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Startups, SMEs and Institutional Arrangements in the Internet of Things Innovation Ecosystem in Brazil

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Abstract

Startups and Small and Medium Enterprises (SMEs), despite their importance to the local economy, generally have limited resources and face significant barriers to innovate and grow, such as lack of access to knowledge, human resources, and efficient forms of financing. This paper reports preliminary results of a research project that aims to analyze the institutional arrangements in the Brazilian Internet of Things (IoT) innovation ecosystem and how these arrangements support the innovation by startups and SMEs. The research method is a longitudinal case study. The preliminary research results show the main groups of actors and resources involved in the IoT innovation ecosystem in Brazil. The results also suggest that the institutional arrangements in this ecosystem usually favors the big players; several controversies exist regarding key elements of the institutional pillars elements related to the IoT development in the country. Besides, the knowledge diffusion about the IoT and its potential is still needed.

Keywords: Internet of Things, Innovation Ecosystem, Institutional Theory, Startups and SMEs

1. Introduction

The IoT is a technological platform that allows for countless innovations in products, services, and processes (Barrett et al., 2015; Ben-Daya et al., 2019; Borgia, 2014; Gubbi et al., 2013). It can be applied in the most varied domains, including manufacturing, smart cities, healthcare, agriculture, smart housing, logistics, education, and tourism, among others. (Borgia, 2014). The IoT is also a key technology for the development of Industry 4.0, the new industrial paradigm in which the integration of manufacturing processes and connected products can help companies to achieve higher industrial performance (Dalenogare et al., 2018).

Therefore, creating an innovation ecosystem for the development of innovations based on the IoT is fundamental for the competitiveness of countries around the world (Vermesan & Friess, 2014). The term innovation ecosystem uses a biological metaphor that defines an emerging, self-organizing and self-sustaining system (Thompson et al., 2018). It is defined here as the evolving set of actors, activities, and artifacts, and the institutions and relations that are important for the innovative performance of an actor or a population of actors (Granstrand & Holgersson, 2020:1). An innovation ecosystem is analogous to an organizational field because it has its own institutional arrangements, including its institutional actors (and respective roles), institutional logics, and governance structures (Autio & Thomas, 2014).

The institutional arrangements in an IoT innovation ecosystem should promote the development of all its members, not only large but also small and medium-sized local companies (SME) and startups. Emerging technologies do not necessarily create economic value; they need to be leveraged and exploited by entrepreneurs (Steininger, 2019). In this sense, contextual knowledge from local entrepreneurs is essential to develop innovations based on the IoT considering some of its capabilities, for example, context awareness and

customization (Atzori et al., 2010; Borgia, 2014). These capabilities can be exploited by local SMEs, smaller and more agile, and also by startups.
However, despite their importance to the local economy, startups and SMEs generally have limited resources. They face significant growth barriers, including lack of access to knowledge, human resources, and efficient forms of financing (Steininger, 2019). When seeking to take advantage of innovation opportunities based on new technologies, these smaller companies often fail to succeed in the "institutional game" (North, 1992), following the same rules of the big players.

Considering this context, this paper addresses the following research question*: to what extent does an emerging IoT innovation ecosystem develop institutional arrangements to promote innovation by startups and SMEs, supporting these companies' development*? The research adopts the Institutional Theory (Dimaggio & Powell, 1983; Meyer, 2017; Scott, 2014, 2017) as a theoretical lens that considers the political process as critical to the performance of economies and explains "inefficient" markets. This theoretical lens assumes that institutions and the way they evolve define economies' performance over time (North, 1992). The institutional perspective is prolific to study digital innovation and transformation, examining how organizations gain social approval and interplay with existing institutional arrangements (Hinings et al., 2018).

Therefore, this research takes part in the effort to overcome the following knowledge gaps and research opportunities: (a) to better understand the link between IS/ICT and entrepreneurship (Steininger, 2019); (b) digital innovations require building institutional infrastructures linking different actors in the innovation ecosystem - how this happens in the world of digital innovation is a significant area of research (Hinings et al., 2018); (c) little is known about the relational, cultural, and contextual factors that help explain why some ecosystems develop in ways that support entrepreneurial opportunities while others do not (Thompson et al., 2018); (d) the need of studying ICT innovation and institutionalization at the field level, a level of analysis that is critical for institutional theory (Hinings et al., 2018; Mignerat & Rivard, 2016). Several scholars have suggested that any analysis of innovation and entrepreneurship in an ecosystem should include understanding institutions and institutionalization (Ritala et al., 2018). Besides, the IoT is a strategic issue for any country's development, not only in economic terms but also in its potential use to effectively manage natural resources and public services provision (Vermesan & Friess, 2014). Therefore, the research theme is relevant when addressing a fundamental issue: how the IoT development process can promote local innovation and entrepreneurship.

