Standardization and regulation barriers to innovation faced by architectural and engineering services companies in Brazil

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Abstract. The present work aims to analyze problems and obstacles to innovation faced by architectural and engineering services companies in Brazil, focusing on standardization and regulation issues. We have drawn the data from the National Innovation Survey 2014 (Pintec 2014) to answer how the companies in this sector perceive the importance of problems and obstacles throughout their cycles of innovation concerning difficulties of meeting government regulations, legal or voluntary standards requirements, and accessing specialized technical/technological services. The respondent companies were asked to inform their perceptions of the importance of the barriers that they face to innovate in a three-point response scale (high, medium, and low importance or not relevant).

Keywords. Innovation metrology; standardization and regulation barriers; architecture and engineering services; National Innovation Survey; Brazil.

1. Introduction

Innovation has long been considered imperative for the survival of knowledge-based companies in several sectors. Nowadays, academicians and policymakers have always emphasized the importance of innovative activities by these companies to reach competitiveness and generate economic growth and benefits for society. Regardless of this positive trend, companies face problems and barriers to implement their innovations, which can be associated to: (i) economic and financial (excessive economic risks; high costs of innovation; and scarcity of appropriate sources of funding); (ii) RD&I governance (organizational rigidity, and centralization of innovative activities in another company of the group); (iii) knowledge (lack of qualified personnel; scarcity of information on market and technological information, and scarce opportunities for cooperation with other companies or institutions); (iv) market (inadequate consumer response to new products); and (v) standardization and regulation (difficulty of meeting government regulations, legal or voluntary standards requirements, and challenging to access specialized technical/technological services) [1-6].

Focusing on the architectural and engineering services companies (hereinafter called AES companies), a housing project requires the contribution of several agents transferring information, goods, and services. As a general rule, such transfers involve more than one organization, such as entrepreneurs (builders or developers), suppliers of goods and services, users, public authorities, and utilities. It is reasonable to expect that, in complex systems in
which several processes compete for the production of the building, there is a well-defined and
pre-established characterization for the respective products — architectural and engineering
projects, distributive systems, water-sanitary subsystems, sealing (walls, windows, doors,
coating, and painting), vertical transport (elevators), roofing, among others [7;8].

A set of constraints, including the presence of foreign competitors, the absence of barriers to
entry of new competitors, and the intensification of the contractors’ requirements, has driven
accentuated changes in the business models of AES companies, inducing increased
competitiveness and business modernization of their services.

Innovation has played a relevant role in meeting the requirements of contractors through the
creation of sustainable competitive advantages. Particularly, innovations in this sector in Brazil
have been driven by the need to meet the requirements of the standard ABNT NBR 15.575:2013
titled 'Performance - Housing Buildings. This standard aims at promoting a systemic view of
buildings with a focus on users’ requirements. From the sustainability perspective, the standard
focuses on durability, maintainability, and environmental impacts [9].

The adoption of this standard by Brazilian AES companies entails a requalification of teams
of designers and engineers, adequacy of projects, revaluation of construction costs, investments
in innovative activities, restructuring in the selection of systems and materials, among other
conditions [7].

On the assumption that: (i) innovation is imperative for the survival of knowledge-based
companies in several sectors, including architectural and engineering services companies; (ii) in
general, many companies face problems and barriers to implement their innovations, which can
be associated with the difficulty of meeting government regulations, legal or voluntary
standards requirements, and accessing local specialized technical/technological services; and
(iii) previous studies using data from National Innovation Surveys (such as Pintec in Brazil)
have not yet investigated the AES sector with the focus that is intended in this research; the
main questions addressed in this paper are:

• Problems and obstacles to innovation associated with standardization and regulation
  issues have been perceived as critical by architectural and engineering services companies
  in Brazil?
• Do these problems and barriers differ between innovative and non-innovative firms?

This work is addressed to answer these research questions by analyzing and comparing the
problems and barriers to innovation associated with standardization and regulation faced by
innovative and non-innovative AES companies in Brazil using publicly available data from the
National Innovation Survey 2014 (Pintec 2014) [10].

The differentiation between innovative and non-innovative companies is pertinent in this
case, once their respective perceptions about problems and barriers are also distinct. When
innovative companies identify a specific problem or barrier to innovation, they denote a
condition that retard or unfeasible their innovative activities. Non-innovative firms mention
that they have found problems or barriers that have obstructed them from conducting their
innovative activities.

