Differences in open innovation practices between headquarters and subsidiaries in the automotive industry: The French case

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Abstract: Open Innovation (OI) is a growing trend as a practice to improve the Product Development Process (PDP). It is changing the way companies create new products and technology. The automotive industry is not an exception to that trend. This industry began to implement this concept many years ago but not in a homogeneous way. Now, more than ever, innovation is playing a vital role in this industry due to the technological revolution it is facing, and new innovation tools are needed. This study aims to compare OI practices in the PDP of French companies at their headquarters and at their subsidiaries located in Brazil. It presents multiple case studies based on interviews with experienced professionals from four different companies. Public documents were also used in the analysis of the innovation process in these companies. A literature review of PDP and OI is presented to ground the questions that guided these interviews. This study reveals that, in addition to stronger technology development, headquarters in France have more structured OI practices than subsidiaries in Brazil. Furthermore, in both countries and industries, “Outside-In” OI practices are much more common than “Inside-Out”.

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PUBLIC INTEREST STATEMENT
Open Innovation (OI) is changing the way companies create new products and technology. The automotive industry began to implement this concept many years ago but not in a homogeneous way. Now, more than ever, innovation is playing a vital role in this industry due to the technological revolution it is facing, and new innovation tools are needed. This study aims to compare OI practices in the PDP of French companies at their headquarters and at their subsidiaries located in Brazil. It presents multiple case studies based on interviews with experienced professionals from four different automotive companies. This study reveals that, in addition to stronger technology development, headquarters in France have more structured OI practices than subsidiaries in Brazil. Furthermore, in both countries and industries, “Outside-In” OI practices are much more common than “Inside-Out”.

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**Keywords:** open innovation; product development; automotive industry; innovation management

1. Introduction

The Product Development Process (PDP) can be defined by “the collective of activities, involving almost all the departments of a company, that have the purpose of transforming market needs into economically viable products or services” (Kaminski, 2000). As an organizational process, it can be divided into a series of activities that can be formalized, measured and optimized, and as such, it has been evolving since its conception during the early 1960s (Evans, 1959) into a model unifying PDP with external knowledge and technology management (Liyanage, Greenfield, & Don, 1999). Hence, the internal infrastructure of a company has an influence on innovation in addition to external knowledge sources, managing globalized research networks, partnerships, and strategic alliances. This is the link between PDP and Open Innovation (OI).

Open Innovation was defined by Chesbrough, Van Haverbeke and West (2006) as “the purposive use of inflows and outflows of knowledge to accelerate innovation in one’s own market, and expand the use of internal knowledge in external markets, respectively”. Although this term was first used in the current century, this concept was implemented in companies much earlier. Freeman (1991), in a review paper from the early 1990s, provided evidence of the use of formal and informal Research and Development (R&D) networks and other types of collaborative arrangements since before World War II. However, the OI practices lacked formal structure. The establishment of the term Open Innovation forced the structuring of the process. According to the OECD (2008), the novelty of the open innovation approach lies in the systematic integration of such practices into firm’s strategy, as well as in the exploitation of the inside-out process by firms.

The automotive sector is facing a phase of major changes in comparison with the last decades (FAPESP, 2018). It used to be an industry of incremental technological development; however, the industry faces a paradigm shift due to the growing demand for revolutionary products. Digital transformation, the creation of intelligent and autonomous vehicles and the emergence of innovative solutions for urban mobility are some of the factors that explain this changes. Furthermore, the ongoing revolutions in industrial production have affected the automotive industry. As stated by Pardi and Calabrese (2018), there are several radical transformations that are expected to disrupt the automotive industry in the very near future, such as the increase of EV (electric vehicles) production, the new mobility revolution, and the Industry 4.0 era. This new market reality requires a transformation in the way automotive companies create their products. In other words, the process of innovating need to be faster and more efficient than ever. Open innovation can be an effective tool in this scenario.

Recent research has demonstrated that collaborative innovations are more likely to have technical significance and commercialization success (Walsh, Lee, & Nagaoka, 2016). Companies, however, are adopting OI practices in different ways and scales. According to Chesbrough (2003a), the “optimum” level of openness depends, for instance, on variables such as technological intensity, value chain position, and product development average lead time. OI practices vary from industry to industry and from company to company. This study goes further by investigating how OI practices vary within the same company by comparing the headquarters and practices of its overseas subsidiaries.

Automotive makers with plant operations in Brazil but headquartered in France were chosen for the purpose of this research because, besides being similar in scale, their automotive industry plays an important role within the economy of both countries. According to ANFAVEA (2017), the
automotive sector, including the automakers and auto parts companies, as well as their suppliers, represents 22% of Brazil’s industrial GDP. In France, this percentage is also a high number—as reported by the Portal of Economy, Finance, Actions and Public Accounts of the French government (Le Portail de l’Economie, des Finances, de l’Action et des Comptes Publics, 2017). The automotive sector represents 16% of the income of French manufacturing industry. Therefore, it is clear that this industry has a significant impact on the development of these countries, not only economically but also socially and is mainly concentrated on two big players—PSA and Renault and their suppliers. PSA and Renault are the main French automakers, they are classified by Tsukada, Telles-Pascoal, Delamaro, Muzio-Candido, and Ibusuki (2017) as transnational firms due to their high levels of global integration and because they usually have strong local answer in respect to product development. They have development centers spread across the world, including Brazil where their subsidiaries are not entirely focused on production, but also promotes product development. Furthermore, comparing OI practices between a developed country and a developing country can provide interesting results, considering the intensity of innovation is usually different in these two realities.