2. **Institutional arrangements**

Recent studies have addressed the importance of institutional arrangements to create innovation ecosystems; they enable coordination between actors of the ecosystem and have regulative, normative, and cognitive functions related to value creation (Langley et al., 2021). In this sense, institutions are "regulative, normative and cultural-cognitive elements that, together with associated activities and resources, provide stability and meaning to social life" (Scott, 2014:56). Institutions comprise durable (formal or informal) practices, rules, standards, and roles that organizations and individuals must follow (Bruton et al., 2010; Hampel et al., 2017). They generate pressures that force organizations to adopt similar practices or structures to gain legitimacy and support (Dimaggio & Powell, 1983; Seo & Creed, 2002). According to Institutional Theory, institutions are the "rules of the game", while organizations are the "players" - including political bodies, economic agents, and educational agents (North, 1992).

In the field of organizational studies, we can identify institutional pillars (Scott, 2014) that deserve analysis to understand the institutional arrangements in the context of innovation ecosystems:

- Regulative Pillar - include regulations and laws that guide organizational actions and perspectives, such as coercion or threat of governmental sanctions.
- Normative Pillar - The normative aspects of institutions include practical rules, occupational standards, and educational curricula. Its ability to guide organizational actions and beliefs stems largely from social obligations.
- Cultural/Cognitive Pillar - it includes symbols, words, signs, gestures, cultural rules (formal or informal), and structures through which meaning is created. These institutional aspects form a basis of culturally supported legitimacy, which often become taken-for-granted.

In the "institutional game" organizations are continually looking for legitimacy, which corresponds to the right to exist and perform an activity in a certain way (Bruton et al., 2010; Suchman, 1995). An organization is legitimate when its activities are perceived as desirable and appropriate within a system of norms, values, beliefs, and definitions (Suchman, 1995). Established organizations can use their performance record to acquire legitimacy and access resources. In contrast, a new venture (such as startups) or small enterprises cannot easily do so due to their limited or non-existent records (Bruton et al., 2010). Therefore, institutional arrangements and changes must be made to increase the legitimacy of smaller and new ventures and, consequently, their access to resources to innovate.

Considering the institutional pillars, we can identify three types of legitimacy (Bruton et al., 2010): (a) *regulative:* occurs when laws and regulations recognize and help to safeguard the right of the organization to exist and operate in a certain way; (c) *normative:* concerns whether the organization's activities are proper and consistent with influential groups and societal norms; (b) *Cultural/cognitive:* Involves the congruence between the organization and its cultural environment.

The innovations based on the IoT bring new possibilities to develop products, services, and innovative business models, affecting competition in several industries (Langley et al., 2021; M. Porter & Heppelmann, 2014). It may demand changes in current institutions or the creation of new institutions to legitimize and include the new solutions and new entrants that conduct these innovations, especially startups and SMEs. The continuous interaction between institutions and organizations in the economic/competitive setting is the key to institutional change (North, 1992).

One concept that helps us to understand how the human agency shapes institutional changes is the concept of institutional work (Lawrence et al., 2009). This concept describes individual and collective actors' practices that aim to create, maintain or disrupt institutions (Lawrence & Suddaby, 2006). The actors work to interpret, translate, transpose, edit and recombine institutions. These actions lead to unintended adaptations, mutations and other institutional consequences (Lawrence et al., 2011). There are several forms of institutional work, such as: creating normative associations, educating, constructing identities, undermining assumptions and beliefs, among several others (Lawrence & Suddaby, 2006). The actors' institutional work is either "*visible"* (documented) or "invisible". The invisible work includes undocumented work to recruit allies, find resources, negotiate with stakeholders, run experiments, design and test symbols, and coordinate strategies for action (Canales, 2016).

