

Please cite the Published Version

Matos, LM, Rampasso, IS, Quelhas, OLG, Leal Filho, W and Anholon, R (2022) Technological innovation management: understanding difficulties in an emerging country to enhance manufacturers performance. *International Journal of Productivity and Performance Management*, 71 (6). pp. 2280-2295. ISSN 0043-8022

DOI: <https://doi.org/10.1108/IJPPM-02-2021-0074>

Publisher: Emerald

Version: Accepted Version

Downloaded from: <https://e-space.mmu.ac.uk/628491/>

Usage rights:  [Creative Commons: Attribution-Noncommercial 4.0](https://creativecommons.org/licenses/by-nc/4.0/)

Additional Information: This is an Author Accepted Manuscript of an article published in *International Journal of Productivity and Performance Management*.

Enquiries:

If you have questions about this document, contact openresearch@mmu.ac.uk. Please include the URL of the record in e-space. If you believe that your, or a third party's rights have been compromised through this document please see our Take Down policy (available from <https://www.mmu.ac.uk/library/using-the-library/policies-and-guidelines>)

Technological innovation management: Understanding difficulties in an emerging country to enhance manufacturers performance

International Journal of Productivity and Performance Management 01 Jan 2021

<http://doi.org/10.1108/IJPPM-02-2021-0074>

Matos, L. M^a; Rampasso, I. S^{a,b*}; Quelhas, O. L. G^c; Leal Filho, W^d;
Anholon, R^a

^a School of Mechanical Engineering, State University of Campinas, Campinas, Brazil.

^b PNPd/CAPES, Doctoral Program in Sustainable Management Systems, Federal Fluminense University, Niterói, Brazil.

^c Master Program in Management Systems and Doctoral Program in Sustainable Management Systems, Federal Fluminense University, Niterói, Brazil.

^d [Hamburg University of Applied Sciences](http://www.hamburg-university.de). Faculty of Life Sciences, Hamburg, Germany.

* Corresponding author: izarampasso@gmail.com (Izabela Simon Rampasso); Mendeleyev Street, 200. Campinas, Brazil. Phone: +55 19 3521-3398.

Abstract

Purpose: This study aims to discuss the difficulties faced by two large Brazilian industrial companies in technological innovation management.

Design/methodology/approach: Initially, a literature review is carried out using meta synthesis technique, to consolidate an expanded and detailed framework that complemented and dialogued with the difficulties presented by Oslo Manual. The difficulties presented in this framework were used as an instrument to conduct two case studies.

Findings: There were several findings, especially the adherence to the structured framework and the identification of short-term management and inflexibility of the regulatory environment as relevant difficulties for both companies.

Originality/value: The understanding of these difficulties can contribute to optimizing manufacturers performance in innovation processes. Although only two companies were analysed, their magnitude and relevance in the sectors they belong should be highlighted. The information presented here can greatly contribute to expanding the debates about the management of innovation by companies in emerging countries.

Keywords: Innovation Management; Performance; Industry; Brazilian companies.

1. Introduction

Currently, there is almost a consensus regarding the fundamental role of technological innovations development for the evolution of different industrial sectors (Azar and Ciabuschi, 2017; Juliao-rossi and Schmutzler, 2016; De la Vega Hernández and Barcellos de Paula, 2020). Industrial companies increasingly need to face global competition, in which constant adaptations are required. It is also noteworthy that products and processes also become technically increasingly complex and, therefore, require more efforts for their understanding and improvement (He, 2015; Liu and Jiang, 2016; Tepic et al., 2013). The context of Industry 4.0 is also increasing the complexity of this scenario (Sharma *et al.*, 2020).

In this reality, companies that innovate in products and processes should be highlighted. They are able to achieve better levels of productivity, performance and growth in the long term when compared to the others (Goedhuys and Veugelers, 2012; Saleem *et al.*, 2020). The high adaptability allows the launch of new products and processes, creating competitive advantages (Johannessen and Olsen, 2009; Liu and Jiang, 2016). Although less consensual, it is possible to observe references to innovation capacity as a key factor for competitiveness (Johannessen and Olsen, 2009; Phusavat *et al.*, 2012). In this sense, the role of leaders and employees competencies are important drivers for companies innovation (Singh and Dhir, 2021). According to Migdadi (2020), the knowledge management process can also influence companies innovation.

Although there is already a consolidated theoretical framework for innovation management, namely the Oslo Manual (OCDE, 2005), there are always possibilities to explore deeper the main challenges faced by large companies when they opt for technological innovation. Indeed, these challenges may vary according to company's culture and the country in which it is located. Thus, it is important to evaluate specific

situations. To expand the debates on this subject, the present article aims to analyse the difficulties faced in technology innovation management by two large industrial companies in Brazil. These two companies were selected due to their magnitude and relevance. Initially, it is conducted an expanded and detailed theoretical reference about the main difficulties found in industrial technology innovation management and, posteriorly, two case studies are performed through semi-structured interviews in two large companies in Brazil. Information presented in this article provides deeper detailed information when compared to Oslo manual and applies it to a specific context. In the next section, the theoretical background is presented.

2. Theoretical background

2.1 Analysed difficulties

Through the meta-synthesis technique, it was possible to perform a literature review to identify the difficulties experienced by companies in technological innovation management. The results are summarized in Table 1. It is important to highlight two points: 1) the analysis is concentrated on industrial technological innovations for products and processes of large companies. Thus, difficulties associated with innovations in marketing, organizational processes and services were out of this review scope. Difficulties related to small and medium-sized business environments were not considered too; 2) In order to show the interface between this theoretical foundation with Manual de Oslo (OCDE, 2005) and to emphasize the expansion of the review presented in this article concerning this manual, the difficulties identified by the manual in 5 major categories are shown in Table 2.

Table 1 position.

2.1.1 Difficulty-1

Generally, companies face several restrictions and risks to finance their actions for technological innovation. Technological innovation requires investment amounts that are not always available in capital markets, especially in developing countries (Bas *et al.*, 2015; Juliao-rossi and Schmutzler, 2016; Sun and Du, 2010). The budget associated with

Research and Development (R&D) activities is sometimes put on the back burner when daily operations require the company's scarce resources to be conducted. It is also difficult to commit high amounts of initial investment to innovation actions that involve risks and uncertain gains (Koschatzky *et al.*, 2001; Lichtenthaler, 2013).