The purpose of this study is to analyze how the Open Innovation process occurs in companies, by investigating its motivations, risks, stage of maturity and main actors. The multiple case study covers two automakers and two suppliers, all French companies, at their headquarters and at their subsidiaries in Brazil. The objective is to analyze how these factors vary by country and industry segment in order to measure the influence of the company culture and the impact of external factors in the construction of PDP in the automotive industry. This paper is structured into seven main topics. Following this introduction, a literature review on PDP and OI is discussed. Then, the methodology of research is presented and right after Brazilian and French industry scenarios are analyzed and compared. The questionnaire used in the multiple case study is explained before the presentation of the results obtained. Finally, the paper is concluded with an analysis on the study inferences.

2. Literature review
Below follows a brief literature review of the concepts of PDP and OI initially presented in the introduction.

2.1. Product development process
The Product Development Process (PDP), also known as New Product Development (NPD), is defined by Rozenfeld et al. (2006) as a set of activities through which one seeks, from the market needs and technological possibilities and constraints, and considering the competitive landscape and product strategies of the company, to reach technical specifications for the design of a product and its production process, so manufacturing can produce it. Once it reaches an organizational process, these activities should be formalized and measured in order to optimize the development of new products and, consequently, respond to the market demand.

PDP must be market-oriented. It is directly linked to technology management and it needs to respect some criteria for costs and quality. Therefore, this process is composed of sets of activities involving numerous departments of any given company and even involving a network that goes beyond the firm’s boundaries. Thus, interaction is paramount to the success of the process. Through interactions, design problems are solved, difficulties are converted into solutions and design incompatibilities are fixed (Martinez Leon, Farris, & Letens, 2013).

There are different approaches to explain how this set of activities should be connected. Wynn and Clarkson (2018) present an extensive in-depth literature review on PDP, classifying and relating the different existent approaches. One segmentation proposed by the authors is the division by type of model, grouping together the approaches that have similar overall purpose. Four model types were identified: procedural models, analytical models, abstract models, and management science/operations research models. In this study, the literature review
encompasses the PDP approaches that can be classified as procedural models, namely models that convey best practices intended to guide real-world situations. Evans (1959) presented a design spiral concept. By this concept, the process, and therefore the product, covers the spiral passing through different functions in each spin until the detailed and final design is obtained. Asimow (1962) considered the PDP as a more linear process that begins with the identification of a need and passes through the design phases. This approach states that along the development process of a product the entire consumption cycle should be considered, which includes four phases: production, distribution, consumption, and recovery.

Cooper (1990) divides the PDP process into very well-defined stages into a linear process and suggested that each stage could—and should—be monitored and controlled. This approach, which is called stage gate system, defends the establishment of “gates” at the end of each process phase to conduct quality assessment reviews on the results obtained and also define actions and next steps. The establishment of a QA process is crucial for PDP management, similar to most, if not all, organizational processes.

Another approach for PDP is what Suh (2001) called the axiomatic design. This concept divides the design into four different domains: the customer’s domain, the functional domain, the physical domain, and the process domain. Weber (2009) focusses on the customer’s domain, which presents a customer-oriented point of view on the product development process, with a particular focus on the automotive industry. This customer-oriented approach is also mentioned in (Clark & Fujimoto, 1991), linking PDP to a simulation of consumer experience.

Clark and Wheelwright (1993) characterized PDP as a linear process represented by the shape of a funnel since the quantity of inputs is larger than the number of outputs. This idea means that the process should filter and recombine the initial ideas until the final product is designed. Clark and Wheelwright (1993) also stated that the PDP should include steps to review past activities and, if necessary, make changes to the project. This concept is similar to the stage gate system from Cooper (1990) as his theory also implemented checking points to analyze the evolution of tasks and even decide if the process can advance to the next phase.

Many other approaches, with different segmentations, can be found in literature, and numerous extensive literature reviews have been conducted on the subject. For instance, Krishnan and Ulrich (2001) analyzed the product development process focusing on three academic fields: marketing, operations management, and engineering design. In turn, Canuto da Silva and Kaminski (2017) present an analysis of PDP frameworks specifically for the automotive sector. Table 1 summarizes the PDP approaches presented in this section and a few more. It encompasses all the PDP concepts that served as the basis for the questionnaire used in this multiple case study and in the analysis of the companies’ public reports. The references highlighted in gray cover the product development process for the automotive industry specifically. The references are presented in chronological order, considering the year of the first edition in the case of the reference being a book or a technical standard.

2.2. Open innovation
Product innovation is the implementation or commercialization of a good or service with improved performance (OECD; Statistical Office of The European Communities, 2005). Analogously, process innovation is basically the adoption of improved production or logistic methods. The link between a company’s or a country’s knowledge and its economic success is increasingly strong. The Oslo Manual (OECD; Statistical Office of The European Communities, 2005) names this trend as “the knowledge-based economy”, which describes the fact that the way companies raise and manage ideas in the innovation process is a crucial factor to its strategy.

One important dimension to analyze in the innovation process of a company is its level of openness. Chesbrough (2003b) was the first author who established a definition for Open Innovation, by which he compared the principles of a closed innovation process to an open
innovation process. As stated by the author, Closed Innovation is based on ideas such as “smart people in our field work for us” to profit from R&D, we must discover it, develop it and ship it ourselves and if we create the most and the best ideas in the industry, we will win (Chesbrough, 2003b). In contrast, a company that practices OI has principles such as we need to work with smart people inside and outside our company, external R&D can create significant value; internal R&D is needed to claim some portion of that value and if we make the best use of internal and external ideas, we will win (Chesbrough, 2003b).