Several institutional studies have documented the ability of actors, particularly those with key

strategic resources and power, to impact on the evolution of institutions and fields (Lawrence & Suddaby, 2006). Therefore, we can consider that the IoT innovation ecosystem's required institutional changes tend to favor big and powerful players. This is justified because, according to North, (2016: 75): "Institutions are not necessarily or, generally, created to be socially efficient; on the contrary, they, or at least the formal rules, are created to serve the interests of those with bargaining power to create new rules". Thus, this research aims to understand these mechanisms and to suggest actions that can be taken so that institutional changes in the IoT innovation ecosystem can confer legitimacy and facilitate access to resources for startups and SMEs and not only favor big companies and technology major providers.

Considering these critical concepts of Institutional Theory (institutional pillars and institutional work), we present the following research propositions and conceptual model of research in Figure 1.

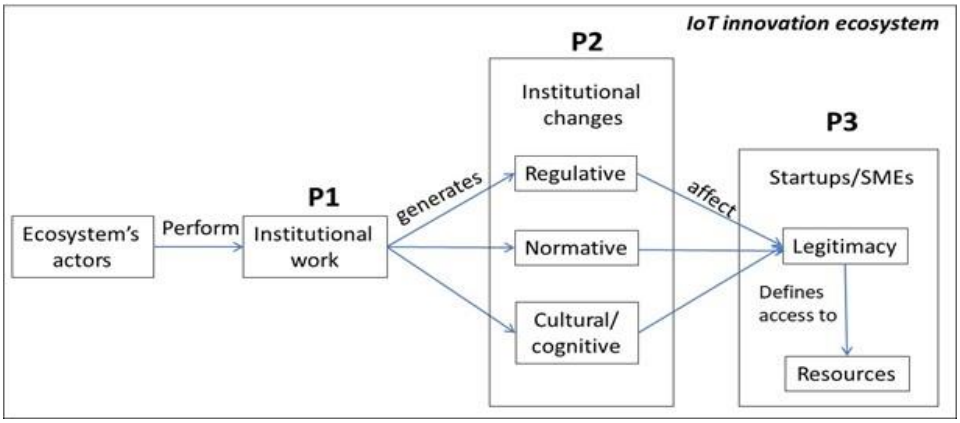

Figure 1. Research framework and propositions

Proposition 1: *Different actors involved in the IoT innovation ecosystem perform different forms of institutional work.* With proposition one, we aim to understand the different types of actors and institutional work (Lawrence et al., 2011; Lawrence & Suddaby, 2006) they perform in the ecosystem and how it affects startups and SMEs' performance. The institutional work performed by different actors can generate changes in the institutional pillars (Scott, 2014): in the regulative pillar (for example, in laws and rules of action), normative (for example, in technological norms and standards), and cultural/cognitive (for example, understanding of technology, its application, and consequences, cultural openness to IoT-based innovations, among others).

Proposition 2: *The institutional work of the different actors leads to regulative, normative, and cultural/cognitive changes that shape the IoT ecosystem.* With proposition 2, we aim to understand the different types of institutional changes and how they affect startups and SMEs' performance in the IoT innovation ecosystem.

Proposition 3: *Institutional changes in the IoT innovation ecosystem affect the legitimacy of startups and SMEs, which, in turn, influences their access to resources to innovate.* Organizational success depends on factors other than technical efficiency; organizations gain legitimacy and needed resources by adjusting themselves to their institutional environments (Seo & Creed, 2002). As already mentioned, nascent and small companies generally have difficulty obtaining legitimacy because they often lack records about their performance history (Bruton et al., 2010). That is why it is necessary to have institutional arrangements to help them build their legitimacy.

3. **Method**

To test and discuss the research propositions, we have been conducting a case study (Eisenhardt, 1989; Flyvbjerg, 2006) in the Brazilian IoT innovation ecosystem. The research is longitudinal (2016-2023); in this paper, we analyze data from 2016 to 2019. It is fundamental because Institutional Theory suggests that institutional changes extend over considerable periods (Hinings et al., 2018). Studying the Brazilian case is adequate to the research goals because emerging markets are characterized by greater informality and less developed government and regulatory infrastructures, educational systems, and financial markets (Canales, 2016; Marquis & Raynard, 2015). Brazil has one of the highest entrepreneurship indexes in the world but, at the same time, one of the worst business environments in the world – e.g., excess of bureaucracy, lack of necessary infrastructure, lack of governmental incentives, many different taxes over businesses (Bosma et al., 2020). Therefore, its institutional environment, as a whole, is particularly adverse for innovation and entrepreneurship, frequently demanding institutional changes to support them.

