



Assessing the impacts of innovation barriers: a qualitative analysis of Brazil's natural resources industry

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ABSTRACT

Innovation obstacles are present in any economy, especially in developing ones. This paper provides a qualitative assessment of innovation barriers faced by Brazilian firms in natural resources-related industries. Our findings suggest that financial obstacles are the main barrier for innovation efforts, especially for radical innovations, although firms sometimes do not know how to distinguish it from other barriers. Knowledge barriers also hamper firms to innovate regardless of their size, yet regulatory is more prominent on small firms. Finally, cooperation is a way to circumvent these barriers.

1. Introduction

Natural resources are essential inputs either for developed or still developing economies. Since they are unevenly distributed, trade across countries is extensive and has an important influence in each country's industrial specialization (Andersen et al., 2018). Developing countries with large natural resources supply face several economic market failures, which prevent them to fully capitalize all potential gains derived from their given means. Although some scholars argue that these might suffer from the Dutch Disease (Rodrik, 2016), others believe that natural resource-intensive industries offer opportunities for learning, innovation and diversification (Figueiredo and Piana, 2018, 2016), which eventually might promote sustainable development.

Companies in these countries, for example, often face all sorts of barriers to innovate (e.g. Gorodnichenko and Schnitzer, 2013). Overcoming these barriers is often a challenge since it hinders these companies' ability to increase their productivity, exports, and diversification. Recently, it has become a topic of great interest for policy-makers and industry stakeholders – especially because those industries have become even more central to some developing economies, such as Latin American countries. In fact, those industries are also seen as windows of opportunity in the growth process of some Latin countries (Crespi et al., 2018).

This paper presents results of a qualitative analysis, which aimed to explore the gaps encountered in the existing literature, particularly from

papers recently published about barriers to innovate in Latin American countries (Arza and López, 2018; Bukstein et al., 2018; Canêdo-Pinheiro et al., 2019; Zahler et al., 2018). For this qualitative analysis, we interviewed three R&D directors and a CEO from four different natural resources-related companies in Brazil. The following qualitative results come from a semi-structured questionnaire built from the quantitative results of four reports on barriers to innovate in Latin American countries that shares the importance of natural resources in their economies, namely Argentina, Brazil, Uruguay, and Chile. To the best of our knowledge, there are not many papers connecting barriers to innovate and natural-resources industries, especially regarding developing countries. Similar works include, for example, research on innovation in some specific natural resource industry in Latin America, such as mining (Pietrobello et al., 2018). Thus, our paper contributes to the literature on evaluating the barriers to innovation in natural-resource industry by making a qualitative analysis for different firm's size.

The remainder of the paper is as follows. Section 2 provides a literature review on resources-based industries and innovation hurdles. Additionally, Section 3 stresses the method for our qualitative strategy, including research design, selection criteria, data collection, and data analysis process. Section 4 explores the results of our qualitative analysis. Finally, Section 5 outlines the paper's final remarks.

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2. Literature review

In this section, we present theoretical and empirical elements regarding two important elements for our research: natural-resources industries and barriers to innovation.

2.1. Natural-resources industries

Since the commodities' boom initiated in the early 2000s due to the increase Chinese demand for these goods after joining the World Trade Organization, most countries with high natural resources exports faced continuous high growth rates. This new paradigm extended the debate on the so-called 'Dutch disease' or 'resource curse' (Auty, 1993). Most of these numerous studies are based on macroeconomic evaluations using different methodologies, yet they are not conclusive (Andersen et al., 2015).

On one hand, part of the literature advocates that natural resources do more harm than good based on different reasons. For instance, some scholars claim that it reduces the size of the manufacturing industries (e.g. Papyrakis and Gerlagh, 2006) or leads to an economic stagnation (Sachs and Warner, 2001, 1999). Others affirm that countries with high dependence on natural resources are vulnerable to corruption (Auty, 1993) or that their spillovers are limited when compared to manufacturing countries (Papyrakis and Gerlagh, 2006; Sachs and Warner, 2001).