Although Chesbrough (2003b) first coined the term Open Innovation, it was already practiced by companies long before. In Chesbrough's work, he stated that the automotive industry, along with other industries such as biotechnology, computers and health care was already in transition between the two paradigms of openness by that time. Moreover, Freeman (1991) showed evidences of collaboration in innovative networks since the 1960s. However, practicing OI is different from having it as an institutionalized process. The coining of the term revealed the necessity of structuring OI practices as an important part of the company's strategy. The biggest challenge is usually how to do this structuring since changing the innovation's openness level is a complex process. As stated by Chiaroni, Chiesa, and Frattini (2011), the implementation of Open Innovation includes three stages (unfreezing, moving and institutionalizing) and involves four dimensions in

| Main author(s) and year | Title | PDP approach |
|------------------------|-------|--------------|
| Evans (1959)           | Basic design concepts | Design spiral |
| Asimow (1962)          | Introduction to design | Production and consumption cycle |
| (VDI 2221 (1986)) (1986) | A systematic approach to the design of technical systems | Guidelines for PDP phases and results |
| Cooper (1990)          | State-gate systems: a new tool for managing | Stage gate systems |
| Clark and Fujimoto (1991) | Product development performance: strategy, organization and management in the world auto industry | Product development as a simulation of consumer experience and an information asset map of the product development |
| Dieter and Schmidt (2009) (1991) | Engineering design | The product development process in the point of view of a mechanical engineer |
| Clark and Wheelwright (1993) | Managing new product and process development | Development of funnel concept |
| Ulrich and Eppinger (2012) (2000) | Product design and development | Generic model with six phases |
| Cooper, Edgett, and Kleinschmidt (2001) | Portfolio management for new products | Step-by-step framework to manage product portfolios |
| Weber (2009)           | Automotive development process | Processes for successful customer-oriented vehicle development |
| Canuto da Silva and Kaminski (2015) | Selection of virtual and physical prototypes in the product development process | Guidelines to select virtual and physical prototypes in PDP; Case study on automotive sector |
| Canuto da Silva and Kaminski (2017) | Propose of framework to managing the automotive product development process | Proposes a PDP framework for the automotive sector |
| Baraldi and Kaminski (2018) | Reference model for the implementation of new assembly processes in the automotive sector | Guidelines for process development of new assembly processes |

1 Year of release of the reference's first edition.
Source: adapted from (Canuto da Silva & Kaminski, 2017) and (Baraldi & Kaminski, 2018)
companies (networks, organizational structures, evaluation processes, and knowledge management systems). Institutionalizing Open Innovation is the challenge that most companies presently face.

Open Innovation can be divided into three different core processes: outside-in process, inside-out process and coupled process (Enkel, Gassmann, & Chesbrough, 2009). The objective of outside-in processes is to improve the company’s knowledge by the outsourcing of external ideas. The inside-out process “refers to earning profits by bringing ideas to market, selling IP, and multiplying technology by transferring ideas to the outside environment” (Enkel et al., 2009). The coupled process involves co-creation through partnerships, alliances, and joint ventures.

Armellini, Kaminski, and Beaudry (2014) proposed a conceptual model, as demonstrated in Figure 1, for an open product development process, identifying the assets required and the ones generated in each R&D activity. Still, according to these authors, “the combination of such assets are the ideas, here defined as creative impulses, that allow the combination of existing data, information, knowledge and technologies into new knowledge, technologies, products and/or processes”. Since the coupled model allows for a good analysis of Open Innovation practices in the Product Development Process, it was partially used to build the questionnaire which guided the interviews in this study.

Table 2 introduces different approaches for Open Innovation in the literature. The references are presented in chronological order and the ones that discuss the subject in the automotive industry are highlighted in gray. The table’s information shows the evolution of the OI concept, even research conducted by the same author, over time. These approaches were also used to base the questions that guided the multiple case study interviews and to analyze its answers.

3. Methodology
This study is based on interviews with experienced employees from French automotive companies who work in product development. Public reports released by these companies were also analyzed as these documents provided some additional insights about the companies’ PDPs. The interviews were guided by a questionnaire that consisted of open questions conducted in a verbal interview to stimulate a personal and extensive conversation. Therefore, the interviews with open-ended questions allowed the interviewee to not only discuss the innovation process at his/her company but also comment in greater detail about it, such as offering reasons for and/or consequences of each practice. This study and its aim fall into the classification of exploratory research. This type of

Figure 1. OI in PDP conceptual model.
Source: (Armellini et al., 2014)
## Table 2. OI approaches