We collected data through interviews with actors directly involved in defining public policies, technologies and promoting innovation with the use of IoT in Brazil from different entities. We also studied five SMEs and startups that offer innovative products and services based on the IoT from different sectors. In addition to interviews with the main entrepreneurs in these businesses, documents, photos, and videos about the companies' solutions were also accessed. Table 1 presents the details of data collection by interviews. In Table 1, the names of the companies (1 to 5) have been omitted to preserve their anonymity. The position of the interviewees is not informed for the same reason. Four of the companies' interviewees are CEOs and one is a Sales Director. In the other organizations, the interviewees occupy management or senior positions in technical areas, with direct involvement in initiatives related to the development of the IoT at the national level. The interviews were performed from November 2017 until June 2019, face to face or via Skype, and lasted one hour on average (15 hours in total).

ID	**Organization**	**Type**
E1	Company 1 - smart public lighting system	SME
E2	Company 2	Startup
E3	Company 3	Startup
E4	Company 4	SME
E5	Company 5	Startup
E6	CPQD	Technology Institute
E7	ABII	Brazilian Association of Industrial Internet
E8	MDIC	Ministry of Industry, Commerce Exterior, and Services
E9	BNDES	National Development Bank
E10	ABINEE	Brazilian electrical and electronics industry association
E11	BPM Consulting Company	Helps companies to implement IoT-based solutions

Table 1: Interviews' details

In addition to the interviews, we collected data at various events related to the development of the IoT and industry 4.0 in Brazil, with approximately 50 hours of participation. At these events, several actors, such as government representatives, companies, universities, research institutes, and industry associations, discussed the actions to develop the IoT ecosystem. Data were collected via a field diary since noisy environments did not allow adequate audio recording during the events. We also collected and analyzed 178 documents created by different actors. One of the main sets was the documents related to the study for generating the

Brazilian national IoT plan. Industry reports, newspapers and magazines, articles, and videos were also collected.

The primary technique adopted in the data analysis was data-driven (inductive) coding (Saldaña, 2009; DeCuir-Gunby et al., 2011). Initially, 136 categories were generated. The content coded in these categories went through a rereading, organization, and grouping of similar categories. From this second reading and understanding of the data, 119 categories were reached, 8 of which are main categories, and the others are secondary. After the codification process, which made it possible to synthesize the main results, a second round of analysis has been carried out, linking the results with the central concepts of the Institutional Theory (the three institutional pillars and the types of institutional work). We present some preliminary results of the analysis next.

4. Preliminary Research Results

4.1 The IoT innovation ecosystem in Brazil

An innovation ecosystem consists of interdependent actors such as firms, governmental and non-governmental organizations (NGOs), and other types of resource providers (Scaringella & Radziwon, 2018). In Figure 2 we present the main types of actors involved in the IoT innovation ecosystem in Brazil and their main relationships, highlighting the SMEs and startups, which are the organizations focused on this research. Only the main direct, indirect, and mutual influences (according to the data collected) are represented to facilitate understanding. In Figure 2, the main types of actors are shown in rectangles. Each group of actors is associated with a type of resource (represented by ellipses) that is essential for companies to innovate based on the IoT. The IoT is highlighted in the center of the figure, comprising a set of related technologies like sensors, networks, devices, applications, among others (Borgia, 2014). The IoT innovation ecosystem is historically connected with the Brazilian National Innovation System (Lundvall, 2016); it is immersed in the country's business environment.

The primary resources for the generation of IoT-based innovations identified were:

- *Qualified human resources, knowledge, and technology* – these are combined resources, as qualified people generate and apply the necessary knowledge for the creation and use of technology.
- *Financial resources* – a crucial factor for innovation and companies' sustainability, especially SMEs and startups in their initial stages.
- *Telecommunications infrastructure* – IoT-based solutions are dependent on that infrastructure. For this reason, telecommunications companies are represented as separate business actors in Figure 2 because they play a strategic role concerning this resource. Consequently, they have significant economic power, being able to pressure, albeit indirectly, the legislation, regulations, and certifications regarding telecommunications.
- *Legislation, regulation, certifications* - these intertwined elements are fundamental for developing innovations based on the IoT, especially those involving certifications of wireless telecommunication devices and hardware quality approvals, and sensitive issues related to IoT applications, such as security and privacy of personal data. Different actors influence these elements directly and indirectly. Although technology changes and evolves quickly, these elements do not change at the same speed.