On the other hand, another stream of this debate argues that natural resource-related industries may offer technological leadership and economic development if some systematic efforts are made – as is the case of Nordic countries (Fagerberg et al., 2009). There is also a growing sense that natural resources can be a platform for a development strategy for latecomer countries (and companies) (Figueiredo, 2010; Figueiredo and Piana, 2018, 2016) – specially for Latin America (Perez et al., 2014). Later studies comparing traditional industries related to natural resources (food products, oil, non-metallic minerals, etc.) show that they have higher technological opportunities compared to industries classified as high tech in the standard industry taxonomies [e.g. TV and communications and electrical machineries (Marin and Petralia, 2018)]. In recent years, most of Latin America countries are developing strategies to aggregate value to those products, mainly because of their competitiveness in the international market (Crespi et al., 2018), especially because the commodities boom and consequently the change in the terms of trade, which seems to be a long term effect (Helbling, 2012).

However, creation of interactions with other industries is fundamental for obtaining all possible benefits derived by natural resource-related industries. Building an institutional framework for natural resources that supports development of knowledge and competences is the key aspect. Findings from the literature argues that institutions play a relevant role in resource curse (Halvor et al., 2006). In the end, the most important thing is to develop innovation systems able to generate economic development – and natural resources industries definitely can contribute to that (Andersen et al., 2015).

2.2. Barriers to innovation

In the innovation literature, barriers to innovation has been given less emphasis than innovation drivers (Hadjimanolis, 2003). However, since many governments implemented policies dedicated to providing incentives to innovation, there is a recent trend to place innovation barriers at the center of innovation policy. Analyzing barriers to innovation allows us to focus on the innovation process, especially from an innovation policy perspective. That includes understanding which factors most constrain innovative activity among countless factors that can affect innovation (Hölzl and Janger, 2012).

Most of the literature divides innovation barriers at the firm level into internal and external (Hadjimanolis, 2003). Internal innovation barriers can be defined as factors that affect innovation process within

enterprises, so they are primarily an issue of management, organization, and firm's competences. External innovation barriers are the lack of external innovative drivers related to institutions and market. While internal innovation barriers can be considered organizational screening devices, which filter innovation projects, external innovation barriers emerge when the firm interacts with other economic agents (Hölzl and Janger, 2012).

Among all the obstacles faced by companies to innovate, the economic literature has focused its attention on financial obstacles to innovate [see (Hall, 2002) for a literature survey on financial barriers]. Recent papers on innovation obstacles [see (Álvarez and Crespi, 2015) as an example] remain emphasizing access to credit as the main barrier to innovate and other aspects have been neglected, such as market constraints, access to knowledge, regulations, and others. Due to the availability of different waves of innovation surveys in different countries, literature started to find that these other barriers are as relevant as financial constraints [see (Pellegrino and Savona, 2017) for the UK and (Mohan et al., 2016) for the Caribbean countries], especially market conditions. For the southern countries in Latin America, recent work was done for Argentina (Arza and López, 2018), Brazil (Cãnedo-Pinheiro et al., 2019), Chile (Zahler et al., 2018) and Uruguay (Bukstein et al., 2018), which showed the relevance of regulatory and knowledge barriers. There is scarcity knowledge on the effects of these other barriers to innovation, especially in developing world.

Some of the factors affecting the innovation barriers discussed in the literature include: (1) firm's size; (2) firm's growth; (3) international and national linkages of firm's activities; (4) sectoral innovation intensities. In addition, the barriers to innovation themselves are: financial; skill barriers to innovation; lack of information on technology; lack of information on markets; and lack of innovation partners (Hölzl and Janger, 2012). However, we limited our investigation to five categories of innovation obstacles based on the questions available in the Brazilian innovation survey: financial; knowledge; market; organizational; regulatory. We discuss further details in Section 4, followed by a discussion on whether and how cooperation could be a way to circumvent these barriers.

3. Method

3.1. Research design

The specific objective of this paper was to enlight and articulate discussions on aspects which are not captured by quantitative results from existing literature, particularly on studies aimed in Latin American countries (Arza and López, 2018; Bukstein et al., 2018; Cãnedo-Pinheiro et al., 2019; Zahler et al., 2018). We follow the literature by generalizing our findings from a case study research of four innovative Brazilian companies (Eisenhardt, 1989).

Despite considering the firm as an important initial point, we concentrate our focus on the obstacles encountered in the innovative process by the selected companies – in terms of specific obstacles related to a particular type of innovation. Hence, we dedicate our research on analyzing the obstacles themselves (orientation to the object). Since the few selected companies represent different types of Brazilian business environment, we argue that any generalization will be better represented in terms of the obstacles these companies encounter rather than the firm themselves.