| Main author(s) and year | Title | PDP approach |
|-------------------------|-------|--------------|
| (Freeman, 1991)         | Networks of innovators: A synthesis of research issues | External information networks and collaboration with users were already highly important on the companies’ PDP in the 1960s. In the 1980s industry and regional networks, as well as government-sponsored innovative activities emerged. |
| (Chesbrough, 2003b)     | Open innovation: the new imperative for creating and profiting from technology | Innovation is invention implemented and taken to market. First definition of Open Innovation: the use of external as well as internal sources of knowledge by firms to create value. The automotive industry is in transition from a closed to an open innovation process. |
| (Chesbrough, van Haverbeke, & West, 2006) | Open Innovation: researching a new paradigm | OI is defined by the exploitation of guided inflow and outflow of knowledge with two objectives: optimize the company innovation process and expand the market for the assets generated by this process. |
| (OECD, 2008)            | Open innovation in global networks | Open Innovation is not a new practice, but the balance between internal and external sources of innovation. It’s being improved in firms. More than practicing it, open innovation activities are being institutionalized as part of the innovative process. |
| (Dahlander & Gann, 2010) | How open is innovation? | The paper classifies OI practices into four forms: acquiring, sourcing, selling and revealing. These forms are conceptualized by analyzing OI in two different dimensions: inbound/outbound and pecuniary/non-pecuniary. |
| (Chioroni et al., 2011) | The Open Innovation journey: How firms dynamically implement the emerging innovation management paradigm | Open Innovation engages four dimensions: networks, organizational structures, evaluation processes and knowledge management systems. Since most companies already practices OI, their challenge is to institutionalize these practices in the innovation process. |
| (Burger-Helmchen, Pénin, Gütard, Schenk, & Dintrich, 2013) | L’innovationouverte: définition, pratiques et perspectives | In the current global scenario of intense technological change, innovative projects must not be developed from scratch to end by a single company. By practicing Open Innovation, their execution includes a wide range of heterogeneous actors. OI stimulates the division of tasks and, therefore, specialization in intensive knowledge activities. |
| Main author(s) and year | Title                                                                 | PDP approach                                                                 |
|------------------------|----------------------------------------------------------------------|------------------------------------------------------------------------------|
| Chesbrough, van Haverbeke, & West, 2014 | New frontiers in Open Innovation                                         | OI is the managed flow of knowledge through the company boundary, using pecuniary and non-pecuniary forms aligned with the firm's business model. |
| Armellini, Beaudry, & Kaminski, 2016  | Open within a box: an analysis of open innovation patterns within Canadian aerospace companies | The paper discusses Open Innovation practices in the Canadian aerospace industry. In this cluster, there is external sourcing and co-development between companies, universities, and the government, but this collaboration is limited within the aerospace industry. |
| Chesbrough, 2017       | The future of Open Innovation                                           | OI is the opposite of the traditional vertical integration model. For the OI paradigm, R&D is seen as an open system. External ideas can be used in PDP and internal ideas can be taken to market through external channels. |
| Marin & Kaminski, 2018 | Analyzing Open Innovation integration to Product Development Process within the Brazilian automotive industry | The paper analyses OI in the Brazilian automotive industry. Open innovation is practiced in the studied companies, but not widely due to the fact that they are subsidiaries. Inbound practices are more common than outbound ones. |

Source: Author
research aims to provide greater familiarity with the problem, with the purpose of making it more explicit or constructing hypotheses (Gil, 2002). It can be said that this type of research has as its main objective the improvement of ideas.

Although exploratory research planning is very flexible, in most cases it takes the form of bibliographic research or case study analysis (Gil, 2002). The latter is how this study was conducted, in its technical sense. The case study is an empirical work that investigates a given phenomenon within a real, contemporary context through the in-depth analysis of one or a few cases analyzed (Miguel et al., 2011), which is a good definition of the objective of this research. On an article about the study of Open Innovation, Huizingh (2011) quoted “Case study research increases our understanding of how things work and enables us to identify important phenomena”. The author also claimed that case studies be followed by quantitative studies involving larger samples. This analysis allows for a wide and detailed explanation about the phenomenon, sometimes even leading to the creation of a theory. This ample knowledge is practically impossible to conquer through other technical procedures (Gil, 2002).

As the research involves not only one but four companies, comparing their headquarters to one of their subsidiaries, it is structured as a multiple case study. It is important to mention that bibliographic research serves as the backbone of this study. PDP and OI concepts serve as the framework for the questions asked to interviewees, the analysis of their answers and the analysis of the study’s results.

4. Multiple case study
The multiple case study consisted of interviews based on a questionnaire and on public information analysis. Ten experienced professionals in the automotive industry were interviewed. They work for four different automotive French companies. One half of the interviewees works in the French headquarters and the other half works in a subsidiary in Brazil.

4.1. The companies
Aiming to understand the differences and similarities between France and Brazil, it is necessary to analyze several key data points. France has a smaller population (64.8 million people) than Brazil (207.7 million) (International Monetary Fund [IMF], 2017a), so its internal market is smaller. However, the south American country is less developed than the European one. The Human Development Index (HDI), a statistical composite index of life expectancy, education, and per capita income indicators, proves this point. France takes the 24th position on the HDI global ranking, while Brazil occupies the 79th position (UNDP, 2018a). The Gross Domestic Product (GDP) per capita in France is USD$39,930 per year, approximately four times larger than the Brazilian GDP (IMF, 2017c). Therefore, the average purchasing power of the population is stronger in France than that of Brazil. The data from the two countries mentioned in this paragraph are presented in Table 3.

| Country | Total Population (million) | GDP (USD$ trillion) | GDP per capita (USD $) | HDI | Position on HDI global rank |
|---------|---------------------------|---------------------|------------------------|-----|-----------------------------|
| France  | 64.8                      | 2.59                | 39,930                 | 0.901 | 24                          |
| Brazil  | 207.7                     | 2.06                | 9,900                  | 0.759 | 79                          |

1 (IMF, 2017a).
2 (IMF, 2017b).
3 (IMF, 2017c).
4 (UNDP, 2018a).
Source: Data obtained from public documents specified on the footnote and consolidated by the author.
France and Brazil have a similar level of industrialization. Therefore, considering the fact that the GDP of both countries are similar, their industry GDP are also similar. Moreover, the automotive industry is equally relevant in the economy of both countries, as evidenced by vehicle production data: the data is similar in both nations (exemplified by Table 4). In both countries, the automotive industry plays a highly important role in economic and social aspects. The revenue of this sector is a relevant part of the country’s industrial GDP: 22% in Brazil (ANFAVEA, 2017) and 16% in France (Le Portail de l’Economie, des Finances, de l’Action et des Comptes Publics, 2017), as already stated in section 1. Consequentially, this industry has a high social impact both in France and Brazil because of the amount of employment generated directly and indirectly.

The number of habitants per vehicle is an important indicator to measure the potential growth of the automotive industry in the region of question. For example, in France, this indicator is already low, 1.7 habitants per vehicle (ANFAVEA, 2017), which means that the internal market is close to being saturated. In contrast, in Brazil, there are 4.8 habitants per vehicle (ANFAVEA, 2018), which in principle indicates a potential for increase in vehicles sales in the country. However, to exploit this potential, it is necessary that the purchasing power of a significant segment of the population increases.