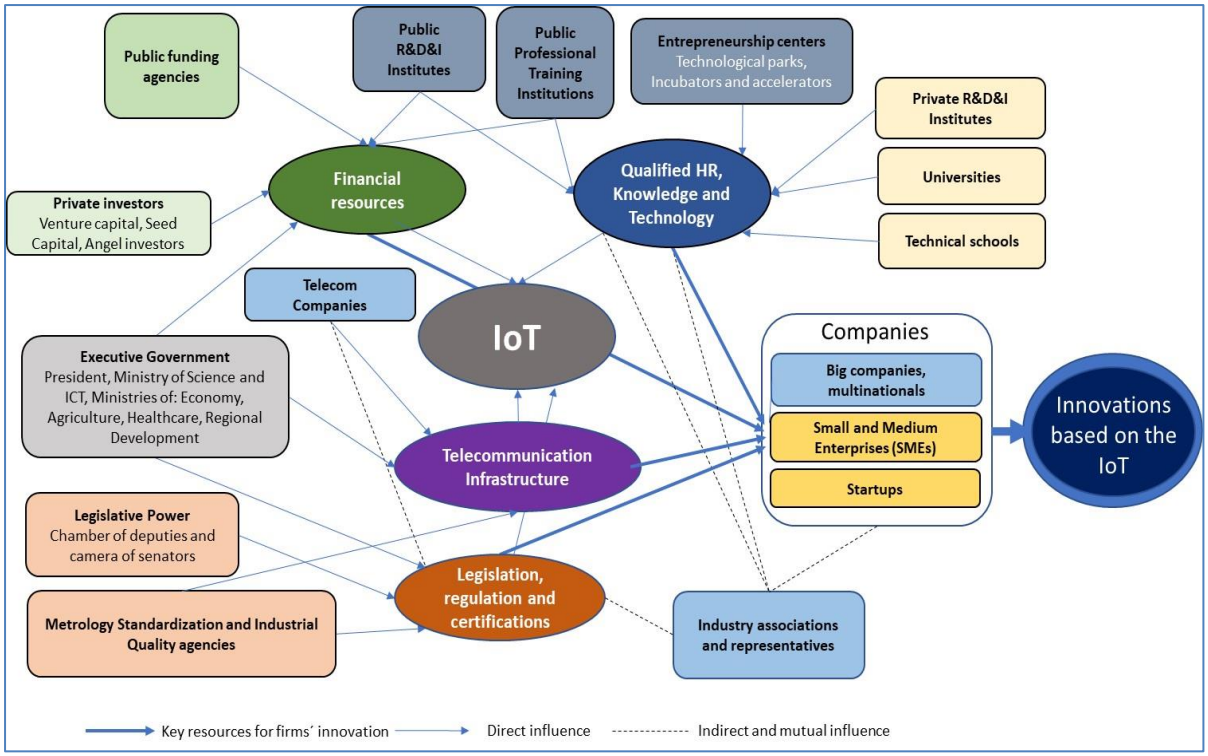

Figure 2: IoT innovation ecosystem in Brazil – main actors, resources, and relationships

Different actors provide each one of the key resources. Mainly, public funding agencies, the executive government, and private investors provide IoT innovation projects´ funds. Public R&D&I institutes also support these projects with public funds. Public professional training institutions, universities, and professional schools provide training for people, technologies (technical and managerial), laboratories, and specialized technicians to help companies develop their IoT innovation projects. Qualified HR, technology, and knowledge are also provided by entrepreneurship centers (tech parks, incubators, accelerators). Private R&D&I institutes stand out in partnerships with industry to develop IoT-based innovations. The trinomial legislation-regulation-certifications are developed under the executive branch's influence, the legislative branch and metrology standardization, and industrial quality agencies. Business associations represent companies (especially big companies) and seek to influence, albeit indirectly, access to various resources, spread knowledge, establish partnerships in R&D&I projects, and support innovation.

Since our research focuses on SMEs and startups in the IoT ecosystem, we show summarized data from the five different companies studied to an overview of how these companies have been innovating with the use of the IoT in the Brazilian context (Table 2).