2.1.2 Difficulty-2

The way the company guides its innovation activities drastically changes process dynamics. “Demand-driven” innovation focus exclusively on market needs can be an inhibiting factor for long-term or disruptive innovations. Market and consumers often focus on the short term. Thus, companies exclusively focused on them may be stuck in a dynamic of incremental innovations (Warren *et al.*, 2000; Zhang and Duan, 2010). “Technology-push” innovations, otherwise, have a higher level of uncertainty about their commercialization potential and often demand larger investments for extended periods (Freeman *et al.*, 1988; Nelson, 2006; Peters *et al.*, 2012; Rosenberg, 1996). This kind of innovation can create new markets.

2.1.3 Difficulty-3

Global markets are dynamic and constantly changing. Keeping up with them, their risks and competitors' developments requires efforts and represents an additional cost for companies (Ardito *et al.*, 2015; Badrinass and Vilà, 2015; Säfsen *et al.*, 2014; Zhang and Duan, 2010). Consumers' perceptions and needs change frequently, making it necessary for companies to map them before defining their strategies (Ardito *et al.*, 2015; Zhang and Duan, 2010). Changes in external scenarios can alter the perspectives related to innovation financial returns and reduce benefits from efforts made by innovative companies.

2.1.4 Difficulty-4

Technical challenges of technological innovation can be significant. In this sense, the management of product and process engineering represents a significant difficulty for the technological innovation process (Berry, 2014; Bonnin Roca *et al.*, 2017; Nahm and Steinfeld, 2014). Transferring results, making adaptations for different markets and integrating geographic regions without generating waste of process are also challenges

experienced by innovative companies (Bergfors and Larsson, 2009; Berry, 2014). In internal communication, another challenge is the effective integration among company's areas. Ensuring, for example, that marketing, finance, R&D and engineering can communicate flexibly is an important challenge for the technological innovation process (Lichtenthaler, 2013; Piening and Salge, 2015; Tepic *et al.*, 2013; Zahra and Nielsen, 2002).

2.1.5 Difficulty-5

According to Tello (2015), similarly to investments in R&D, investments in human resource development can make technological innovation activities prohibitive due to the longer time horizons required. This observation is corroborated by Goh (2005) and Sun and Du (2010) that emphasize the difficulty of assimilating new technologies for innovations development in countries with low literacy rates and a weak educational system. This difficulty means that these countries do not have basic human capital, scientific knowledge and technical skills necessary to foster technological innovation processes (Reynolds and Uygun, 2015). For companies, this difficulty is observed regarding attraction and retainment of talents needed for innovation process, which are not always available in the local markets where they operate. Even when they are, not all companies can make attractive offers to hire and then retain these talents (He, 2015).

2.1.6 Difficulty-5

Government regulatory activities represent an additional cost in the innovation process. When laws and regulatory processes are not focused on streamlining investment in R&D, they can represent a difficulty for companies to overcome (Ardito *et al.*, 2015; Bi *et al.*, 2016; Bonnín Roca *et al.*, 2017; Busom and Vélez-Ospina, 2017; Cao *et al.*, 2017; Goh, 2005). This difficulty can be observed in several ways. Among them, Goh (2005) highlights that overly restrictive private property policies have the potential to inhibit private sector participation in investments related to the subject. In this sense, Bi *et al.* (2016) and Busom and Vélez-Ospina (2017) identify that another influencing factor is the information asymmetry between regulatory agencies and innovation investors. The rules for investment and ownership of these efforts are not clear and integrated. In addition to these factors, Bonnín Roca *et al.* (2017) highlight the existence of inflexible regulations

that favour specific technologies without incorporating performance criteria.

2.1.7 Difficulty-7

The most innovative companies are those that can establish more mutual links of knowledge with other institutions, such as universities, global networks of suppliers, industries, consumers and international research networks (Ardito *et al.*, 2015; Bagherinejad, 2006). Cantista and Tylecote (2008) also highlight the need of links among companies, suppliers and consumers. In this sense, Goh (2005) argues that if institutional rigidities preclude better integration, the innovation process will be hampered. Transaction costs for establishing external connections can be high (Koschatzky *et al.*, 2001). It is difficult for companies to establish adequate partnerships that enable them to effectively produce knowledge and transfer technology, since this is a process that requires sharing confidential information and a high trust among partners (Bergfors and Larsson, 2009; Berry, 2014; Bianchi *et al.*, 2014; Lichtenthaler, 2013; Nahm and Steinfeld, 2014; Zahra and Nielsen, 2002). Therefore, a poor integration between among actors can impair innovation actions (Sun and Du, 2010).

2.1.8 Difficulty-8

Fostering innovation culture can become a challenge for individual companies, whole sectors and countries (Bonnín Roca *et al.*, 2017; Koschatzky *et al.*, 2001; Warren *et al.*, 2000). According to Bagherinejad (2006), companies in developing countries have remained technologically underdeveloped due to the lack of an enabling environment for innovation. Similarly, Koschatzky *et al.* (2001) and Warren *et al.* (2000) also corroborate with this argue. In the first study, studying a developing country, they found that the absence of an active climate of interactions generated technological delays. In the second study, the authors observed that a stagnant attitude towards the modernization of a British industrial sector was a detractor in the modernization of industry. Also in the sectoral aspect, Bonnín Roca *et al.* (2017) identified the absence of an “innovative culture” as a barrier to technological innovations in the aftermarket auto parts sector.

2.1.9 Difficulty-9

Not all technological innovations mature and generate returns to their entrepreneurs in the short term. Bergfors and Larsson (2009) identified in their research that companies' commitment increase for projects that aim at short-term gains, often neglecting initiatives of greater uncertainty or longer terms for maturation. According to Tello (2015), this difficulty is closely linked with the lack of capital to innovate. In Latin American countries, for example, technological innovations are restricted to technology transfers and the acquisition of machinery and parts shipped. Pressure under management also contributes to this difficulty. According to Cantista and Tylecote (2008), another factor that hinders the enterprise in the longer term is the pressure on management to deliver results.

2.1.10 Difficulty-10

According to Woodside and Biemans (2006), high profits from existing customers and businesses can give a false sense of security and make companies satisfied to maintain the status quo temporarily, creating an inertia for change. Azar and Ciabuschi (2017) corroborate this statement stating that large companies often lag behind startups in terms of innovation when they transform their core capabilities into core rigidities. In the long run, however, without efforts to look further, they can inhibit the exploration of innovations that require significant changes and, consequently, reduce new fronts growth to be explored, compromising the sustainability of the business (Badrinas and Vilà, 2015).