Another important analysis is how much of development these countries execute. In general, French companies invest relatively more in R&D than firms in Brazil. The percentage of the country GDP spent on R&D is 2.2% in France (UNDP, 2018b) and 1.2% in Brazil (UNDP, 2018c). This data can be an indicator that product development is stronger in France. An additional evidence is that in the European country the labor force is more skilled, as shown in Table 5. This hypothesis will be evaluated through the multiple case study.

The four French companies involved in the multiple case study (PSA, Renault, Faurecia, and Valeo) have both development centers and production plants in Brazil. Tsukada et al. (2017) classify PSA and Renault as transnational companies because they have numerous R&D centers worldwide and they are strongly integrated, globally, and have an intense local response. This allows the firms to have geographically dispersed R&D in an efficient way since the development centers are independent and specialized.

### Table 4. Industry activity data

| Country | % of GDP stemming from industry activity in 2017 | Industry GDP in 2017 (USD$ million) | Vehicles production in 2017 (million) | Habitant per vehicle in 2015 |
|---------|-----------------------------------------------|-----------------------------------|------------------------------------|-----------------------------|
| France  | 20%                                           | 520,600                           | 2,227                              | 1.7                         |
| Brazil  | 21%                                           | 432,600                           | 2,699                              | 4.8                         |

1 (CIA, 2018).  
2 (ANFAVEA, 2018).  
Source: Data obtained from public documents specified on the footnote and consolidated by the author

### Table 5. Education and R&D data from year 2017

| Country | Skilled labor force (% of labor force) | R&D expenditure (% of GDP) |
|---------|--------------------------------------|-----------------------------|
| France  | 82.6                                 | 2.2                         |
| Brazil  | 62.0                                 | 1.2                         |

1 (UNDP, 2018b).  
2 (UNDP, 2018c).  
Source: Data obtained from public documents specified on the footnote and consolidated by the author
Together, they represent an annual global revenue of €162,750 million and they have 614,000 employees worldwide. Two of them, PSA and Renault are automakers and the other two, Valeo and Faurecia, are automotive suppliers. Specific information about each company is presented in Table 6.

In Brazil, the automotive companies are commonly classified according to the year they started their operation in the country. The first comers are the firms which installed a plant during the 1950s or the 1960s, when public policies led to an intense industrialization process of the nation. In the 1990s the economic liberalization brought other automotive companies to Brazil, the called newcomers. The latecomers are those firms which were installed in Brazil in the late 2000s. All the companies analyzed in this study are classified as newcomers. According to Marin and Kaminski (2018), regarding Open Innovation, the first comers are more advanced in the practices’ implementation, but the newcomers’ innovative process has had a stronger evolution in the recent years.

As previously mentioned, the automotive industry is facing a technological revolution. It is possible to infer from their annual reports that the four French companies in question are already reacting to this challenge, and their actions are completely linked to the production development process and, of course, innovation. Three main trends for the future of automobile are identified: electrification, connectivity, and autonomous vehicles. In their book of results for 2017 (PSA Groupe, 2018b), PSA claims that these three functionalities form their core technology strategy. According to Valeo (Valeo Siemens Eautomotive Technology, 2018), these three technological revolutions are happening because of regulatory pressure and strong demand for new technology. Furthermore, the development of these innovations aims to produce greener vehicles, improve road safety and enhance user comfort.

Some plans or predictions of the French companies quantify the three megatrends taking place in the automotive market. For instance, Faurecia (2018) states that “electrification of the powertrain is an undisputed trend and hybrid vehicles could represent over 30% of the market by 2025”. In turn, Groupe Renault (2018) affirms that the company is targeting 100% connected vehicles in their key markets by 2022, and also the launch of 15 autonomous cars. PSA Groupe (2018b) predicts that by 2025 all their brands vehicles (more than 40 models) will be electrified.

| Company | Position on value chain | Number of global direct employees | Annual global revenue (€ million) |
|---------|-------------------------|-----------------------------------|----------------------------------|
| PSA²    | Automaker               | 212,000²                         | 65,200³                         |
| Renault | Automaker               | 181,344⁴                         | 58,770⁴                         |
| Valeo   | Supplier                | 111,600⁵                         | 18,600⁵                         |
| Faurecia| Supplier                | 109,275⁵                         | 20,180⁶                         |

1 Once the company Faurecia takes part on PSA Group, the data on the group includes data from Faurecia among with the other companies that compose the conglomerate.
2 (PSA Groupe, 2018a).
3 (PSA Groupe, 2018b).
4 (Groupe Renault, 2018).
5 (Valeo Siemens Eautomotive Technology, 2018).
6 (FAURECIA, 2018).

Source: Data obtained from public documents specified on the footnote and consolidated by the author.
It is evident that the faster and more intensive development of new technologies manifests itself in higher spending on R&D. The analysis of the financial results from PSA, Renault, Valeo, and Faurecia prove this point. The revenue percentage spent on innovation is increasing. In 2017, Valeo increased the number of employees focused on R&D by 39% as compared to 2016 (Valeo Siemens Eautomotive Technology, 2018). Following the same trend, in 2017 Faurecia invested 26% more in R&D than in 2016, while its sales increased in a lower level (15.4%) (FAURECIA, 2018). Consequently, the innovation process is even more strategic and important for automotive firms. Moreover, open innovation is a possible solution to optimize these higher expenditures on technology development.

4.2. The questionnaire

The questionnaire aimed to obtain the information needed to characterize the product development process in the company and the influence of open innovation practices on it. The questions were divided in six sections, named from A to F and included in the Appendix. Before the interview, the concept of OI was explained to the interviewees in order to guarantee an alignment of ideas.

