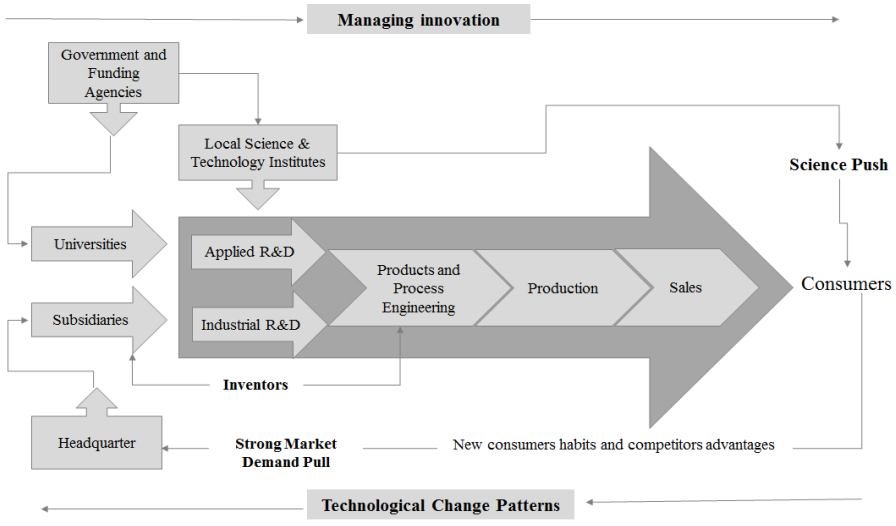
1. Innovative interaction model
   The companies we investigated recognize, based on Pavitt´s model (1984), a greater resemblance to innovation practice for several interactions. But, those companies identified a necessity to reset the model, aiming to include new external agents' category such as: headquarters as a source of innovation and local Science and Technology Institutes; related to subsidiaries as innovation source when innovative project is previously approved by headquarter; and local inventors. Related to internal agents, companies' representatives suggested improving Industrial R&D as well as Innovation Management towards taking better advantage of the innovation, as shown in Fig. 4.
2. Innovation Source
   The answers obtained pointed out a clear diversified group as a potential source of innovation to be exploited such as: Headquarter; local competitor through a collaborative strategy; customers' needs; post-graduating students in Engineering, Marketing and Business Administration Programs; Research Institutes; Engineer Association, local suppliers and Technology & Development Centers.
3. Conditions to Innovation
   The research identified the existence of an entrepreneur attitude led mostly by director, managers, engineers and technicians, who plan and implement knowledge exchange and also stimulate other contributors to participate in decision making process. They also challenge people to propose improvements in products and processes. Besides that, a bulk of innovation developed in the ABC Region has influenced other subsidiaries all over the world. Even those related to the new plants openings in South America.
4. Human Resources
   The searched companies offer financial support to their employees in post-graduated programs when they are aligned with the company´s objectives. They even have an agreement with some first class universities, such as Polytechnic School of Engineering at USP; State University, in Campinas; Aeronautics Technological Institute – ITA, and others; to develop researches in automotive field and to attend the contents in Corporate Universities.
5. Open *versus* Closed Innovation
   The information gathered indicated the Open Innovation Practice whenever related with

incremental type of innovation. Closed Innovation is also practiced aiming to develop bigger and strategic changes. In this case, according to the participants, after all, innovation spills over the productive chain, mostly of them related to the automakers and autoparts firms, such as flex motor, electronic ignition and improvements in processes such as Lean Manufacturing.

