

Innovation and Performance in Brazilian Civil Construction

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Abstract

Innovation can be understood as a strategy of organizations, sectors and countries in the search for market positioning and sustainability and performance can be understood as a method of measuring the efficiency and effectiveness of the organization. The Brazilian construction industry is considered strategic for the development of the Brazilian economy and accounts for over 50% of the Gross domestic fixed capital, 5.2% of GDP, 24.4% of the industry's GDP (2017), more than 2 million direct workers (2017) in 215,000 establishments (2016). This research project intended to better understand: What factors generating innovation and performance in the Brazilian Construction? The overall objective of the research was to analyze which innovation and performance, generating factors in the Brazilian civil construction, from 2007 to 2015. The study is a descriptive research, using secondary data relating to Brazil's civil construction. Data processing was quantitative using dependency model from the canonical correlation analysis. The results showed that some factors relate to innovation: gross fixed capital formation; the labor cost and material cost. The results of canonical correlation also show that the cost of the workforce has a strong influence on innovation. From the analysis about performance it was found that the value added of construction and wages variables caused impacts to performance. Considering the studied theory, indicators and variables chosen to compose the model tested returned a high explanatory power (98.08%) which reinforces the relevance of the study and alignment the specific sector. New studies were suggested besides some limitations were shown.

Key-words: innovation, performance, Brazilian construction sector, canonical analysis.

Introduction

In a global scenario of competition, innovation is possibly a strategy of organizations, sectors and countries seek positioning and sustainability. In this sense innovation can have a strategic approach to organizations, as demonstrated in several studies (Lin et al., 2016; Watkins et al., 2015; Abdul Hamid & Tasmin, 2013; Rodriguez-Pose & Crescenzi, 2008; Berkhout, Hartmann, Van Der Duin, & Ortt, 2006; Damanpour & Wischnevsky, 2006; Damanpour & Schneider, 2006; O'Regan, Ghobadian, & Sims, 2006).

The term performance can be defined as Neely (1999), as a method to evaluate the efficiency and effectiveness of past actions, through the acquisition, collection, classification, analysis, interpretation and dissemination of appropriate information.

The construction sector is considered a strategic field for the development of the Brazilian economy, since according to the Pesquisa Nacional por Amostra de Domicílios Contínua (PNAD, 2017), published monthly by IBGE, the number of persons employed in industry (in the quarter from October to December 2017) was 6.9 million, which represented 7.54% of the total employed population in the country.

Given this scenario, this research intended to investigate: What factors generating innovation and performance in the Brazilian Construction?

The general objective was to analyze which innovation and performance factors are relevant to the Brazilian civil construction sector, from 2007 to 2015.

Specifically, it was intended:

- a) Identify the innovation variables related to the construction sector;
- b) Identify performance variables related to the construction sector;
- c) Investigate the dependence between innovation and performance variables, based on canonical correlation analysis.

We can justify this study by the relevance of the sector to Brazilian economy that have 6.9 million workers (IBGE, 2017) and because there is a demand of houses in Brazil of about 6.068 million, which highlights the need for investment in the activities of this segment to achieve solve this social problem (Fundação João Pinheiro, 2017). It also intends to academically advance empirical study that seeks to understand innovation and performance characteristics as set by previous studies (Andreassi & Sbragia, 2004; Brito, Brito, & Morganti, 2009; Santos & Popadiuk, 2011; La Falce, De Muylder, & Toivanen, 2014).

This article was organized into six chapters. The first topic addressed, setting, problem, objectives and justifications. The second deal with theoretical discussions; the third presents the methodology. The fourth included description and results' discussions and the fifth with conclusions, international and managerial implications followed by references and acknowledgement.

Theoretical Discussion

La Falce, De Muylder and Toivanen (2014) mention a bibliometric research by Fagerberg and Sapprasert (2011), which evaluated the database Web of Science publications from 1994 to 2010, showing that most of the scientific literature on innovation is divided into four lines study. The first is focused on the evolutionary conceptual basis of innovation, with authors such as Nelson and Winter (1982), and Schumpeter (1988), which address the role of innovation in organizations and its impact on economic changes over the long term. The second line, according to La Falce, De Muylder and Toivanen (2014), can be classified as interpretative, consisting of surveys reflect the knowledge accumulated up to that point. The third line, according to the authors, discusses innovation as a competitive advantage for an organization, and Freeman (1987) as its most prominent author, which assessed the impact of innovation systems of Japanese organizations. Freeman (1987) and Lundvall, Dosi and Freeman (1988) are authors who can be recognized, as the fourth line of study, that aims to evaluate the economic growth as a result of innovation and diffusion of technology (La Falce, De Muylder, & Toivanen, 2014).

Innovation can be a new or a significantly improved product (good or service), a process, a new marketing method, or use a new method of organization. Innovative activities relate to all scientific, technological, organizational, financial and commercial transactions leading effectively, or are aimed at driving, the introduction of innovations. Innovation is central to economic change (Manual of Oslo, 2005).