2.1.11 Difficulty-11

The absence of a well-articulated strategy can become the main impediment for an organization to achieve its innovation goals (Badrinas and Vilà, 2015). Technological innovation efforts are a continuous process of seeking competitive advantages. The regularity of these efforts when it is considered the process uncertainty requires companies to have a structured and continuous strategy for the development of new products and processes (Koschatzky *et al.*, 2001). There are chances of an inadequate identification of risks, deadlines and returns of innovation projects, losing strategic focus when they go beyond what was planned. In large companies, the difficulty that arises is also the coordination of a unique strategy to undertake technological innovation (Bergfors

and Larsson, 2009).

2.1.12 Difficulty-12

A new technology does not guarantee positive results. The biggest challenge is often not to think or develop technological innovations, but to develop demand, markets and make their applications viable and profitable (Beynon *et al.*, 2016; Bi *et al.*, 2016; Bianchi *et al.*, 2014; Nahm and Steinfeld, 2014; Wallin *et al.*, 2015). In this sense, Ardito *et al.* (2015) note that the development of appropriate business models is one of the main difficulties perceived by executives involved in innovation processes. Even if an innovation presents value to the customer, the feasibility of its implementation depends on the creation of an effective and profitable business model (Bianchi *et al.*, 2014; Wallin *et al.*, 2015).

2.1.13 Difficulty-13

The development and application of new technologies has potential to generate direct impacts, both positive and negative, for organizations' workers (Beynon *et al.*, 2016; Lichtenthaler, 2013; Woodside and Biemans, 2006). On the negative side, new technological innovations can threaten established functions or prestige reduction for certain business units. The insecurity generated in the teams by this phenomenon can be an impediment to efforts to develop and implement new technologies that must be considered by organizations. The balance of these interests is an additional difficulty to be managed (Woodside and Biemans, 2006).

2.2 Comparison with Oslo Manual (2005)

As previously mentioned, considering the relevance of the Oslo Manual in the field, this section shows how the theoretical foundation presented dialogues with Oslo Manual (OCDE, 2005) and expand it, the difficulties from Oslo Manual are presented in Table 2.

Table 2 position.

It is worth mentioning that the Oslo Manual published in 2018 (OCDE/Eurostat, 2018) presents a framework for these difficulties less detailed than the version of 2005. This is the reason for the use of a previous version of the manual. Comparing this list with the difficulties presented in Table 1, it is possible to confirm the previous statement regarding the level of detail with the difficulties in innovation management. As an example, it can be mentioned “No need to innovate due to earlier innovations” (in Oslo Manual) that is related to the item “Operational inertia” (from Table 1); despite the similarity between the two items, the difficulty presented in Table 1 is better specified and is connected with evidence from academic literature.

3. Methodological procedures

This research was developed through four stages, presented in Figure 1, and detailed in the sequence.

Figure 1 position.

To conduct the literature review meta-synthesis analysis was used according to the guidelines of Catalano (2013), Hoon (2013), Siau and Long (2006), Wong et al. (2018) and an application similar to Wong et al. (2018). For this analysis, it is recommended to follow four phases: (1) Review planning; (2) Studies selection; (3) Applicability analysis and (4) Synthesis presentation.

In the Review planning phase, the terms to be consulted and the scientific databases were defined. The terms consulted were: Industrial Innovation, Innovation Management, Product Innovation, Process Innovation, Technology, Technological Innovation, Technology Management, Innovation Models, Product Technology, Process Technology, Product Technology Management, Process Technology Management. The databases used were: Emerald Insight, Scopus, Periódicos CAPES, Wiley, EbscoHost and ScienceDirect.

Using the terms mentioned, articles were collected and selected in the phase called Studies selection. The focus for this selection was for studies from the period between 1998 and 2018. An analysis of the selected articles characterized the Applicability

analysis phase. The articles were entirely read, and the difficulties faced by companies in innovation management were identified in 38 articles. Finally, in the Synthesis presentation phase, these difficulties were grouped by similarity, the results are presented in Table 1.

Using the information from Table 1, we structured the research instrument that guided the case studies. It should be noted that in Brazil, research involving human need to be appreciated by Ethics Committee and this research was approved. It should be emphasized that, although only two cases are considered in this research, the companies selected are large, present mature innovation management systems and are relevant for the sectors they belong (more details about them are presented in the next section). In this sense, the findings presented here show the performance of companies expected to present better technological innovation management than others.

The case studies were performed according Cauchik et al. (2012) guidelines: 1) Definition of a theoretical conceptual framework (presented in the theoretical background); 2) plan the cases; 3) conduct a pilot test; 4) collect data; 5) analyse the data and 6) generate a report.

Cauchik et al. (2012), as well as Yin (2014), emphasize the need of multiple source of data. In this sense, triangulation was performed through documental analysis, visits to the companies and semi-structured interviews with the innovation directors of analysed companies. The difficulties presented in Table 1 were used as a base for these interviews. After a debate about the subject, directors were asked to attribute a score from 0 to 10 for each difficulty, in which 0 indicated the non-observation of the difficulty and 10 indicated extreme observation of the difficulty. Data analysis, for its turn, was conducted through meta-synthesis technique, as used in literature review. This was possible because, according to Catalano (2013), meta-synthesis can also be used to produce interpretative analyses, narratives and theories by compiling results and conclusions from qualitative studies. Hoon (2013) recommends the use of meta-synthesis for data analysis in exploratory research. This is exactly the condition of this study.

4. Results and discussions

4.1 Case study 1

The first case study was developed in a large multinational company. The organization

offers business solutions in 11 different industrial sectors and invest around 5.8% of its revenue in R&D. The company produces a large variety of products, among them, it can be highlighted products for health care, decorative products, products related to buildings safety, products related to house cleaning, among others. It produces around 3,000 annual patents and has an accumulated bank of nearly 110,000 patents. In Brazil, it has an important centre that develops research focused on serving national or regional customers. The interview for the case study was conducted with the innovation director of the company, who attributed scores for each analysed difficulty. These scores are presented in Figure 2.

Figure 2 position.

As it is shown in Figure 2, only one difficulty from the literature review did not present any observation level for company 1. This difficulty is “Difficulty in establishing the proper orientation for the innovation process”. According to the director, this difficulty is not observed in company’s reality because it uses mixed innovation strategies, merging strategies of technology-push and demand pull. For the other difficulties, they were observed in the company even in a low level.