So, the Pintec 2014 questionnaire addresses two questions concerning problems and
obstacles to innovation, differentiating innovative and non-innovative firms. Innovative firms
are asked to answer this question: “During the three-year period 2012-2014, has the company
encountered problems or barriers that may have slowed the implementation of certain projects
or made them unfeasible?” For non-innovative firms, the question is: "During the period 2012-
2014, has the company faced problems or barriers that have impeded the development of
innovative activities?”. The questionnaire presents twelve factors related to problems and
barriers to innovation with three options regarding the degree of importance of the problems and
barriers (high, medium, low, or not relevant).

This paper is structured into six sections. Following this introduction, Section 2 briefly
reviews the literature on the central themes of the research, covering 1999-2019, with particular
attention on factors influencing the innovative activities conducted by companies from different
sectors, highlighting the main problems and obstacles they face to innovate. Section 3 describes
the methodology adopted for developing the study, and Section 4 presents the primary data
source- Pintec 2014, published by the Brazilian Institute of Geography and Statistics (IBGE). In
Section 5, the main results are presented and discussed. Finally, Section 6 synthesizes its concluding remarks.

2. **Theoretical background**

The literature review and documentary analysis covering the period of 1999-2019 focused on: (i) classification and definition of barriers to innovation; (ii) the determinants of barriers to innovation; and (iii) the impacts of innovation barriers on company activities.

2.1. **Classification and definition of barriers to innovation**

According to the Oslo Manual, barriers to innovation may be the reason why companies are unable to implement and sustain innovative activities or perhaps be the reasons why firms are unable to achieve the expected innovations [1]. Hadjimano listed relevant claims that enterprises in the process of innovation will be affected by the innovation environment or exogenous obstacles (for example, policies, laws, and regulations), demand barriers (like R&D market), and market barriers (namely market information, competition, scale, and acceptance) [2]. D’Este et al. reinforced this idea arguing that some businesses are prevented from innovation and relying on inertial paths because of the inability to overcome innovation barriers [3]. Furthermore, Huang and Chi pointed out that companies need to have specific resources and external environmental conditions, like funds, personnel, or other resources in the process of innovation, when carrying out innovation activities [4].

2.2. **Determinants of barriers to innovation**

Companies’ innovation barriers are connected to many factors (as location, size, industry, age, among others) [5-6; 11-17]. Baldwin and Lin suggested that newly established companies are more susceptible to face cost, institutional, and labor barriers [11]. Segarra-Blasco et al. argued that small companies are more likely to perceive barriers to innovation and that innovative firms are more likely to perceive costs and knowledge barriers [12]. Blind et al. found that firm size, group attributes, and employee qualification levels have a significant positive impact on cost barriers [13]. Aghion et al. concluded that the market structure and level of competition in which an enterprise is situated would affect its degree of innovation [14]. Hölz and Janger pointed out that enterprises in technologically advanced countries perceived different innovation barriers and are more likely to notice knowledge barriers [15].

Other studies also suggested that the higher the degree of innovation activities implemented in the companies (like internal RD&I), the easier it is to identify and manage obstacles to innovate [16; 17].

2.3. **Impacts of innovation barriers on company activities**

Innovation barriers have negative impacts on a company's innovation performance, as suggested by [5;18-22]. According to Pellegrino and Savona, market and regulatory barriers have a significant impediment to enterprise innovation trajectories. The cost barriers are the most likely to reduce the likelihood of innovation investment being transformed into an innovation output [18]. As highlighted by Antonioli, the cost barriers and knowledge barriers of enterprises actively promoted cooperation on an empiric study [19]. Kanama and Nishikawa found that when enterprises face financial obstacles, technical barriers, and market demand barriers, they are more likely to encourage enterprises to acquire university knowledge, which leads to obtaining the required technology [20]. Adeyeye et al. demonstrated that higher levels of knowledge and regulatory barriers are associated with a lower degree of the breadth for external search and that knowledge and market barriers have a positive impact on the depth of external knowledge search [22].

3. **Methodology**

The research methodology encompasses: (i) literature review on problems and barriers to innovation faced by companies; (ii) definition of research scope and analytical framework, according to the structure of the primary data source – the National Innovation Survey, published by the Brazilian Institute of Geography and Statistics (IBGE); (iii) data gathering and descriptive statistics to analyze and compare the problems and barriers faced by innovative and
non-innovative architecture and engineering services firms in Brazil, focusing on standardization and regulation issues; and (iv) discussion of the main results and implications for Brazilian Science & Technology (S&T) policies and government agencies to enhance the innovation of architecture and engineering in the services industry.

4. Sample and data about innovation in architecture and engineering services firms

Pintec is conducted once in three years by the Brazilian Institute of Geography and Statistics (IBGE). Pintec 2014 covers the data of 4,454 AES companies from 2012 to 2014. From this total, 1,235 informed having implemented product or process innovations or both types. In turn, non-innovative firms summed 3,219, as indicated in Figure 1.