Innovation approach, as Hendriksen and Van Breda (1999), can be analyzed from a monetary perspective, using accounting and financial data, or so, from the perspective of non-monetary information. The union of those two kinds of information (monetary and non-monetary) can lead to a performance evaluation system with a different condition, generating prospects capable of contributing to the decision-making process.

For Brito, Brito and Morganti (2009), innovation is a key factor in the performance of companies. Regardless of innovative practice, it should result in better performance for the

company, compared to the achieved by companies that do not innovate. In assessing this performance several data are used. Most of the time, measures of financial performance, consider sales per employee, exports per employee, sales growth rates, total assets or resources, total employment, operating income and return on investment (Archibugi & Sirilli, 2000).

Arguing about the relevance of innovation to business (Chaney, Devinney, & Winer, 1991) many empirical evaluations show a solid relationship between indicators associated with innovation, such as spending on R&D, and business performance.

Due to the existence of different ways to measure innovation and performance and the results achieved even controversial, Santos, Lima, Basso, Kimura e Sobreiro (2017) believe that it is not possible to define the best variables for an explanation of the process and the results of innovation, as well as the financial performance of companies. For Sbragia, Stal, Bell and Andreassi (2006) over the variables used to measure innovation are: R&D, patents, direct monitoring of innovation, bibliometric indicators and evaluation of R&D performance. Still stand out as a possible correlation between innovation and performance: investment in R&D and profitability, investment in R&D and sales, investment in R&D and market share, investment in new products introduced in the market and profitability, patents and billing.

The following variables can be used to name the innovation suggested by Brito, Brito and Morganti (2009): investment in innovation, academia, technical support personnel, sales and international locations and sales of new products covered by patents.

Method

The study is a descriptive research (Figure 1), using secondary data relating to Brazil's civil construction sector from 1995 to 2016. Data processing was quantitative using dependency model from the canonical correlation analysis (CCA) that consists of a model with two or more dependent variables and two or more independent variables.

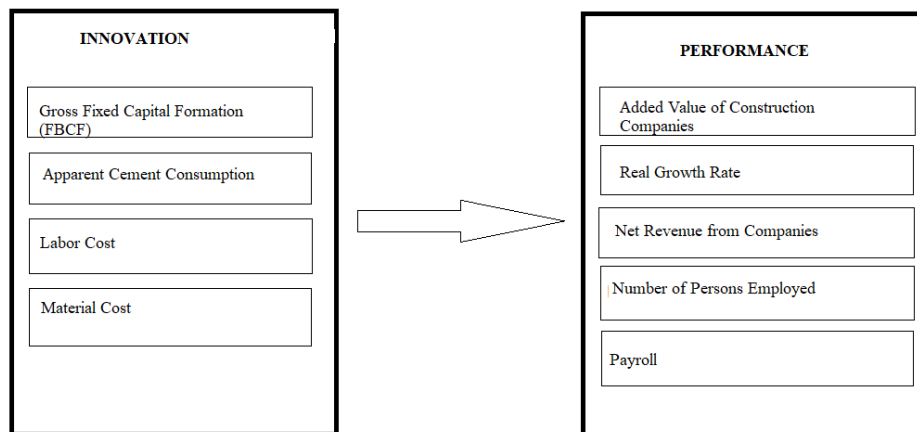


Figure 1: Model of innovation and performance in construction sector
Source: Developed by authors.

For the source of the data were representative documents sector databases (Union of Construction Industry in the State of Minas Gerais - Sinduscon-MG, Brazilian Chamber of Construction Industry - CBIC), Brazilian Institute of Geography Statistics (IBGE) and the Ministry of Labor (MT) (Table 1).