We have also investigated the concept of failure – not only its meaning to the interviewees but also on what it represents in terms of barriers to innovation. This comes from the perception that the interviewee may consider failure to be the common sense meaning (i.e. a specific result of any effort that ends in some sort of flop) or the result of the firm strategy (i.e. not necessarily a bad thing, but a common end to an innovative effort). This is an important topic for a vast body of literature (e.g. van der Panne et al., 2003). It is important to mention that the interviews were made in Portuguese and this language has

different words for failures. In most cases, the Portuguese word ‘*insucesso*’ (unsuccessfulness) was used – this word has a softer meaning than the literal translation of failure into Portuguese.

3.2. Selection criteria

Companies chosen for our qualitative analysis need to meet two criteria: be well known for innovating in their specific area; and operate in natural resources-related activities. As barriers might differ across companies’ size, we interviewed two large companies and two small ones. Our first criterion was met by selecting those that were listed as the most innovative Brazilian companies considering ‘*Inovação Brasil*’ from 2015, 2016, and 2017 (Valor Econômico, 2015; Valor Econômico, 2016; Valor Econômico, 2017). This publication is elaborated by PricewaterhouseCoopers in association with *Valor Econômico* (Brazilian most important business newspaper). Since its first edition, launched in 2015, it is the most trustworthy publication regarding Brazilian most innovative companies. Through qualitative and quantitative evaluation, the ‘*Inovação Brasil*’ report analyzes all Brazilian companies with at least 5% of private equity in its capital share and net income higher than 500 million BRL in one of the last two fiscal years. The ‘*Inovação Brasil*’ report lists 100 companies from 18 different sectors annually. Since this report only include large companies, it was not feasible to select the two small companies from this publication. Since natural resources are an important driver for the Brazilian economy and most of its innovating companies come from this type of industrial activities, especially those who export, we selected that as our second criterion. Also, innovative companies are usually more aware of the difficulties encountered in the innovation processes, even when without preventing them from pursuing innovation projects (Baldwin and Lin, 2002; Galia and Legros, 2004).

After some consideration, we chose two companies from the ‘*Inovação Brasil*’ reports of 2015, 2016 and 2017 and two others used in Cândido Pinheiro et al. (2017).¹ The companies did not want to be identified by their names, so from now on we will use Greek letters to identify them.

Alfa, our first selected firm, is one of the largest Brazilian companies in the sugarcane industry, employing nearly 13 thousand workers. Inside market circles is well known for being the most innovative firm in the sugarcane industry and most of its sugar production is exported to Asia, Europe and the United States. Brazilian sugarcane companies produce sugar and bioethanol for automobiles and Alfa is known for a high productivity in both segments. One of its most innovative efforts was to create new varieties of sugarcane with higher productivity and another was developing new machinery for sugarcane harvest in association with automobile companies.

The second firm is a multinational steel firm that has a global R&D center in Brazil: Beta. This firm is known as one of the greatest innovators in the steel market and even its competitors acknowledge its leadership. It employed more than 10 thousand people in 2019. In a recent effort to produce a new type of steel, this firm had to deal with regulation-related issues on the energy market that almost lead to the discontinuation of its product.

The third one is a small-size equipment firm with less than 100 employees that supply its products to large mining, oil and gas and pulp and paper companies: Gama. Although it is not alongside the biggest players in Brazil’s industry, it is well known for different innovating activities.

The fourth and last selected firm is a small oil and gas player that has different innovations on its portfolio: Zeta. This company is a spillover

originated from Petrobras² Research Center (CENPES) and has a wide range of products that meets the needs of oil exploration in ultra-deep waters. It is the smallest firm in our sample, with only 30 employees. Table 1 summarizes company’s main characteristics.

3.3. Data collection

To meet our goals, we contacted the four chosen companies by telephone or e-mail. Some of the companies were in Brazil’s countryside, so we used telephones for the interview. Only Beta’s representatives were interviewed in their respective offices. All interviews took place between October and December of 2017 and they were recorded and transcribed. The average time per interview was 30 minutes. We contacted the companies in other opportunities to deepen our impressions, but those were not recorded.