Section A encompasses questions about the PDP, the innovation process and the importance of innovation on the company's strategy. It also includes the discussion whether the unit practices open innovation or not, and in what level of maturity. Section B covers the advantages, disadvantages, and risks of open innovation under the company's perspective. It also questions if OI takes part on the firm culture and if employees are encouraged to implement it on their daily work. On section C, it is discussed how PDP has changed in the last 3 years, how the innovation process has evolved and how high is the influence of OI on the new products' development. Section D covers the company satisfaction level with the results brought by open innovation practices. In turn, section E embraces questions about the actors of these processes, such as who the company's main partners in the innovation process are and why these partnerships are important. Finally, on section F one question about the future of urban mobility is asked: "on the interviewee opinion, in 2030 how much of the automotive companies' market share will be represented by completely electric vehicles and by hybrid ones. Particularly in this section, the interviewee is encouraged to give his/her own opinion instead of speaking on behalf of the firm he/she works for. This question has as only objective to perceive trends on the automotive sector when it comes to energy source.

4.3. The interviewees

For each company, at least one employee of the headquarter and one employee of the subsidiary in Brazil were questioned. Aiming to assure a high quality and reliability of the answers, the interviewees were chosen according to their position and their experience. All the 10 professionals are engineer and work directly with product development process in their respective company. Furthermore, they have on average 13.4 years of experience on the automotive industry.

The identity of the interviewees is confidential, but Table 7 presents relevant informational about each one. It can be inferred from these data that the automotive professionals involved in this study have a high position on their firm. Therefore, they have a strong understanding of the product development process and of innovation practices and, thus, they are able to properly answer the questionnaire. The information is disposed in the chronological order that the interviews were done, the order is not related to the companies' order presented before.

5. Results

Each section of the questionnaire generated interesting results and relevant comparisons between the two countries and the two industry segments (automakers and automotive suppliers). Therefore, the analysis obtained from the multiple case study are presented by section of the questionnaire. The analysis gathers answers from the interviewees and relevant insights obtained in public documents.
5.1. Section a – PDP, innovation and OI practices

In France, product development is an activity much more important to the automotive companies than in their subsidiaries in Brazil. In the headquarter country, the R&D centers are highly important to the company’s strategy, there is a heavy investment in innovation and new products and technology are usually developed from scratch to the commercialization. Otherwise, in the automotive companies in Brazil, PDP is focused mainly in adapting the products developed abroad to the Brazilian market and local regulation.

All the collaborators in France recognize OI practices in their work environment, as well as the automakers’ employees in Brazil. The maturity stage in Open Innovation in these cases are seen as “in development”, which means there are large-scale internal learning and promotion, but there are heterogeneous practices and convictions. A French collaborator quoted “In the past, technological development in the automotive industry was confidential, but in the new scenario of high competitiveness and demand for breakthrough products, open innovation is not an option for automotive companies, it is a must”. A Brazilian professional claimed that all automakers involve external knowledge in the PDP and he said that “it wouldn’t be possible for the company to launch a subsidiary in Brazil without OI practices, because it doesn’t have the resources necessary to develop the products by itself”.

On the other hand, it was revealed from the interviews that the automotive suppliers in Brazil do not practice Open Innovation because product development is little or not relevant to the local subsidiary. One of the professionals interviewed explained that there is indeed some product development in the Brazilian subsidiary, but it is spare, and it has been reduced since Brazilian economic crisis begun. Therefore, “the development is restricted to an entirely internal process”, he quoted. By analyzing public documents, there are evidences of this difference between automotive suppliers and automakers in Brazil concerning local development. For instance, automakers industry’s trade balance in Brazil was positive in 2017, while the trade balance for automotive suppliers was negative (ANFAVEA, 2018).

Collaborators from both suppliers’ subsidiaries in Brazil cited two main reasons for the minimal local product development. The first one is related to the Brazilian internal market, which has a demand for less advanced technology than in developed countries, mainly due to the lower purchase power of Brazilians. The second one is concerned with local government, which offers less incentives for technology development and applies high taxes on the automotive products.

| Interviewee ID | Position                                      | Years of professional experience in the automotive industry |
|---------------|-----------------------------------------------|-----------------------------------------------------------|
| Interviewee 1  | Product manager                               | 3                                                        |
| Interviewee 2  | General manager                               | 20                                                       |
| Interviewee 3  | Simulation expert and team leader             | 19                                                       |
| Interviewee 4  | Project manager                               | 4                                                        |
| Interviewee 5  | Engineering director                          | 22                                                       |
| Interviewee 6  | Product manager                               | 12                                                       |
| Interviewee 7  | Chief engineer                                | 16                                                       |
| Interviewee 8  | Engineering analyst                           | 10                                                       |
| Interviewee 9  | Acquisition manager—New business development  | 18                                                       |
| Interviewee 10 | R&D Manager                                   | 10                                                       |

Source: Author

Table 7. Information about the interviewees

Martins & Kaminski, Cogent Engineering (2019), 6: 1684806
https://doi.org/10.1080/23311916.2019.1684806
One of the interviewees quoted, “In general Brazilians don’t have much money, taxes are high and the productivity is low. Consequently, in Brazil people buy cars that carry technology with 20 years of delay comparing to European market”.

These results lead to the conclusion that Brazil is less attractive to the implementation of automotive product development than France. Aiming to overturn this situation, Brazilian government has launched an incentive programs for this sector called Inovar-Auto. This program, for instance, consisted mainly of tax reductions for automotive companies tied to objectives such as increasing investments in R&D, engineering and collaborator’s training that existed between 2013 and 2017 (MDIC, 2012). In 2018, a new government program was created, called Rota 2030—Mobility and Logistics (Diário Oficial da UNIÃO, 2018), with the same purpose of the previous one but adding environmental sustainability objectives, by implementing regulations regarding energetic efficiency. These initiatives do have an impact on the local technology development, once “government support has a strong impact on shaping both internal and external collaboration” (Jugend et al., 2018). However, it’s not enough to nullify the high cost of running an R&D center in Brazil.