![Figure 1. Sample characterization according to the innovation performance of AES companies in Brazil: 2012-2014](image)

In this Pintec edition (2014) [10], the respondent firms (innovative and non-innovative) were asked about the presence and the degree of importance of twelve factors related to problems and barriers to innovation, as follows: (i) excessive economic risks; (ii) high costs of innovation; (iii) scarcity of appropriate sources of funding; (iv) organizational rigidity; (v) lack of qualified personnel; (vi) lack of technological information; (vii) lack of market information; (viii) scarce opportunities for cooperation with other companies or institutions; (ix) difficulty of meeting government regulations, legal or voluntary standards requirements; (x) poor consumer response to new products; (xi) scarcity of adequate external technical and technological services; and (xii) centralization of innovative activities in another company of the group.

The other variables of this empirical study are the innovation performance (if the firm is innovative or not from 2012 to 2014) and the National Classification of Economic Activities (Acronym in Portuguese CNAE) corresponding to the activities of the AES companies. These variables are summarized in Table 1, clustered by the nature of the problem and barrier, as follows: (i) economic and financial factors; (ii) RD&I governance; (iii) knowledge; (iv) market characteristics; and (v) standardization and regulation.

**Table 1. Summary of Pintec 2014 variables**

| Description                        | Label | Type   | Metric                                      |
|------------------------------------|-------|--------|---------------------------------------------|
| Excessive economic risks           | ECON  | Ordinal| 3 – high importance; 2 – medium importance; |
|                                    |       |        | 1 – low importance or not relevant.         |
| High costs of innovation           | COST  | Ordinal| 3 – high importance; 2 – medium importance; |
|                                    |       |        | 1 – low importance or not relevant.         |
| Scarcity of appropriate sources of funding | FUND  | Ordinal| 3 – high importance; 2 – medium importance; |
|                                    |       |        | 1 – low importance or not relevant.         |
| Organizational rigidity            | ORGA  | Ordinal| 3 – high importance; 2 – medium importance; |
|                                    |       |        | 1 – low importance or not relevant.         |
| Lack of qualified personnel        | PERS  | Ordinal| 3 – high importance; 2 – medium importance; |
|                                    |       |        | 1 – low importance or not relevant.         |
5. Problems and barriers to innovation in AES companies in Brazil

Descriptive statistics results are summarized by comparing data about AES companies and innovation performance (innovative and non-innovative companies). Accordingly, Table 2 refers to the results of the descriptive statistics concerning innovative and non-innovative AES companies.

Economic and financial factors explain the obstacles that a company faces to finance its innovation projects. R&D&I governance refers to organizational rigidity and adverse culture to innovation, and also to eventual centralization of innovative activities in another company of the group. Knowledge barriers are concerned with lack of qualified personnel; lack of technological and market information; and scarce opportunities for cooperation with other companies or institutions. Market barriers are associated with poor consumer response to new products. Finally, regulatory factors explain a company's difficulties in meeting government regulations, legal or voluntary standards requirements, and also the scarcity of adequate external technical and technological services.

From Table 2, the results suggest that the highest barriers to innovation perceived by innovative AES companies are related to ‘excessive economic risks’ and ‘scarcity of appropriate sources of funding’, both classified into the ‘economic and financial’ category.

At the second and third levels of importance, the innovative AES companies considered the items ‘organizational rigidity’, ‘related to RD&I governance’, and ‘lack of qualified personnel’, summarized as ‘knowledge’, as critical barriers to innovation. Conversely, the lowest barriers to innovation perceived by innovative AES companies are those related to ‘standardization and regulation’.

Similar to the empirical evidence concerning problems and obstacles faced by innovative AES companies, Table 2 also shows the results regarding non-innovative ones in Brazil. This is in line with previous works, which found that the highest barriers to innovation perceived by non-innovative companies are related to ‘high costs of innovation’ and ‘scarcity of appropriate sources of funding’, both classified into the ‘economic and financial’ category.