As our main goal is to understand how barriers hamper companies to innovate, our approach was to interview those responsible for the innovation in each firm. We chose to interview them because they have a wider view of the whole innovation process as well as a broader understanding of the internal and external factors affecting their activities. We ended up interviewing those who could really tell us about the company R&D efforts and struggles, such as R&D directors or CEOs. In the end, we interviewed Alfa, Beta, and Gama’s R&D directors and Zeta’s CEO – who is also in charge of the company’s R&D activities.

We used a semi-structured questionnaire with open-ended questions. We used an interview guide from three main topics detailed into six broad questions in the meetings to assist the researcher throughout the interviews. The precise object of the interview was not to explicitly answer the questions, but to get aware of the obstacles preventing innovation in Brazil’s companies. The interviewees were encouraged to speak freely in their answers since we elaborated open-ended questions in our questionnaire. We captured information that reflected the variability needed to understand the phenomenon studied in the research (Patton, 2002) and the collected cases provided relevant examples of the phenomena under scrutiny (Siggelkow, 2007) with minimum of analytical generalization (Yin, 2009).

We emphasize that the aim of our qualitative approach was to complement the results found in the quantitative analysis regarding the difficulties to innovate in Brazil’s business environment. As a reference, we consulted the firm-level data questionnaire from the Brazilian Innovation Survey (PINTEC), in Portuguese. Hence, some questions tried to unpack some of the PINTEC’s questions – especially the ones that

Table 1
Summary of companies’ information.

	Number of employees in 2016 (proxy)	Sector/ Industry	Ownership	Other information
Alfa	13.000	Sugar and biofuels	Anonymous Society, Brazil	Leading innovative firm
Beta	10.000	Steel	Multinational	One of the biggest steel firms in the world
Gama	100	Oil and Gas/ Paper and Pulp supplier	Familiar, Brazil	Leading innovative firm
Zeta	30	Oil and Gas	Familiar, Brazil	Spillover originated from Petrobras Research Center (CENPES)

¹ Cândido-Pinheiro et al. (2017) investigates how the technological capabilities accumulation enables firms and sectors to improve their competitiveness through a qualitative assessment of innovative Brazilian firms from different sizes, including SMEs.

² Petrobras is the Brazilian National Oil Company and the dominant player in the Brazilian market.

ask companies on innovation obstacles.

Our interview guide was built from the companies' reports on its biggest obstacles and achievements in terms of innovation. From there, we asked them about all the steps in each scenario, pointing out all obstacles along the way and how did they work around them (if so). We tried to connect each obstacle pointed by the companies with a specific category of barrier listed in PINTEC's questionnaire. We added or withdrawn some questions depending on the interviewed firm.

3.4. Data analysis

We used a CAQDAS (Computer Assisted Qualitative Data Analysis) software called NVivo to organize, manage, and analyze our qualitative data. NVivo is a proprietary software commonly used for qualitative analysis like ours (Bazeley and Jackson, 2013) and is referred to as an excellent tool to explore multiple meanings in the data (Richards, 2002). It also makes possible to become aware of gaps in the collected data (Wickham and Woods, 2005), to revisit data with new conceptual lens (Sin, 2007) and reflect on social construction of research evidences (Kaczynski and Kelly, 2004).

NVivo offers a range of visualization possibilities that are used to better understand and analyze our interviews sample. First, we use a case map to link words that were used by our interviewees – this gave us a better sense of how the nodes (words) told the history from the perspective of each participant. Then, we used a chart to compare our data and to give us an alternative view of our results. We also created relationships between the mains concepts of our research (innovation, barriers, etc.) and used it to better analyze the data.

Our main goal in the software was to make a qualitative matrix analysis, where information from interviewed companies was compared and analyzed. This is an efficient way to contrast data from all in-depth interviews and it helps us to make sure no information is lost on the analysis process.

4. Results and discussion

From our qualitative matrix analysis and data generated by NVivo, we organized our research findings into two different categories. First, we summarized the results from the quantitative analysis generated from micro-level data from different papers (Arza and López, 2018; Bukstein et al., 2018; Cãnedo-Pinheiro et al., 2019; Zahler et al., 2018). Results from these papers are summarized in Table 2. All papers include finance, knowledge, market, and regulation barriers. Brazil's paper also analyses organization barriers, meanwhile Uruguay's paper analyses context barriers and Chile's paper analyses demand-related barriers. We also separate the results from Brazil's paper between product and process innovation.