As shown in Table 2, the innovations generated by the five companies surveyed have several characteristics in common, despite targeting different market segments and clients. The first is the development of “smart products” (Porter & Heppelmann, 2014), based on the IoT technologies: sensors, microprocessors, and actuators, Wi-Fi, cloud computing (Borgia, 2014). All the companies offer applications for accessing data services by the end-user, based on the concept of big data, selling data services associated with their hardware. This is aligned with the concept of servitization, which is common in business models based on the IoT (Frank et al., 2019; Klein et al., 2017). Innovations generated by the companies are innovations in goods and services (hardware plus software) at the local and national levels (firm's market) but not at the global level (OECD/Eurostat, 2018). These firms compete by locally providing simpler

and, in some cases, cheaper solutions, especially via customized projects, based on their knowledge of the local business context. However, the process of innovating both in hardware and in software is complex and, fundamentally, all of them are companies dependent on a high level of technical knowledge.

Company	Solution/value proposition
Company 1 - smart public lighting system	A device attached to lamps, which makes them "smart", connected to a public lighting management software (web/app); a gateway that manages a wireless communication network, to which several IoT devices for smart cities can be connected. The lighting management system monitors, controls, and collects data, allows the lighting scheduling, monitoring, and dimming of lamps. It can serve as an IoT platform, providing other tracking and geo-referencing services.
Company 2 - System for monitoring temperature	An IoT platform solution (SaaS model), with a gateway and temperature sensors, connected via Wi-Fi to the Internet. The solution monitors the temperature of counters, freezers, cold rooms, and greenhouses, sending data to the user via an app. It provides dashboards and alerts by email or Telegram and generates information for presentation to the sanitary inspection. The solution prevents product losses due to inadequate temperatures and reduces errors of manual temperature readings.
Company 3 – Smartcards/ smart readers	Smart card readers and writers for electronic transactions and payment means, with a touch display version for data entry, plus a security solution for industrial IoT networks, with customization.
Company 4 - IoT-based manufacturing automation systems	Smart devices (SaaS model) capable of collecting data and operating various manufacturing equipment safely over the Internet, as well as monitoring the industrial environment (capture of temperature data, humidity, noise levels, light, and CO2 levels) - a gateway of industrial IoT. It allows SMEs and large companies to become smart, data-driven factories.
Company 5 - Smart lighting systems - Home	Smart switches and sockets connected to the Internet via Wi-Fi, allowing monitoring and remote control via a smartphone app. It allows home automation without construction work/breaking walls, generating comfort in the home environment.

Table 2: Examples of IoT-based innovations developed by SMEs and startups

4.2 Key institutional changes and institutional work in the ecosystem

First, regarding the regulative pillar (Scott, 2014), one of the main institutional changes was the creation of the national IoT plan, led by The Ministry of Science, Technology, and Innovation (MCTIC), in partnership with the national development bank (BNDES). They started creating the plan in 2016, based on a broad study, and the plan was made official through decree #9,854, from June 2019. This plan is the main guide for public policies for the development of IoT in Brazil. The decree defined IoT priority application sectors: (1) healthcare, (2) smart cities, (3) manufacturing, and (4) agriculture. It also defined strategic themes linked to the IoT: science, technology, and innovation; international insertion; education and professional training; connectivity and interoperability infrastructure; regulation, security and privacy; and economic viability.

As registered in the study documents for the national plan generation, several actors were heard in its creation via public consultations on the MCTIC website and a series of public events. However, evidence was found that most of the participants in these consultations were industry associations, large companies, especially foreign multinationals, technological institutes, universities, and specialists concentrated in the country's more developed areas (especially the Southeast and Midwest). There was low participation of smaller companies and a lack of representation from all regions of the country. As stated by most interviewees, traditionally, the R&D&I initiatives and innovation public policies in Brazil favor big companies and organizations. Therefore, a first step would be to consider SMEs, startups, and other civil

society groups at the beginning of the process of policies and legislation creation, with greater transparency in these processes.

The national IoT plan guides public funding. In this sense, the lack of funds to innovate affects the SMEs and startups researched. These smaller companies mentioned their difficulties in obtaining public funding, mostly due to the excess of bureaucracy and the guarantees and counterparts demanded. For example: *"For us, it has been difficult to use the BNDES* [national development bank] *because they always ask for guarantees, which is something that I, a startup, do not have. It cannot be one of the partners to take the loan too, so a third party will need to guarantee a loan, even if it is a very good investment in innovation. There are excellent credit lines at BNDES, but we cannot access them, and this is a difficulty that we have"* (E3, Company 3). For example, a public funding program was launched in June 2018 by BNDES called "IoT pilots". However, only technological institutes or universities could submit projects in this program. Although they could include SMEs and startups in their projects' teams (which was encouraged by the BNDES), the values of the demanded counterparts from these companies to their participation were high, making it difficult for them to engage in partnerships with the leading organizations.