6. Social Networks and Relational Capital Development
   Data obtained during the interviews pointed out a great level of relationship with universities and research centers and with some funding agencies such as CNPq and FAPESP, but showed up the difficulties in developing partnership with other Government representative. ANFAVEA leaning on AEA has reached Union´s support to deal with the Government. Through this support some initiatives have succeeded as: Inovar Auto and Inovar Peças Programs; fuel regulation (biodiesel and low-led gasoline); air-bag implementation.
7. Brazilian Subsidiaries Local Knowledge
   Participants develop and acquire specific knowledge from global structures and existent processes merging them with projects and processes ongoing locally aiming to improve local knowledge towards the international level, as expressed in Fig. 4
8. Innovation Management and Technological Changes
   Innovation Management follows headquarters' guidelines and their approval. Anyhow, the subsidiary may develop new products and processes locally in accordance with the local specific knowledge and characteristics regarding adaptation, as seen in Fig. 4.
9. De-industrialization and re-industrializations in ABC Region
   The respondents mentioned that the crisis in automotive industry experienced during de-industrialization process in the 1990s , when two automaker companies closed, taking with them a considerable group of local small and medium-sized suppliers. In this same period, national companies were bought or merged with multinational companies, reorganizing the productive structure in the Region, with straight impacts on the local labor force and, as consequence, on the local economy. It took a long time negociation with the Union, suppliers and employees and the sector kept paralised untill the re-industrialization process what required a large investiment from the headquarter to update production processes, to create Technological Development Centers and to automatize productivity and production control, enlarge plants and to generate job opportunities in the ABC Region.

In order to reflect the local innovation management, based on the interviews, the innovation process models by Pavitt (1984, apud Santos, 2012) and the triple helix twins by Etzkowitz and Zhou (2006) were adapted on the Figure 4 and 5, respectively, as follows:

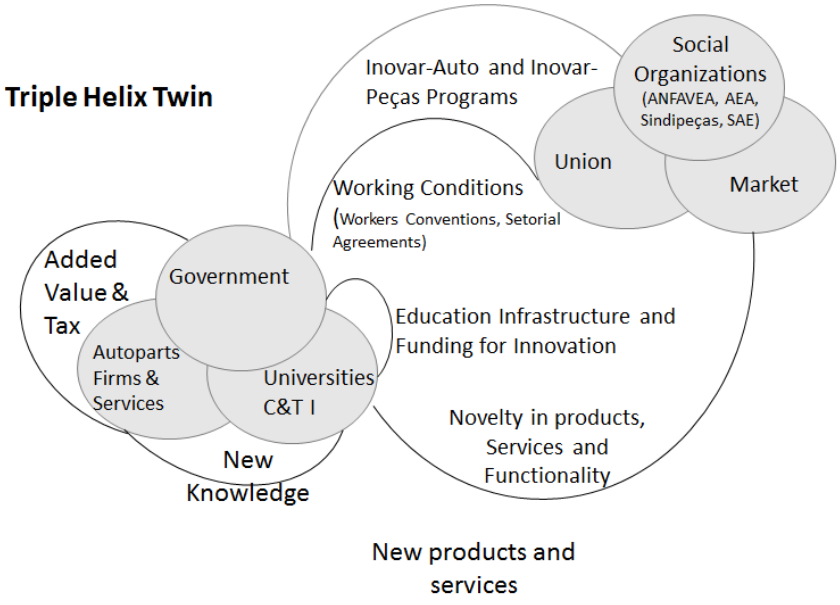
Figure 4: Adaptation of the technological change pattern - local practice on the agent-innovation management



Source: The author, based on Pavitt (1984, apud Santos, 2012).

The adjustments shown on Figure 4 summarize this research contribution on Pavitt's model (1984, apud Santos, 2012), featuring the innovation process followed by the studied companies. For the Brazilian subsidiaries, this model is complete; for the Brazilian suppliers, one must just remove the head office and the confirmation alongside the head office for the model to reflect the innovation process on those companies.

Figure 5 - Triple Helix Twin Applied to the ABC Region Automotive Industry



Source: The Authors.

An interesting fact: almost all interviewees claimed to have great concern with the environment and social responsibilities. They suggested using the triple helix twin system to represent the relationship between the companies, science and technology, research and development in universities and institutes, and society as a whole and the government. The suggestions were discussed and included, being graphically shown on Figure 5.

5 CONCLUSION

The information gathered from the field research through the selected methodology made it possible to answer this research problem, pointing out the innovation process in the automotive production system through the studied companies and production chain. We achieved the general objective of describing the innovation model practiced in the automotive industry in the ABC Region and the relationship between the companies. We also achieved the research specific objectives by identifying locally produced innovation, which embraces the flow of information, learning and mutual benefits, such as model designing and vehicle development, actions that guarantee, as time passses, further developments and the continuity of the supply chain relationship.