4.1. Understanding the quantitative outcomes through qualitative assessments

Results derived from four studies on barriers to innovate in Latin American countries using similar strategies and database (Arza and López, 2018; Bukstein et al., 2018; Cãnedo-Pinheiro et al., 2019; Zahler et al., 2018) were considered in our qualitative analysis. Additionally,

we also tried to understand other innovation-related topics, such as interpretation of each obstacle, identification of different hurdles (internal and external) faced by the companies along the innovation cycle, how they deal with obstacles and their understanding of the concept of failure. In some cases, we asked the interviewee to tell us a story of a successful innovation created by the firm and another story of a failed innovation project.

At first, one can say that most of the results found on the literature (Arza and López, 2018; Bukstein et al., 2018; Cãnedo-Pinheiro et al., 2019; Zahler et al., 2018) were confirmed by the interviewees. The only contradictory view was related to higher organizational obstacles for multinationals and companies that belong to groups in the eyes of Alfa's representative, which was found in the Brazilian quantitative analysis (Cãnedo-Pinheiro et al., 2019). For him, in terms of organizational barriers, there was no distinction between bigger and smaller companies.

4.1.1. Financial barriers

Regarding financial barriers, the interviewees stressed that they feel the government should help them with more radical innovations, mainly through financing. Our interviewees acknowledge that radical innovations are riskier, therefore support for its development might stimulate them, because it mitigates the market failure for this type of investment. They claim that financial support is essential for radical innovation because it involves large investment with uncertain results, especially because demand for its new products is uncertain. As shown in Table 2, financial barriers affect innovation negatively in all consulted papers.

Companies understand the concept of innovation cycle, but it was hard for them to stress which barriers affect each stage of this cycle. In the majority of the cases, the interviewees said financial hurdles were the most important and affect innovation cycle as a whole despite the innovation stage. When innovation is more radical, this is more relevant in the first stages of the cycle. According to the results from South American countries' investigations, financial barrier is the most robust result on preventing firms to decide to innovate (propensity to invest in innovation) as well as on the magnitude of this decision (total amount spent on innovation). Here, there is also a difference for companies with different sizes. Smaller companies complain about financial hurdles with more emphasis than the bigger ones. For smaller companies, financial barriers are perhaps the biggest hurdle for their innovation efforts – and the Brazilian business environment can often worsen that. In other words, financial barriers are relevant hurdles not only on innovation inputs (expenditure in innovation, either its propensity or its magnitude) but also in innovation outputs (product and/or process innovation).

Zeta's representative told us that their hurdles increased exponentially after they started to export their products. Brazil's business environment is well known for its complexity, but it seems that companies internalize this reality as it is and focus more in cost reduction in the search for greater competitiveness. It seems that in many cases, exports are unintended results from companies' competitive environments. In other words, Brazil's chaotic logistics makes exporting so difficult that those companies tend to do it when facing extreme competition or lack of internal demand. In most cases, being innovative and exporting at the

Table 2
Barriers to innovation.

Barriers	Argentina	Chile	Uruguay	Brazil	Brazil Product	Brazil Process
Finance	Negative	Negative	Negative	Negative	Negative	Negative
Knowledge	Non-Significant	Non-Significant	Negative	Negative	Negative	Negative
Market	Negative	Negative	Negative	Non-Significant	Non-Significant	Non-Significant
Regulation	Non-Significant	Negative	Non-Significant	Non-Significant	Positive	Negative
Organizational				Non-Significant	Negative	Non-Significant
Context			Negative			
Demand		Negative				

same time financially constrains companies located in catching-up countries and it hampers their private sector development (Gorodnichenko and Schnitzer, 2013).

Financial constraints are key to understand how companies postpone their innovation investments (as pointed out by Zeta's representative) and how it affects the innovation process all along the innovation cycle (as pointed out by Gama's representative). However, it is important to emphasize that interviewees might also confuse what kind of barriers they are referring to. For instance, Beta's representative described the import tariff for capital goods as a financial barrier, while it is essentially a regulatory obstacle. The argument was that investing in new imported machinery would cost the company 40% more. In other words, the company has to spend 1.4 million dollars for a capital good priced one million dollars in the international market. Therefore, the conclusion was that the government should reduce this "financial obstacle". In other words, the barrier faced is a regulatory one that makes imported capital goods more expensive for domestic companies, therefore reducing the import tariffs alleviate the firm efforts to innovate. As observed, financial barriers might also correspond to other types of obstacles.