Investments in innovation activities are fully performed with company 1 own capital. In this sense, according to organization’s director, it does not face significantly the difficulty observed by Bas et al., (2015), Juliao-Rossi and Schmutzler (2016) and Sun and Du (2010), that is, difficulty to access capital markets, especially when it is considered that this company’s unit is installed in a developing country. However, the company faces difficulty to justify internally its innovation activities, a difficulty mentioned by Koschatzky et al. (2001) and Lichtenthaler (2013).

The main difficulty pointed out in company 1 is the interpretation and constant adaptation to external scenario. With an increasingly dynamic environment, at regional and global level, for both policies and technologies, the difficulty observed by Ardito et al. (2015), Badrinass and Vilà (2015), Säfsen et al. (2014), Zhang and Duan (2010) in reacting quickly to constantly changing scenarios is presented as core competence requirement for the company.

Internally, dealing with the complexities of innovation processes is not considered a significant challenge and is considered natural. Activities structuring is done on key technology platforms. Competencies are internalized for both basic and applied research, which facilitates the answer to the “difficult questions” of innovation process pointed out by Berry (2014) and Bonnín Roca et al. (2017) about what technologies the company should develop and how processes will be managed. All innovation activities have a commercial focus and there is a global vision to seek convergence of objectives from all areas regarding innovation activities.

Only occasional difficulties are observed in human resources management for innovation activities. Among these difficulties, the most relevant is talent retention. There is no reported difficulty in finding qualified labour for the activities development, despite Goh (2005) and Sun and Du (2010) observe this difficulty in companies from countries with low educational level. Regarding the maintenance of a culture prone to innovation, difficulties are mentioned mainly at national level. Internally, innovation is incorporated as one of the company's strategic pillars and, therefore, permeates all activities at all levels. There is no difficulty in maintaining this perspective. At national level, however, the company considers the efforts promoted insufficient and believes that it would benefit if more initiatives with this focus were disseminated in the national economy.

Additionally, the national regulatory environment is considered inadequate. This observation is corroborated by the literature (Ardito *et al.*, 2015; Bi *et al.*, 2016; Bonnín Roca *et al.*, 2017; Busom and Vélez-Ospina, 2017; Cao *et al.*, 2017; Goh, 2005). Among the difficulties, Large costs are mentioned with bureaucratic and time-consuming intellectual property processes, in addition to the asymmetry of information between regulators and investors. In practice, in many cases the company declares that it prefers to send its property registration processes to other countries with a more favourable regulatory environment.

The pursuit of shorter-term goals is also considered a hindrance to innovation due to its uncertainty of time period and results. As noted by Bergfors and Larsson (2009), financial goals often prevent certain efforts from being carried out. At this point, the company's strategy is to focus mainly on the maturation of innovations already developed and to ensure that the desired leverage levels in these innovations are adequate before proceeding on to the next ones.

Operational inertia is solved through metrics and minimum percentages of new products in the portfolio composition. Specific targets for incremental innovations and new products are incorporated to contribute with the solution for operational inertia, which is not considered a relevant challenge for the company. Likewise, developing strategies for general management of industrial innovation processes is an internal structured process that is not considered challenging for this company. The guidelines are established globally and deployed to subsidiaries in a continuous and adaptive process. Continuity breaks the difficulty of gradually dispersing knowledge and the strategy observed by Bergfors and Larsson (2009).

The development of business models for the innovations created is considered something inherent to all projects. This premise ensures that this process is also not perceived as a relevant difficulty in the innovation process. No technological product or process innovation follows without a clearly explained and viable business model. The model may even be the innovation itself. Sometimes the company declares that even without making technological developments, it innovates in business models, starting to extract value from a process or product in fields that were not previously explored.

Finally, the management of internal political interests is considered a significant difficulty by the company. There are no specific strategies to carry out interest management at the operational and strategic levels, something argued about by Beynon et al. (2016) and Lichtenthaler (2013) as important in this sense.

4.2 Case study 2

The second case study was developed in a large industrial multinational company, it has around 440 subsidiaries and have a large portfolio of products. Among these products, technologies for industry and buildings, goods for consumers (such as tools for domestic use), and development of solutions for vehicles can be highlighted. Globally, it invests around 10% of its revenue in R&D, which is equivalent to around 7.5 billion euros. The R&D activities developed by the company in Brazil represented an investment of around 5 billion. The interview for this case study was also conducted with innovation director, who attributed scores for each difficulty, as presented in Figure 3.

Figure 3 position.

As in case study 1, only one difficulty did not present any level of observation in company 2, namely "Difficulties associated with internal policies". Although the financing of its innovation activities is done with its own capital, the director attributed a level 6 for the score of this difficulty, consistent with the observations of Koschatzky et al. (2001) and Lichtenthaler (2013). The main barrier for this is to justify the investments internally, mainly in a macroeconomic scenario considered challenging.

In Brazil, the company uses a "Market Pull" or "Demand Driven" approach, in which technological innovations are developed based on requirements and demands from the market, in line with what is stated in the literature (Ardito *et al.*, 2015; Goh, 2005; Peters *et al.*, 2012; Tello, 2015). This is done in Brazil because the company does not carry out basic research in the country. In this sense, it is observed a high difficulty level and, as discussed by Warren et al. (2000) and Zhang and Duan (2010), which emphasize that the exclusive focus on market demands can lead to opportunity losses to explore other technologies.

In company 2, the interpretation of internal market and external scenario is not always a challenge. Given the company's position in global scenario of industrial technological innovations and the amount of investments made, in many of its innovation fields, it is company 2 that sets the trends. Managing the technical complexities of processes is a punctual challenge. Technical complexity of technologies does not generate great barriers, since the company has specialized research centres and investments in technical capacity. Integration among company's areas involved in innovation process, however, is a challenge, as it is mentioned in the literature (Bergfors and Larsson, 2009; Berry, 2014; Piening and Salge, 2015).

Company's strong name and brand facilitates the development and retention of adequate human resources. Since talents attraction and retention are properly managed, it is not observed in the company significant difficulties in this regard. The offer and educational level of professionals in Brazil is considered adequate for company's needs.

Regarding regulatory environment, company 2 faces more challenges. This is one of the most important challenges for this company in Brazil. As it is observed by several authors (Ardito *et al.*, 2015; Bi *et al.*, 2016; Bonnín Roca *et al.*, 2017; Busom and Vélez-Ospina, 2017; Cao *et al.*, 2017; Goh, 2005), a regulatory environment not focused on agility generates significant additional costs. For this reason, the local environment is considered to inhibit the developed innovation activities.