At the second and third level of importance, the non-innovative AES companies considered as severe barriers to innovation the following items: ‘organizational rigidity’, associated to ‘RD&I governance’, and ‘lack of qualified personnel’. The economic and financial factors, together with the inflexibility at internal policies and difficulty in finding qualified workers, seem to be also the most important obstacles perceived by non-innovative AES companies.
Table 2. Problems and barriers faced by AES companies in Brazil: 2012-2014

| Problems and barriers | AES companies that answered Pintec 2014 |
|-----------------------|---------------------------------------|
|                       | Presence of problems and barriers [Number of firms] | Degree of importance [High [%], Medium [%], Low or not relevant [%]] | Presence of problems and barriers [Number of firms] | Degree of importance [High [%], Medium [%], Low or not relevant [%]] |
| Economic and financial | ECON 768 | 61.4 32.8 05.8 | 17 | 10.3 10.4 79.3 |
|                       | COST 768 | 09.3 03.6 87.1 | 739 | 51.8 37.5 10.7 |
|                       | FUND 82  | 44.9 25.8 29.4 | 739 | 56.3 31.0 12.7 |
| Economic and financial |                       | 51.5 28.3 20.2 |                       | 53.5 34.0 12.5 |
| RD&I governance       | ORGA 768 | 47.4 18.2 34.3 | 739 | 32.7 45.8 21.5 |
|                       | CENT 768 | 27.1 05.7 67.1 | 739 | 09.4 10.8 79.8 |
|                       | RD&I governance | 37.3 12.0 50.7 | RD&I governance | 21.1 28.3 50.7 |
| Knowledge             | PERS 768 | 38.2 26.8 34.9 | 739 | 27.4 46.5 26.0 |
|                       | TINF 768 | 28.3 26.5 45.2 | 739 | 25.8 42.2 31.9 |
|                       | MINF 768 | 07.3 46.2 45.9 | 739 | 28.5 32.9 38.6 |
|                       | COOP 768 | 16.6 35.0 48.3 | 739 | 24.9 29.5 45.7 |
|                       | Knowledge | 18.9 33.9 47.2 | Knowledge | 26.6 37.8 35.6 |
| Market                | RESP 768 | 18.1 29.3 52.6 | 739 | 14.2 31.2 54.6 |
|                       | Market   | 18.1 29.3 52.6 | Market | 14.2 31.2 54.6 |
| Standardization and regulation | SERV 768 | 21.0 24.2 54.8 | 739 | 15.1 15.6 71.3 |
|                       | CONF 768 | 24.4 23.7 51.8 | 739 | 07.1 39.5 53.4 |
|                       | Standardization and regulation | 22.7 24.0 53.3 | Standardization and regulation | 10.1 27.6 62.3 |

In common with innovative AES companies, the lowest barriers to innovation perceived by non-innovative AES firms are those related to ‘standardization and regulation’ issues. The low importance assigned by both – innovative and non-innovative AES companies – can be attributed to the period of analysis (2012-2014), although the ABNT NBR 15.575:2013 has been applied by the AES companies since 2013 [9]. On the other hand, the high importance attributed to ‘economic and financial’ items supports the idea that enterprises in less technologically advanced countries are more likely to perceived cost barriers [14]. Lastly, the ‘knowledge’ cluster results can be understood as a consequence of the difficulties to access knowledge within the whole supply chain of this sector. In addition to that, most of the AES companies in Brazil do not have an internal RD&I organizational structure. Also, the innovation has not been perceived as a value-adding mechanism due to their managers’ short term vision [8].

Figure 2 compares in a radial graphic the perceptions of all innovative and non-innovative AES companies about the importance of problems and barriers that they face to innovate. The vertices of the graph represent the averages of the percentage of innovative and non-innovative firms that assigned high and medium importance grades to the items in each category. This graph confirms significant similarities in the way innovative and non-innovative firms perceive barriers to innovation, differing slightly only by the degree of importance attributed to these items.

The ‘economic and financial’ items are the highest barriers to innovative and non-innovative AES companies, appearing to be slightly lower to the group of innovative companies. Next, ‘RD&I governance’ has the same importance to both groups, but ‘knowledge barriers’ appear to be the second more critical obstacle for non-innovative companies. The item ‘Standardization and regulation barriers’ is more relevant to innovative companies than to non-innovative ones during the period 2012-2014.

Essentially, this exploratory and descriptive work allows gathering evidence on barriers and problems faced by the architecture and engineering firms in Brazil, focusing on standardization and regulation issues. Figure 2 shows that these problems and barriers do not differ so much from innovative and non-innovative AES companies.
6. Final remarks

Based on empirical evidence from the Pintec 2014 data, the present paper has attempted to analyze and compare the problems and barriers faced by AES companies in Brazil, focusing on standardization and regulation issues. One main result of the empirical analysis is that a large percentage of innovative companies find barriers to their innovation projects. In general, both innovative and non-innovative companies claim that difficulties of meeting government regulations, legal or voluntary standards requirements, and accessing specialized technical/technological services are not the highest barriers to innovation. On the other hand, the results suggest that the highest barriers to innovation perceived by innovative AES companies are those classified into the 'economic and financial' category, namely 'excessive economic risks', 'high costs of innovation', and 'scarcity of appropriate sources of funding'.

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