4.1.2. Regulatory barriers

Regulatory obstacles were expected to be one of the main barriers in our interviews but that was not the case for all companies. Alfa's and Beta's representatives pointed out that they have the means to dialogue with government in federal and state jurisdiction. Beta's representative informed us that they have a permanent access to government committees, for example. Gama and Zeta have more difficulties regarding regulatory barriers, but they underline that those barriers were not as important as one may think. The literature points out that regulation barriers are usually important to reduce companies' innovation propensity (Pellegrino and Savona, 2017; Zahler et al., 2018). As an example, some of them pointed out that Brazil has recently dedicated some regulations for innovation purposes, such as the 'Lei do Bem'. In Brazil, those regulations are often very complex and bigger companies tend to benefit more because only those companies have the means to allocate workers in company's areas dedicated to get this funding.

Those results for regulatory barriers show us how their impact differs according to firm's size. Interviewing small and large firms provide us evidence on the heterogeneity of regulatory barriers effects on distinct firms' size. Previous studies suggest that regulatory obstacles reduce the chance of doing innovative activities, yet our qualitative findings emphasize that regulatory barriers affect companies disproportionately according to their size, where smaller firms face higher shortcomings. Since all the companies in our sample are in natural resources-related industries, we tried to exemplify regulations barriers as the ones found in environmental laws. Companies pointed out that sometimes their innovative processes and products are ahead of the regulations, and they must wait for it to be updated, so they can launch it. Even so, Zeta's representative highlighted that regulation does more good than harm for their company.

4.1.3. Knowledge barriers

As for the knowledge obstacles, it is not hard to imagine that bigger companies such as multinationals and companies that belong to groups face fewer barriers in this area, as suggested by Brazil's and Uruguay's papers. Both Alfa's and Beta's representatives underline that it is easier for them to get to know the most innovative efforts in their industry since they have financial means and dedicated workers. Gama and Zeta are smaller and more specialized companies and their representatives pointed out that they try to be as quick as possible to follow bigger leader companies in their industry regarding more innovative products.

Comparing Latin American countries outcomes with other regions, it seems that country's level of human capital tends to lessen the importance of knowledge barriers. While firms in large and developed economies, like the United Kingdom [see (Pellegrino and Savona, 2017)], do

not present any impact of knowledge barrier in their innovation efforts, firms in developing and smaller countries, such as those in the Caribbean region [see (Mohan et al., 2016)], are hampered by knowledge obstacles when they try to innovate. In this regard, Brazil due to its lower human capital and Uruguay, for its limited domestic market, tend to suffer more from knowledge barriers compared to Argentina and Chile, both being larger than Uruguay and with more human capital than Brazil.

4.1.4. Market barriers

This analysis can be further interpreted by the absence of market barriers mentioned in our interviews, which is also an outcome found in the Brazilian investigation (Cáñedo-Pinheiro et al., 2019). However, market and demand obstacles affect negatively firms' innovation efforts in Argentina, Chile and Uruguay. Considering that Brazil is the largest economy compared to these other South American countries, our interpretation is that having a diversified market lessened their barriers to innovation. Given that these three countries will not be able to have a domestic market the size of Brazil, they need to look at the external market (exports) in order to circumvent this shortcoming.

Nevertheless, business cycle is a relevant aspect for innovation patterns (Geroski and Walters, 1995) and one of our interviewees pointed that the Brazilian economic downturn in 2015/16 (the steepest recession in Brazilian economic history) was a challenging moment for them, since lower demand impose higher risks for their innovation strategy. This is a neglected aspect in Cáñedo-Pinheiro et al. (2019) because the Brazilian innovation survey does not ask about economic cycles directly, only indirectly through lower market demand. Only Uruguay's innovation survey query firms about macroeconomic stability as a relevant barrier; however, the quantitative investigation using Uruguayan data renames it as context barrier by adding poor infrastructure as another possible explanation of the "context". According to this paper, context barrier affects negatively firm's innovation outcomes, yet we are not sure if this represents poor infrastructure or macroeconomic stability. In summary, we believe that macroeconomic stability might interfere in innovation patterns, but not as strongly as expected by the literature.³

4.1.5. Organizational barriers

In terms of organizational obstacles, it was clear that shortcomings increase with firm's size. The R&D director of the larger and only multinational firm in our sample (Beta) stressed organizational barrier as an important hurdle for its company development. Zeta's CEO underline that because of the size of its firm, it was easier for them to change their innovative strategy when compared to bigger companies. However, the literature underlines that larger companies are usually less vulnerable to barriers to innovation, including organizational (Canepa and Stoneman, 2005; Mohnen and Röller, 2005).