In addition, there is a development of connection networks with external actors. In line with what is stated by several authors (Ardito *et al.*, 2015; Bagherinejad, 2006; Goh, 2005; Koschatzky *et al.*, 2001), in the company, they understand that organization performance does not depend only on internal efforts, the whole innovation system need to be aligned for company's success. In this sense, there are partnerships between the organization, universities and suppliers, for example. Although the barriers for sharing and developing joint capabilities with the local supplier network are considered low, supply gaps can be verified in specific points. Because of this, international suppliers are sometimes necessary. Among the reasons for these gaps, insufficient investments in R&D by companies in the network.

The promotion of a technological innovation culture is pointed out as a national problem of Brazil; the national difficulty is considered greater than the internal difficulty in the company. As mentioned by Ardito *et al.* (2015), Brazilian cultural diversity may foster a more innovative culture, however, government efforts are considered by the author insufficient to create a "macro" environment to foster innovation.

Management immediacy is a relevant challenge for this company. The pressure to deliver quick results generates pressure, as noted by Cantista and Tylecote (2008). There are significant difficulties in approving longer-term projects. In addition, due to the challenging macroeconomic scenario, there is a great need for justifications for maintaining long-term business in the country.

To interrupt operational inertia, businesses that become commodities are not maintained. In this sense, and to avoid the risk of agility loss, as mentioned by Azar and Ciabuschi (2017) the company quickly sells businesses that become commodities. It has several startups incubated internally and constantly renews its product portfolio. For this reason, the difficulty related to operational inertial is little observed in the organization.

Having technological innovation as a central pillar of the global strategy makes it difficult to observe challenges in macro strategy elaboration for company's innovation management. The activities are organized globally and there are only punctual reviews during their execution. This process of structuring a strategy for innovation management is considered to require significant efforts, but it is not considered a difficulty.

As in case study 1, the development of business models for technological innovations is inherent to company's management. Business models are developed

simultaneously with the innovations. In the same line of reasoning of Busom and Vélez-Ospina (2017), Kivimaa and Kautto (2010) and Warren et al. (2000), the company incorporates marketing skills and market intelligence in this process. The sum of all these efforts makes this process one of the least significant challenging for the company.

Internal policy difficulties are not perceived as a barrier for the company. To eliminate this issue, company 2 has objective processes that guarantee a quick dissolution of businesses that become commodities. The main difficulty of this process is the costs of sale or dissolution of the business.

4.3 Comparisons between case studies

To facilitate the comparison between the case studies, the scores attributed were grouped into Figure 4.

Figure 4 position.

The first point to be highlighted in the comparison between the case studies is that it can be observed an adherence between the conceptual framework and what is observed in practice. None of the companies brought additional difficulties that were not mentioned in the conceptual framework. There were two difficulties that were not observed by the companies, but these difficulties were different for each company.

There is no unanimous difficulty as the greatest for both companies. The areas with the highest score as the main difficulties are the barriers created by short-term management and the regulatory environment. These are potential points of attention for industrial technological innovation ventures in Brazil.

The biggest difference in the scores occurs in the difficulty related to establishing adequate guidance for the innovation process. This divergence may occur since company 1 develops basic research in Brazil. Despite both declaring to be focused on the market, in company 2, there is a loss of opportunity regarding the low investment in this area in the country.

Internal policy difficulties prove to be difficult in just one of the case studies. In company 2, it was showed that there is a very clear and well-defined strategy in relation

to this point when it is decided that a business became commodity and it should be sold. In company 1, in contrast, there is a greater effort in exploring existing business lines.

5. Conclusions

Considering the scarcity of studies focusing on technology innovation management at companies in Brazil, this study aimed to discuss the difficulties encountered by two large industrial companies located in Brazil, regarding their technological innovation management. Two case studies were carried out in companies with high levels of technological innovation, of great magnitude and with mature structures of management. Considering the results presented, it can be stated that the objectives were achieved.

The main conclusion of this research is that the conceptual framework is present in the environment of the companies analysed and that the main difficulties are those associated with short-term management and inflexibilities of the regulatory environment. As previously highlighted as practical implication, these are points that deserve attention of companies in Brazil in their management of technological innovation. Considering the maturity level of analysed companies, the issues most evidenced by them should also be carefully analysed by other companies, as critical topics. The two main difficulties evidenced also show the need of Brazilian government to improve regulatory issues to stimulate innovation in the country. Improvements in Brazilian regulations can also contribute to expand management perspectives, increasing long-term perspectives on strategical issues related to technological innovation.

In addition, regarding theoretical implications of the present study, the difficulties in technological innovation management collected from literature can be useful for future studies to analyse other countries realities. We emphasize, however, that the selection of companies to be evaluated should consider the maturity level of their technological innovation management, in order to identify the most challenging difficulties.

Logically, there are limitations about this study, since only two companies were studied. However, their importance for the economy of the regions in which they are installed stands out as well as their relevance in international scenario. In addition, it should be emphasized that the companies were selected due to their relevance in R&D scenario. In this sense, the difficulties presented by these companies are expected to be

lower than in other companies (smaller and/or with a less mature innovation management system).

As future study, it is suggested to carry out surveys with innovation directors of Brazilian companies and to analyse data using statistical tools that allow generalization of results.

References

- Ardito, L., Messeni Petruzzelli, A. and Albino, V. (2015), "From Technological Inventions to New Products: A Systematic Review and Research Agenda of the Main Enabling Factors", *European Management Review*, Vol. 12 No. 3, pp. 113–147.
- Azar, G. and Ciabuschi, F. (2017), "Organizational innovation, technological innovation, and export performance: The effects of innovation radicalness and extensiveness", *International Business Review*, Elsevier Ltd, Vol. 26 No. 2, pp. 324–336.
- Badrinas, J. and Vilà, J. (2015), "An Innovation Management System to Create by An Innovation Management System to Create", *International Journal of Innovation Science*, Vol. 7 No. 4, pp. 263–279.
- Bagherinejad, J. (2006), "Cultivating technological innovations in Middle Eastern countries Factors affecting firms ' technological", *Cross Cultural Management: An International Journal*, Vol. 13 No. 4, pp. 361–380.
- Bas, C. Le, Mothe, C. and Nguyen-Thi, T.U. (2015), "The differentiated impacts of organizational innovation practices on technological innovation persistence", *European Journal of Innovation Management*, Vol. 18 No. 1, pp. 110–127.
- Bergfors, M.E. and Larsson, A. (2009), "Product and process innovation in process industry: a new perspective on development", *Journal of Strategy and Management*, Vol. 2 No. 3, pp. 261–276.
- Berry, H. (2014), "Global integration and innovation: Multicountry knowledge generation within MNCs", *Strategic Management Journal*, Vol. 35 No. 6, pp. 869–890.
- Beynon, M., Jones, P. and Pickernell, D. (2016), "Country-level investigation of