Regarding the regulative pillar, a controversy was identified in the research data: the "Create legislation" x "Reduce legislation" debate. On the one hand, there are arguments to "create legislation". Different actors argue that changes and additions to the legislation are needed to contemplate technological advances of the IoT and guarantee fundamental aspects such as access, security, and data privacy. New legislation should also favor developments in telecommunications services, reducing costs, especially the high tax burden, and increasing access to the wireless spectrum to expand networks throughout the national territory. Another aspect highlighted is that the legislation increasingly needs to promote the purchase of solutions based on IoT by the government. It was pointed out by the companies researched and is corroborated by several other actors in the IoT ecosystem. However, on the other side of the controversy is the argument of "reducing legislation". Several actors reinforce that legislation and regulation should be reduced and minimized to avoid hindering the "freedom of the market" to create IoT-based innovations.
Regarding the normative pillar (Scott, 2014), the work performed by the public and private R&D&I institutes – especially the later - technical schools, universities, training institutions and entrepreneurship centers has been essential to generate knowledge that qualified people apply in the development of IoT-based innovations. They also provide normative guidance to professional roles and standards related to the IoT and Industry 4.0 advancements. They also work to propagate the entrepreneurship culture in the country, a role strongly performed by tech parks, incubators and accelerators. Industry associations (such as ABII – Brazilian Association of Industrial Internet) also influence the roles and standards and the culture of innovation among their associates. However, the majority of them are big companies.

A controversy was identified in the normative pillar: the "Open standards" x "Market standards". In this controversy, several actors argue that open standards should be prioritized to democratize access to technology, facilitate systems interoperability, and be preferred when purchasing IoT solutions, especially in purchases by the government and public agencies. One initiative linked to this is the Dojot Platform (http://www.dojot.com.br/), an IoT development open platform whose creation was led by the CPQD (a private telecommunications R&D&I Institute, one of the biggest in Latin America). However, on the other side of the controversy, other actors defend free competition and the choice of the most advanced standards, but not necessarily open. They also defend not to favor local solutions but standards defined by the

global market.

Finally, regarding the cultural/cognitive pillar (Scott, 2014), a barrier for the development of innovations based on the IoT is the lack of knowledge, in the country, about the IoT and Industry 4.0. Since the IoT and the industry 4.0 involves knowledge not of only one, but of diverse connected technologies, several actors commented that there is a lack of knowledge not only about the technologies involved but about the business opportunities, especially concerning new business models, value propositions and return on investment for innovations based on the IoT. "*The problem with the IoT is not technological, but rather the lack of understanding and engagement by society to understand that the segment is important for the country's economic development*" (BNDES representative – Press Document).

Rocha et al. (2019) also pointed out the lack of existing knowledge about industry 4.0 in the country. Many companies fail to realize the value of new digital solutions and the competitive advantages they can offer. The institutional work of educating ("*educating actors in the skills and knowledge necessary to support the new institution*" - Lawrence & Suddaby, 2006:221) has been performed, for example, by organizations such as technical schools, R&D&I institutes and universities, but still they do not reach the majority of the companies and other innovative agents.

5. Final Remarks

The IoT is a strategic theme for any country's development (Vermesan & Fries, 2014). The emergence of the IoT and the new cyber-physical systems (Lee, 2008) challenges current institutions. Despite this new technological platform's generativity, institutional changes are necessary to support innovation based on it by SMEs and startups.

The preliminary research results analysis showed the main groups of actors and resources involved in the IoT innovation ecosystem in Brazil. The data we analyzed so far also suggests that: (1) the institutional arrangements in the IoT ecosystem in Brazil usually favors the big players; (2) several controversies exist regarding critical elements of the institutional pillars related to the IoT development in the country, and (3) the knowledge diffusion about the IoT and industry 4.0 and their potential is still needed.

As research limitations, more data needs to be collected and analyzed via the longitudinal case study. In this paper, only the main findings identified so far have been presented. The careful testing of the research propositions (Figure 1) is still pending. Future research needs to deepen the understanding of the institutional arrangements and institutional work needed to support IoT-based innovation by SMEs and startups in different settings, generating insights for concrete actions and public policies.

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