4.1.6. Cooperation

The common denominator between all companies was the role of cooperation in their innovative process. All of them pointed out that cooperation is essential for their innovative performance. According to our interviewees, open innovation model is much more efficient mainly because it is more agile and less expensive. There are some concerns regarding the divisions of intellectual property rights, but those are not reasons to end the partnerships in most cases.

Our interviewees also mentioned that cooperation with other economic agents might help tackle financial barriers and risk-related

³ The last Brazilian innovation survey from 2017, which includes the recession period (2015/16) provides further evidence on our interpretation. While some innovation indicators, such as process innovation, have dropped when comparing the last three innovation surveys, others increased (product innovation) or remained stable (expenditure on innovation over revenue). Therefore, unstable macroeconomic environment is relevant barrier for innovation efforts, yet its strength remains debatable.

innovation costs. The literature shows negative impacts of innovation barriers in terms of delaying, abandoning or not initiating innovative projects (Canepa and Stoneman, 2005; Hölzl and Janger, 2012).

In our interviews, all representatives said cooperation with research institutions is very important for them. But only a handful mentioned suppliers or clients. Literature (Crespi et al., 2018; Figueiredo and Piana, 2018) shows that knowledge-intensive service firms are essential to natural resource-related industries. Particularly in the oil & gas industry, R&D activities were transferred from operators to suppliers (Economides and Texas, 1995; Jacquier-Roux and Bourgeois, 2002). In the Brazilian market, oil companies are under a minimum national content regulation and mandatory R&D investment clause, which potentially reinforces that transfer at the local level and the role of Brazilian knowledge-intensive service firms.

However, of the two oil and gas related interviewed companies, only Zeta reported that knowledge-intensive service firms were key to their current level of competitiveness. This result deserves more investigation in the future, but it can mean that those regulations had a minor impact on fostering the relations between oil companies and local service firms, as well as that those knowledge-based firms have played only a minor role (Mancini and Paz, 2018).

Alfa, from sugar and biofuel sector, also mentioned that knowledge-intensive service firms were important. This result confirms the relevance of cooperation and partnerships with other companies to explain the successful accumulation of innovative capabilities in this sector, at least in the context of the Brazilian sugar and biofuel market (Figueiredo et al., 2016).

4.1.7. Summing up

We can also add that companies clearly see differences between internal and external barriers to innovate. However, they tend to affirm external barriers are more relevant than internal ones. That includes lack of funding for radical innovation from the government and lack of skilled workers for innovation-related jobs.

Comparing quantitative and qualitative analysis, our evidence shows that both approaches present similar conclusions. In the quantitative approach, financial aspects are the most cited obstacle by innovators, followed by knowledge barriers, which were also explored extensively by our interviewees in our qualitative analysis. Our interviewees qualify these barriers by stressing that radical innovations are the most hampered by financial barriers. Regulatory, market and organizational are also undermined in both approaches.

4.2. Exploring extra areas not covered by quantitative analysis

Regarding failure, we sensed that it was difficult for the representatives to assume their company had any sort of failure in its innovation process sometime in the past. However, when we soften the term and ask for the least successful experiences in their innovation processes, we were able to get a glimpse of some hurdles. The most common case was to postpone innovation until they had more capital or until there were changes in some restrictive regulation. That normally seems to be the case since companies which abandon projects tend to be more subject to economic barriers than to technological or organizational ones (Galia and Legros, 2004). Additionally, financial constraints tend to hamper the beginning of regular projects, while skill and knowledge barriers slow down innovative projects (Mohnen et al., 2008).

One of the interviewees underlined that there is a difference between not reaching the goal imagined by an innovation and not understanding why that happened. Sometimes, even when a goal is not achieved, the learning of this initiative becomes an important asset for the firm. In that case, one may consider a failure as a learning opportunity rather than a waste of time.