- innovation investment in manufacturing: Paired fsQCA of two models”, *Journal of Business Research*, Elsevier B.V., Vol. 69 No. 11, pp. 5401–5407.
- Bi, K., Huang, P. and Wang, X. (2016), “Innovation performance and influencing factors of low-carbon technological innovation under the global value chain: A case of Chinese manufacturing industry”, *Technological Forecasting and Social Change*, Elsevier Inc., Vol. 111, pp. 275–284.
- Bianchi, M., Frattini, F., Lejarraga, J. and Di Minin, A. (2014), “Technology exploitation paths: Combining technological and complementary resources in new product development and licensing”, *Journal of Product Innovation Management*, Vol. 31 No. S1, pp. 146–169.
- Bonnín Roca, J., Vaishnav, P., Morgan, M.G., Mendonça, J. and Fuchs, E. (2017), “When risks cannot be seen: Regulating uncertainty in emerging technologies”, *Research Policy*, Elsevier, Vol. 46 No. 7, pp. 1215–1233.
- Busom, I. and Vélez-Ospina, J.A. (2017), “Innovation, Public Support, and Productivity in Colombia. A Cross-industry Comparison”, *World Development*, Vol. 99, pp. 75–94.
- Cantista, I. and Tylecote, A. (2008), “Industrial innovation , corporate governance and supplier-customer relationships”, *Journal of Manufacturing Technology Management*, Vol. 19 No. 5, pp. 576–590.
- Cao, Y.-H., You, J.-X. and Liu, H.-C. (2017), “Optimal Environmental Regulation Intensity of Manufacturing Technology Innovation in View of Pollution Heterogeneity”, *Sustainability*, Vol. 9 No. 7, p. 1240.
- Catalano, A. (2013), “Patterns of graduate students ’ information seeking behavior : a meta-synthesis of the literature”, *Journal of Documentation*, Vol. 69 No. 2, pp. 243–274.
- Cauchik, P.A., Fleury, A., Mello, C.H.P., Nakano, D.N., de Lima, E.P., Turrioni, J.B., Ho, L.L., *et al.* (2012), *Metodologia de Pesquisa Em Engenharia de Produção e Gestão de Operações*, 2nd ed., Elsevier, Rio de Janeiro.
- Freeman, C., Dosi, G., Nelson, R., Silverberg, G. and Soete, L. (1988), *Technical Change and Economic Theory*, Burns & Oates.
- Goedhuys, M. and Veugelers, R. (2012), “Innovation strategies, process and product

- innovations and growth: Firm-level evidence from Brazil”, *Structural Change and Economic Dynamics*, Elsevier B.V., Vol. 23 No. 4, pp. 516–529.
- Goh, A.L.S. (2005), “Promoting innovation in aid of industrial development: the Singaporean experience”, *International Journal of Public Sector Management*, Vol. 18 No. 3, pp. 216–240.
- Hardaker, G. (1998), “An integrated approach towards product innovation in international manufacturing organisations”, *European Journal of Innovation Management*, Vol. 1 No. 2, pp. 67–73.
- He, Q. (2015), “Link education to industrial upgrading: a comparison between South Korea and China”, *Asian Education and Development Studies*, Vol. 4 No. 2, pp. 163–179.
- Hoon, C. (2013), “Meta-Synthesis of Qualitative Case Studies: An Approach to Theory Building”, Vol. 16 No. 4, pp. 522–556.
- Johannessen, J. and Olsen, B. (2009), “Systemic knowledge processes, innovation and sustainable competitive advantages”, *Kybernetes*, Vol. 38 No. 3/4, pp. 559–580.
- Juliao-rossi, J. and Schmutzler, J. (2016), “Persistence in generating and adopting product innovations: Evidence for manufacturing firms in a developing country”, *Academia Revista Latinoamericana de Administración*, Vol. 29 No. 2, pp. 125–146.
- Kivimaa, P. and Kautto, P. (2010), “Making or breaking environmental innovation?”, edited by Gollagher, M. *Management Research Review*, Vol. 33 No. 4, pp. 289–305.
- Koschatzky, K., Bross, U. and Stanovnik, P. (2001), “Development and innovation potential in the Slovene manufacturing industry: Analysis of an industrial innovation survey”, *Technovation*, Vol. 21 No. 5, pp. 311–324.
- De la Vega Hernández, I.M. and Barcellos de Paula, L. (2020), “Scientific mapping on the convergence of innovation and sustainability (innovability): 1990–2018”, *Kybernetes*, Vol. ahead-of-p No. ahead-of-print, available at: <https://doi.org/10.1108/K-05-2020-0328>.
- Li, W., Wu, W., Yu, B. and Foo, C.-T. (2015), “Is China transmuting to fast overtake the USA in innovation?”, *Chinese Management Studies*, Vol. 9 No. 1, pp. 8–26.
- Lichtenthaler, U. (2013), “The collaboration of innovation intermediaries and