An interesting fact observed is the non-awareness of the term Open Innovation even 15 years after its coinining. The majority of professionals interviewed claimed not knowing what OI is, but after explaining its concept, they instantly recognized some Open Innovation practices in their work.

5.2. Section b – advantages, disadvantages, and risks
Even though the questions were open, which means the interviewees were not induced to the answers, all the professionals mentioned basically the same advantages, disadvantages, and risks of developing technology externally. The advantages named are the requirement of a lower investment and of less human capital and a shorter time to conclude the project, if compared to an internal technology development. The necessity of fewer resources enables the creation of products and technology at the speed the market demands, which, by the way, is getting faster and faster.

The main aspect of OI pointed as a disadvantage is the product development not being totally under the control of the company. Consequently, the project management is tougher and ensuring the product quality is challenging. There is also an issue involving the project’s confidentiality, which is seen as the stronger risk of external development. The Intellectual Property (IP) is still important for automotive companies for two reasons: it provides competitive advantage to firms and it is one of the indicators used to define a company’s value. This finding on the importance of IP is consistent with a study on the implementation of OI in large multinational companies (Mortara & Minshall, 2011) which states that “firms may reconsider originally open and flexible attitudes in favor of a more controlling approach to IP”.

5.3. Section c – evolution of PDP and innovation practices on the last three years and OI influence on it
For the headquarters in France, the PDP has changed little on the last 3 years. The process is the same, the only change is on the project’s timescale: the product development is a faster process nowadays. In the subsidiaries in Brazil, product development has neither changed a lot. However, a stronger independence from the headquarter is a trend in the automakers, which allows a higher level of local development.

The practice of OI has been intensified in both countries since 2015. Concerning partnerships with suppliers and competitors, it has always been present in automotive companies, thus no change can be observed. However, partnerships with universities became more common. An interesting novelty is the approach of French automotive companies to startups. An employee from one of the French automaker’s headquarter stated that “on the last three years, the major change in the innovative process was the emergence and growth of partnerships with startups, which allows the development of projects in a more agile way”. This trend can also be observed in
the annual reports from the four companies. For example, in its 2017 Registration Document, Faurecia (2018) recognized the need to develop an open innovation ecosystem and one of their recent responses to this demand was accelerating the investment in startups. Similarly, “Valeo is expanding its own start-up and open innovation ecosystem by investing in venture capital funds” (Valeo Siemens Eautomotive Technology, 2018).

5.4. Section d – companies’ satisfaction brought by OI practices
In general, the professionals interviewed didn’t have much information about the results obtained from OI practices because either this data was restricted to the top management of the firm or the result brought by open innovative process was not analyzed separately from closed innovative process. Therefore, it is not possible to evaluate the satisfaction of automotive companies with Open Innovation, but there are important insights that can be inferred from the answers. All the companies involved in the multiple case study have at least one out of two problems. The first one is the lack of internal communication about the firm’s results, which is an important practice to engage collaborators to feel part of the company and, consequently, feel motivated to work for its success. The second issue is concerning the evaluation of indicators. If the company does not collect and analyze data on the results brought by a new practice, such as Open Innovation, it won’t have solid evidence to take a future decision on how much the firm should invest in this practice.

5.5. Section e – actors and method
The automakers, both in the Brazilian subsidiary and headquartered in France, cited suppliers and universities as their key network of knowledge exchange. However, partnerships with universities is a practice more structured in France than in Brazil. The automotive suppliers in France also named, besides universities and their suppliers, their clients as key partners as expected, once their clients are the automakers.

Collaborators from the automakers’ and suppliers’ headquarters in France also named startups as strategic partners, although it is a recent trend, as described in section 6.3.

It was quite mentioned in the interviews the networking of knowledge exchange between the different offices of the company around the world, in a very structured and institutionalized way. However, as this is a practice does not overcome the boundary of the company, it does not constitute Open Innovation.

Collaborators mentioned many outside-in practices, such as buying technology from a startup or even acquiring a startup and financing academic researches, and some few coupled process such as partnerships with clients to develop products in cooperation. However, no inside-out process was cited. This finding is consistent with previous studies on this subject. Marin and Kaminski (2018) presented a study on Open Innovation in the automotive industry in France and Brazil and one of the article’s conclusions was that “inbound practices were slightly more present than outbound practices, with a strong presence of the supplier in the design process”.

Although common, the predominance of outside-in practices is not beneficial to companies once they do not exploit the synergy from practicing simultaneously outbound and inbound OI. According to (Hung & Chou, 2013), “managers should be aware that externally acquiring new technological knowledge to renew and broaden their knowledge bases helps their firms achieve enhanced performance by selling or co-developing outside technology”. The adaptation and structuring of inside-out practices are thus another challenge for the automotive companies.

5.6. Section f—urban mobility trends on energy source
The answers about the future of urban mobility concerning to energy matrix were quite dispersed, which is an evidence that they were based on the interviewees’ opinion and not on a grounded forecast. This shows an uncertainty about the future, even when considering a not so distant scenario, mainly because of the revolution this industry sector is facing on electrification. However,
it is possible to identify a relevant gap between the trend perceived in France and in Brazil. The average answer from French collaborators predicts that the production of electric or hybrid cars will represent 58.0% of the market by 2030. On the other hand, for the professionals in Brazil the average response was 29.6%.

It is also common sense between the interviewees that the electrification depends more on the local government than on the companies’ strategy. Restrictions on the emission of combustion gases and other regulations for the automotive market, the existence of subsidies to electric cars, fiscal incentives, the system of charging stations and the country’s energy matrix were all cited as the most important factors that determine the level of electrification in a nation, and they are all related to government policies. The French government has been stimulating electric and hybrid cars much more intensely than the Brazilian state. This can explain the distinct electrification trend in the two countries.