There were also other common denominators between companies in this set of questions. All the interviewees said their superiors support innovation and understand the barriers as they are referred in

innovation surveys. They all characterized the innovation cycle in the same manner and saw differences between internal and external barriers to innovate.

It was hard for the interviewees to think on how the barriers relate to failure on innovation process. They tend to believe that the reason for failures in innovation processes is mainly internal. However, at the same time, they do not see organizational barriers as an important factor for innovation performance in their specific companies – only in a more generic manner. Financial and regulatory hurdles are considered to be external and more related to non-innovative activities in the firm.

The relationship between the firm size and its innovative performance was also an interesting topic of discussion. On one hand, larger companies (Alfa and Beta) claimed that their size helped their innovative performance because they had more money to invest in innovation activities and had access to resources that were not available to smaller companies. On the other hand, Zeta's representative claimed that their smaller size usually helps its company innovation activities because of their agility and specialization. However, the recent Brazilian economic crisis hampered some of their R&D investments because of their limited size.

One of the most discussed topics by our interviewees was the mindset limitations regarding innovation on Brazilian culture. It is difficult to evaluate further something that is beyond innovation surveys and relates more to cognitive sciences. The so-called 'mindset' barrier is a recurrent research subject in the literature (Assink, 2006; Baker and Sinkula, 2002; Sinkula, 2002). It is often associated with the ability to unlearn in the firm i.e. the process by which people and companies eliminate the traditional way of doing something and substitute it with something new (Assink, 2006).

Particularly, we found hard to believe that this limitation is as representative as the interviewees made it seem. They failed to justify this opinion and often compared Brazil with more developed countries and their more developed business environment. In the end, it is reasonable to assume that under a different business environment, those mindset limitations regarding innovation would change, as it is the case for some of Brazil's most competitive industries.

5. Final remarks

This paper has explored some interesting elements regarding the impacts of obstacles on innovation. From only four interviews, we were able to get a glimpse of the Brazilian business environment and how different barriers affect companies from different industrial sectors and sizes.

Our main findings suggest that financial obstacles are the main barrier for innovation efforts, especially for radical innovations. Firms reported that financial obstacles impinge their innovation efforts during the whole innovation cycle, but it affects more in the early stages when radical innovation takes place. All companies interviewed pointed out that the lack of resources prevents them from innovating, including the possibility of interrupting an innovation process that has already started. Nonetheless, firms also confuse financial barriers with other obstacle types. This raises caution with results of innovation surveys that indicate that most companies face financial obstacles, as respondents may not distinguish exactly what each obstacle represents. Knowledge barriers also prevent companies to implement innovation, yet at a lower importance compared to financial aspects. Moreover, hurdles encountered by companies in this regard decrease as firm's size increases. In other words, growing is an important aspect for reducing knowledge barriers. Findings for market obstacles, including macroeconomic volatility, suggest a resistance to innovate, but the strength of this barrier needs further investigation, because results from quantitative are blurred and firms have not mentioned market obstacles as the crucial ones.

Although our selected companies converge in a diverse range of topics regarding obstacles to innovation, differences between large and

small companies emerged. On one hand, larger companies claimed that they could dialogue with governments on legislation that affect their businesses; therefore, regulatory barriers are lessened by their size. On the other hand, small companies affirmed that they face higher obstacles to regulatory issues compared to larger companies. In summary, regulatory barriers importance decreases with firm's size.

Interviewees reported that cooperation is a way to overcome the barriers faced in their innovation process. More specifically, our qualitative analysis suggests that cooperation with universities and research institutions seem to be the most frequent. In terms of failure, our interviewees refrain to admit their non-successful innovation projects. According to them, any project that was not able to reach the final stage of innovation process was always postponed until they were able to overcome the faced obstacle. Furthermore, any "failure" is also considered as a learning opportunity that can be used in the same project at a later stage or even in a different project.

Although our qualitative analysis provides some insights on the obstacles faced by large and small companies, some limitations can be highlighted. Ideally, interviewing employees at different hierarchical levels in the company and having more than one observation period could allow us to understand in more detail how the obstacles affect the company's innovation activity. Furthermore, increasing the number of interviewed companies could provide robust evidence for generalizations on the subject, but our results seem to be in line with quantitative analysis found in the literature, which means that our focus on the object rather than the firm seems plausible.

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Appendix A. Supplementary data

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