- manufacturing firms in the markets for technology”, *Journal of Product Innovation Management*, Vol. 30 No. SUPPL 1, pp. 142–158.
- Liu, L. and Jiang, Z. (2016), “Influence of technological innovation capabilities on product competitiveness”, *Industrial Management & Data Systems*, Vol. 116 No. 5, pp. 883–902.
- Migdadi, M.M. (2020), “Knowledge management processes, innovation capability and organizational performance”, *International Journal of Productivity and Performance Management*, Vol. ahead-of-p No. ahead-of-print, available at: <https://doi.org/10.1108/IJPPM-04-2020-0154>.
- Nahm, J. and Steinfeld, E.S. (2014), “Scale-up Nation: China’s Specialization in Innovative Manufacturing”, *World Development*, Elsevier Ltd, Vol. 54, pp. 288–300.
- Nelson, R.R. (2006), *As Fontes Do Crescimento Econômico*, Editora da Unicamp, Campinas, São Paulo.
- OCDE/Eurostat. (2018), *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation, 4th Edition*, Luxembourg.
- OCDE. (2005), *Oslo Manual*, OECD, available at: <https://doi.org/10.1787/9789264013100-en>.
- Olausson, D. and Berggren, C. (2012), “Managing asymmetries in information flows and interaction between R&D, manufacturing, and service in complex product development”, *R&D Management*, Vol. 42 No. 4, pp. 342–357.
- Peters, M., Schneider, M., Griesshaber, T. and Hoffmann, V.H. (2012), “The impact of technology-push and demand-pull policies on technical change – Does the locus of policies matter?”, *Research Policy*, Elsevier B.V., Vol. 41 No. 8, pp. 1296–1308.
- Phusavat, K., Comepa, N., Sitko-Lutek, A. and Ooi, K. (2012), “Intellectual capital: national implications for industrial competitiveness”, *Industrial Management & Data Systems*, Vol. 112 No. 6, pp. 866–890.
- Piening, E.P. and Salge, T.O. (2015), “Understanding the antecedents, contingencies, and performance implications of process innovation: A dynamic capabilities perspective”, *Journal of Product Innovation Management*, Vol. 32 No. 1, pp. 80–97.

- Reynolds, E.B. and Uygun, Y. (2015), "Strengthening advanced manufacturing innovation ecosystems: The case of Massachusetts", *Technological Forecasting and Social Change*, Elsevier, No. December 2015, pp. 0–1.
- Rosenberg, N. (1996), "Innovation and Economic Growth", *OECD*, Vol. 2 No. 0277, pp. 487–513.
- Säfsten, K., Johansson, G., Lakemond, N. and Magnusson, T. (2014), "Interface challenges and managerial issues in the industrial innovation process", *Journal of Manufacturing Technology Management*, Vol. 25 No. 2, pp. 218–239.
- Saleem, H., Li, Y., Ali, Z., Ayyoub, M., Wang, Y. and Mehreen, A. (2020), "Big data use and its outcomes in supply chain context: the roles of information sharing and technological innovation", *Journal of Enterprise Information Management*, Vol. ahead-of-p No. ahead-of-print, available at: <https://doi.org/10.1108/JEIM-03-2020-0119>.
- Sharma, R., Jabbour, C.J.C. and Lopes de Sousa Jabbour, A.B. (2020), "Sustainable manufacturing and industry 4.0: what we know and what we don't", *Journal of Enterprise Information Management*, Vol. ahead-of-p No. ahead-of-print, available at: <https://doi.org/10.1108/JEIM-01-2020-0024>.
- Siau, K. and Long, Y. (2006), "Synthesizing e-government stage models – a meta-synthesis based on meta-ethnography approach", *Industrial Management & Data Systems*, Vol. 105 No. 4, pp. 443–458.
- Singh, S. and Dhir, S. (2021), "Modified total interpretive structural modelling of innovation implementation antecedents", *International Journal of Productivity and Performance Management*, available at: <https://doi.org/10.1108/IJPPM-05-2020-0239>.
- Sun, Y. and Du, D. (2010), "Determinants of industrial innovation in China: Evidence from its recent economic census", *Technovation*, Elsevier, Vol. 30 No. 9–10, pp. 540–550.
- Tello, M.D. (2015), "Firms' innovation, public financial support, and total factor productivity: The case of manufactures in Peru", *Review of Development Economics*, Vol. 19 No. 2, pp. 358–374.
- Tepic, M., Kemp, R., Omta, O. and Fortuin, F. (2013), *Complexities in Innovation*

Management in Companies from the European Industry, *European Journal of Innovation Management*, Vol. 16, available at:<https://doi.org/10.1108/EJIM-05-2012-0053>.

Wallin, J., Parida, V. and Isaksson, O. (2015), "Understanding product-service system innovation capabilities development for manufacturing companies", *Journal of Manufacturing Technology Management*, Vol. 26 No. 5, pp. 763–787.

Warren, M.P., Forrester, P.L., Hassard, J.S. and Cotton, J.W. (2000), "Technological innovation antecedents in the UK ceramics industry", *International Journal of Production Economics*, Vol. 65 No. 1, pp. 85–98.

Wong, S.S.K., Cross, J.A. and Mueller, P.S. (2018), "Impact of mentoring on practicing engineers : a meta-synthesis", available at:<https://doi.org/10.1108/JWL-10-2017-0097>.

Woodside, A.G. and Biemans, W.G. (2006), "Modeling innovation , manufacturing , diffusion and adoption / rejection processes", *Journal of Business & Industrial Marketing*, Vol. 20 No. 7, pp. 380–393.

Yin, R.K. (2014), *Case Study Research: Design and Methods*, 5th ed., SAGE Publications, Inc., Thousand Oaks.

Zahra, S.A. and Nielsen, A.P. (2002), "Sources of capabilities, integration and technology commercialization", *Strategic Management Journal*, Vol. 23 No. 5, pp. 377–398.

Zhang, J. and Duan, Y. (2010), "Empirical study on the impact of market orientation and innovation orientation on new product performance of Chinese manufacturers", *Nankai Business Review International*, Vol. 1 No. 2, pp. 214–231.

Table 1. Summary of the difficulties in technological innovation management according to the literature. Source: see references in the Table.

Code	Difficulties	References ¹
D1	Difficulties to obtain capital to innovate	[1,2,11–13,3–10]
D2	Difficulty in establishing the proper orientation for the innovation process	[1,3,14–16]
D3	Difficulty to track changes and understand the external environment	[1,9,14,17]
D4	Difficulty in managing technical complexity intrinsic to the innovation process	[1,3,21–27,4,7–9,11,18–20]
D5	Difficulty in obtaining adequate human resources	[3–5,7,10,12,28]
D6	Difficulties associated to regulatory restrictions	[6,7,9,28–30]
D7	Difficulty in managing external connections, such as relationships among universities, companies and customers	[3,4,31,32,5,7,8,20,22–24,28]
D8	Absence of initiatives that foster the promotion of innovations in business	[3,7,15,32]
D9	Organizational culture focused on short-term management	[10,16,31]
D10	Operational inertia	[13,17,18,33]
D11	Absence of a structured strategy for innovation management	[3,5,16,17]
D12	Difficulty in developing a profitable business model to commercialize products resulting from the innovation process	[6,9,11,15,20,24,29,34,35]
D13	Difficulties associated to internal policies	[8,18,35]