The innovation process in the observed companies is made clear by Pavitt's model (1984, apud Santos, 2012) and described with other agents in it, such as the head office, subsidiary, science and technology institutes and inventors as innovation source, in order to describe the innovation process better. Besides that, there is a great market demand due to competition, by more than 50 automakers are shaking the national market, making that competition the biggest source for the need of innovation in the local companies, which align their innovation process with their respective head offices.

Besides that, the triple helix twin model by Etzkowitz and Zhou (2006) calls to reflect on the local innovation process over specific matters by the studied subsidiaries. That innovation process management is characterized by open innovation as incremental innovation, and by closed innovation as strategic and more technological innovation.

The academic contribution made by this research is the description of the innovation process in the studied subsidiaries, and notices a valuable contribution by local management, along with company's contributors, engineers and technicians, who developed great knowledge in the light and commercial vehicles.

That knowledge led to the design, development and implementation of several vehicles from global structures, but with local Technological Development Center's projects. It also led to adapt projects from the head office. There is also some open innovation and coopetition between the main automakers and suppliers for incremental innovation, and closed innovation for strategic and more technological innovation.

The competition generated by over 50 automakers in Brazil is stronger than the influence made by the head offices in the innovation model adopted by the Region, and it has engineers, technicians, managers and local directors that deal and work with the global projects, proposing new ones with backing research, development, design and local implementation.

Therefore, the innovation model spotted in the local automotive chain practice is an adaptation made with contribution from R&D center from the head office, benchmarking with competitors, contributions by other local institutes, contribution by local R&D, local contributors, a discreet contribution by local research institutes, few governmental programs (which are only made to use tax incentives to support some innovation, such as Inovar-Auto and the likely outcome Inovar-Peças) and some regulation by the Federal Government agreed with automakers, suppliers, syndicates and associations, like the mandatory air-bag and low-led gasoline.

The Region's automotive industries also improved on administrative processes and work relations, including investment negotiation, strategic change on the production mix, production system innovation and factory changes, without risking strategic commercial topics.

The Innovation Management on the studied companies is independent on their specific knowledge and is only presented to the head offices for confirmation. In some cases, it's even "exported" to other units in Brazil, South America and the world.

Amongst the studied companies, Alpha, Beta and some suppliers are developing official programs with local universities for research and development through contributors linked to research programs, involving masters and doctorates; other companies support the contributor upon request and also with contributors' international exchange among their company's area, besides amplifying the usage or corporative universities.

Although the local automakers' trend is to adopt global structure when building vehicles, the studied local companies have developed knowledge for local and South American market, and they started developing some local structures for busses frames; and also some local structures were developed from global structures, such as the models Gol, Fox, Ecosport, Celta, Meriva, Zafira, Classic, Onix, Cobalt and Spin.

By developing knowledge, the studied subsidiaries attracted great investments in technology and HR from the head offices, focused on Research and Development Technological Centers in the ABC Region, which started to create vehicles for the world production.

We may also note that the three automakers are administrative and directive headquarters for the country and South America, along with their respective Technological Centers in the Region. They remain managing investments, developments, administrative decisions and technological innovation from their units in the ABC Region.

The automotive industry keeps generating management and technological innovation models, sharing the local subsidiaries' development and research, their knowledge, processes and technology with their suppliers in the production chain. Some innovation processes led to Just in Time, Kaizen, Lean Manufacturing and the Toyota Production System in the automaker's production system – two of them are international benchmark for their corporation.

There is an opportunity to research more deeply the importance of process innovation and its contribution to the innovation products and to strengthen innovative capacities to the company. We hope that this research may help future studies in this field.

We also recommend that future studies amplify the number of studied automakers, suppliers and syndicates in order to be a more representative study of the innovation process practiced by the subsidiaries in the ABC Region; even those that didn't take part in this research, seeking to understand the part this innovation process takes nationally and internationally.

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