6. Conclusions

Once the automotive industry is facing a technological revolution and the development of new products must be performed faster and more efficiently, it was expected throughout this research, to find evidences of changes in the PDP of the companies objects of this study, mainly by the integral incorporation of methodologies such as Open Innovation, in order to make their development process more efficient. Open Innovation was the chosen methodology to be considered mainly due to its great success among similar industry sectors such as the aeronautic. Not only that, but this research main task was to verify and compare the OI practices in the French automotive companies at their headquarters levels (in France) and, also at their subsidiaries level (in Brazil). French companies were chosen because of their recognition as being innovative companies within the automotive sector and because of their similarities in terms of scale and national importance, both in France and Brazil, respectively, when both automotive sectors in both countries are compared.

The first hypothesis that the case study confirmed is the fact that France has a higher level of technology development than Brazil. Generally speaking, innovation is highly dependent on the internal market and on local government politics and France offers a more favorable situation regarding these two aspects. Consequently, the process of innovation, especially OI practices, are better structured in France. Aware of this situation, Brazilian government could work to launch additional incentive programs for its automotive sector. Past policies have had a positive result on the technology development in this industry, but the gap between the company’s headquarters (in this study, located in France) and its subsidiaries located in Brazil is still existent.

One interesting insight brought by the case study is the motivation that leads companies to practice OI: it is not the same in France and in Brazil. In France, the main reason that leads companies to practice OI is to develop technology faster so as they can respond to market demand. On the other hand, in Brazil the motivation is related to resources: it would not be possible to the French automakers to implement development centers in the South American countries without partnerships that would reduce the financial investment and knowledge and skills necessary.

Another key learning aspect is that country-wise speaking, in Brazil, a clear difference between the automakers and the automotive suppliers could be identified from the respondents. According to the questionnaire, the suppliers’ subsidiaries practices on product development are, in most cases, adaptive or even nonexistent (so no Open Innovation is performed). That is already a crucial problem that should be faced by current company leaders and innovation specialists within companies and public agencies in Brazil. In turn, it was identified some OI practices in automakers in Brazil, although these practices are less structured and institutionalized than in France as already mentioned. From the questionnaire responses, it could also be inferred that the company culture also has a relevant influence on the innovative process, but it is not as decisive as the
location of the industry, since in these French automotive companies the subsidiaries have a certain autonomy to build their own innovation processes.

Last but not least, the research made evident the predominance of outside-in practices rather than inside-out ones in both countries and industries. Therefore, considering the synergy from practicing both outbound and inbound OI, companies must invest heavier in the implementation of inside-out OI practices, such as selling technology to third parties.

The multiple case study provided some important insights to the study of OI practices in automotive companies and, also to compare these practices between headquarters and subsidiaries. However, it is important to consider that the research had some limitations, such as the number of companies analyzed, and the number of employees interviewed from each company. A wider research can be done as a continuation of this study. For instance, a quantitative survey could assure the answers obtained. A similar multiple case study on another mechanical industry, such as aerospace and machine, would also complement this article.

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Appendix
The questionnaire that guided the interviews.

Section A: Open Innovation Practices

Open innovation is defined by Chesbrough et al. (2006): “the purposive use of inflows and outflows of knowledge to accelerate innovation in one’s own market and expand the use of internal knowledge in external markets, respectively”.

Open innovation refers to modes of innovation based on sharing or collaboration. This can include sharing knowledge to find solutions to complex problems, or sharing the risks and investments required for a project.

1. Based on this definition, does your company adopt open innovation practices?
2. For how long has your company been engaged in open innovation practices?
3. What importance does open innovation have in your unit’s innovation strategy?
4. There are three stages of maturity in open innovation:
   - Introduction (Willingness shown but few facts, Local experiments)
   - Development (Large-scale internal learning and promotion, Heterogeneous practices and convictions)
   - Essential (Structured management method and tools, generalization in progress, Open innovation at the heart of strategy and practices)

   What stage best describes your current practice?
5. For which reasons does your company makes use of open innovation?
6. What percentage of your revenue is devoted to innovation? What about open innovation?
7. Since 2015, have the open innovation practices in your company been developed? Did the number of projects relate to that grow? Did the tools and process been improved?

Section B: Your Plant’s Organizational Culture

8. By your experience, what are the main advantages of using outside technologies instead of developing it internally? And what are the disadvantages?
9. Talking about the HR management, does the company offers trainings to its employees? Does the company encourage people to participate in the search for solutions? Does the unit management encourage teamwork?
10. In your company, which are the risks that could hinder the deployment of open innovation projects?

Section C: Innovation and Product Development

11. With respect to product (and/or services and processes) development
in your plant/unit, especially since 2015, how disruptive are the products developed? Are they developed for new targets and for a new business model? Or are they just incremental for prior products/projects?

12. How much has the way PDP is done in your plant/unit changed since 2015? Did open innovation influenced the way PDP is done?

Section D: Satisfaction

13. Is the company satisfied with the results brought by open innovation practices? What has changed regarding the costs, the quality, the project management and the marketing?

Section E: Cluster Building

14. Which are the most important partners for innovation in your unit? (You don’t have to name the partners; we would like to know just the type of partnership it is. For example: a university, a public or private research company, a key customer, a competitor ...)

15. Why are these partners important for your unit? What do these partnerships bring as results?

Section F: The Future of Urban Mobility

16. In your opinion, concerning [country] in 2030, how much (in percentage) of the automotive companies' market share will be represented by completely electric vehicles (with no internal combustion engine)? What about hybrid vehicles?