¹ 1. Säfsen et al. (2014); 2. Bas, Mothe, and Nguyen-Thi (2015); 3. Koschatzky, Bross, and Stanovnik (2001); 4. Sun and Du (2010); 5. Reynolds and Uygun (2015); 6. Busom and Vélez-Ospina (2017); 7. Bonnín Roca et al. (2017); 8. Lichtenthaler (2013); 9. Ardito, Messeni Petruzzelli, and Albino (2015); 10. Tello (2015); 11. Kivimaa and Kautto (2010); 12. He (2015); 13. Juliao-rossi and Schmutzler (2016); 14. Zhang and Duan (2010); 15. Warren et al. (2010); 16. Bergfors and Larsson (2009); 17. Badrinass and Vilà (2015); 18. Woodside and Biemans (2006); 19. Li et al. (2015); 20. Nahm and Steinfeld (2014); 21. Olausson and Berggren (2012); 22. Berry (2014); 23. Zahra and Nielsen (2002); 24. Bianchi et al. (2014); 25. Piening and Salge (2015); 26. Hardaker (1998); 27. Tepic et al. (2013); 28. Goh (2005); 29. Bi, Huang and Wang (2016); 30. Cao, You and Liu (2017); 31. Cantista and Tylecote (2008); 32. Bagherinejad (2006); 33. Azar and Ciabuschi (2017); 34. Wallin, Parida and Isaksson (2015); 35. Beynon, Jones and Pickernell (2016).

Table 2. Difficulties in innovation management – Oslo Manual. Source: (OCDE 2005, 113):

Factors	Items
“Cost factors”	“Excessive perceived risks”; “Cost too high”; “Lack of funds within the enterprise”; “Lack of finance from sources outside the enterprise” (“Venture capital”; “Public sources of funding”)
“Knowledge factors”	“Innovation potential (R&D, design, etc.) insufficient”; “Lack of qualified personnel” (“Within the enterprise”; “In the labour market”); “Lack of information on technology”; “Lack of information on markets”; “Deficiencies in the availability of external services”; “Difficulty in finding co-operation partners for” (“Product or process development”; “Marketing partnerships”); “Organisational rigidities within the enterprise” (“Attitude of personnel towards change”; “Attitude of managers towards change”; “Managerial structure of enterprise”); “Inability to devote staff to innovation activity due to production requirements”
“Market factors”	“Uncertain demand for innovative goods or services”; “Potential market dominated by established enterprises”
“Institutional factors”	“Lack of infrastructure”; “Weakness of property rights”; “Legislation, regulations, standards, taxation”
“Other reasons for not innovating”	“No need to innovate due to earlier innovations”; “No need because of lack of demand for innovations”

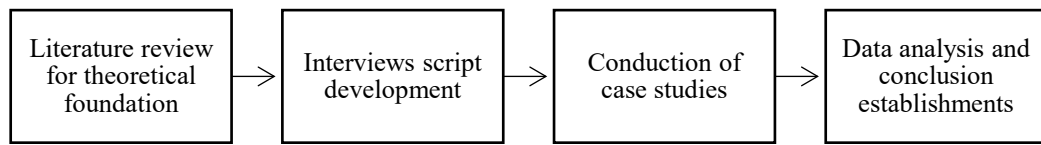


Figure 1. Stages conducted for research development.

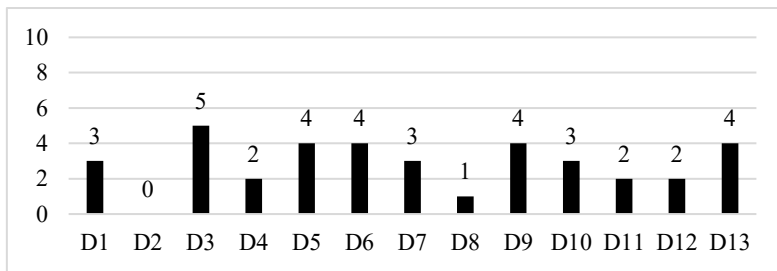


Figure 2. Scores attributed by the innovation director of company 1 for each difficulty.

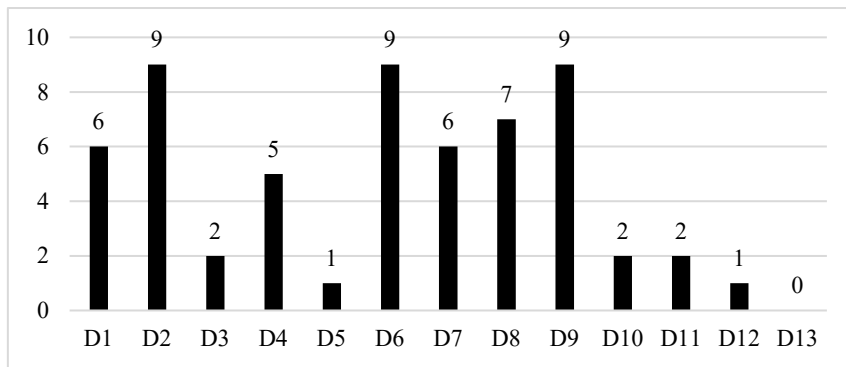


Figure 3. Scores attributed by the innovation director of company 2 for each difficulty.

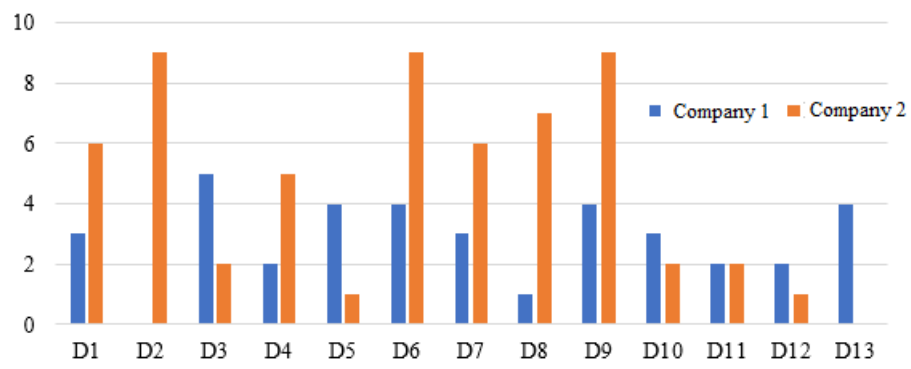


Figure 4. Comparison between the scores attributed by companies' directors.