Table 1 – Variables of the Model

Gross Fixed Capital Formation (FBCF)	The values of FBCF the years 1995 to 1999 have been updated from the Table of Resources and Uses (TRU) Summary-Level 12 IBGE National Accounts 2005, IBGE. For the years 2000 to 2009, data were updated by TRU of National Accounts 2015. From 2010 to 2017, the values were updated based on the Quarterly National Accounts (4th / Trim / 2017 - Ref. 2010 -. New Series) of IBGE.
Apparent cement consumption	From 1995 to 2013, the values were updated according to the latest annual report released SNIC and in the year 2013. From 2014 to 2016, we used the total consumption value in Brazil. The total of the year 2017 was estimated from the years 2012 to 2016.
Labor cost	We used the data of the cost component of the labor Cost of Basic Unit Brazil, calculated and published by CBIC.
Material cost	We used the data component of the building material cost of the Basic Unit Cost Brazil, calculated and published by CBIC.
Added Value of Construction Companies	From 1995 to 2001, we used PAIC/IBGE in SIDRA, referring to the CNAE 1.0. In the years 2002 to 2006, amounts referred to CNAE 1.0. From 2007 to 2015, amounts referred to CNAE 2.0. For the years 2016 and 2017, the amounts were calculated based on the Value Added (VA) published by the National Accounts (IBGE).
Real growth rate	The data from the Added Value of Construction released by IBGE in the System of National Accounts (SNC).
Net Revenue from Companies	From 1995 to 2001 were calculated based on the difference in total Gross Revenue minus their respective deductions, as disclosed by PAIC/ with reference values to the CNAE. From 2002 to 2006, values disclosed by PAIC / IBGE in SIDRA, with reference to CNAE 1.0. From 2007 to 2015, amounts referred to CNAE 2.0 and disclosed by PAIC / IBGE. For 2016 and 2017, the values were calculated based on the Value Added (VA) of the Construction companies published by PAIC/IBGE.
Number of persons employed	From 1996 to 1999, the information was updated according to the publication "National Accounts 1998-2000". From 2000 to 2015 were, according to the series of National Accounts 2015. In 2016 and 2017 were based on the National Survey by Household Sampling Continuous (National Household Survey) IBGE.
Table Wages, withdrawals and other compensation (payroll).	From 1995 to 2001 were used PAIC / IBGE in SIDRA data. From 2002 to 2006, amounts referred to CNAE 1.0. From 2007 to 2015 referred to CNAE 2.0.

Source: Data from research.

Results

From the analysis of the proposed model and the variables corresponding to innovation and performance, can be confirmed as the innovation:

$$\text{Innovation}_{1i} = 0,924.z\text{FBCF} + 0,187. z \text{ LaborCost}_i - 0,178.z\text{MaterialCost}_i \text{ that is:}$$

a) The Gross Fixed Capital Formation (FBCF - representing investment) causes an increase of 0.924 units in innovation.

b) The Labor cost causes an increase of 0.187 units in innovation.

c) The Material cost causes a reduction of 0,178 units on innovation.

The alignment of FBCF variable, which represents the national economy, investment measure and which includes, among others, residences, buildings and structures, machinery and equipment, as described by Ferreira et al. (2012) and Batista Jr. (1987), is the most important variable in the composition of the construct innovation of the Brazilian Civil Construction, in the period analyzed.

As for the Labor Cost, the relationship with innovation corroborates the findings of Muylder (2004) and La Falce (2014) who analyzed other sector (Brazilian Steel) and with the

definitions of Nonnenberg et al (2008) of the variable itself that was relevant but less important innovation of the Brazilian Civil Construction.

The inverse of the Material Cost corroborates that innovation corresponds to new products and greater control and better use of resources, thus feasible a reduction in material cost. It is understood as material cost inputs for basic construction (Lima, 1998).

The canonical correlation also showed that the cost of the workforce has a strong influence on innovation and this could be explained by the different types of innovation. Some factors are related to (Willerding et al., 2015; Costa, 1993), characteristic of production that involve natural resources, capital and labor and it could be more important based on a knowledge, intellectual and human capital environmental enhancement. According to Willerding et al. (2015) companies are responsible for strengthening and innovation of its powers, with a qualitative and quantitative growth in the form of increased productivity, added value and innovation. According to the Oslo Manual (2005) diverse knowledge on innovation are embedded in people and their skills. Therefore, the role of human capital in innovation is important.

Thus, the results indicated a relevance and adherence of the proposed study the topics innovation and performance in the industry, where for every increased unit cost in manpower can get an increase of 0.187 units in innovation.

In relation to the material cost, the relationship is negative, it is not the increase in the cost of material that causes an increase in innovation. The canonical analysis results showed that the material cost has less impact on the selected variable (innovation).

The results are related to the type of innovation, as the Oslo Manual (2005), because there are several types of innovation that does not involve only the material cost and process innovation, marketing innovation and organizational innovation. In this context, it is worth remembering, which can be considered as innovative as the Oslo Manual (2005) the implementation of a process, or a new marketing method or a new organizational method in business practices, the organization of the workplace or in external relations. Especially, related to organizational innovation the Oslo Manual points out that they may have to achieve better performance of a company by reducing administrative costs, or, transaction cost reduction or even stimulating the satisfaction in the workplace (and thus labor productivity), gaining access to non-marketable assets (as unencrypted external knowledge) or reducing costs of supplies.

Thus, explains the result obtained in the canonical correlation: for each unit added in material costs obtains a reduction in the cost of 0.178 innovations.

From the analysis of the proposed model can be confirmed as the performance:

Performance_i = 0,293.zVAConst_i + 0,697.zWages, that is:

- a. The Added Value of construction, is the amount that the industry adds to the GDP of Brazil, causes an increase of 0,293 units in its performance.
- b. Wages cause an increase of 0,697 units of performance.

The performance variables of the canonical correlation analysis showed a high significance level, that according to Light (2016) and Cosenza (2003) indicate that there is a relation to the value-added wealth and performance. This result confirms the theory indicating that the added value is the result of industry performance involving the entire production and therefore it explains that for each unit of added value increases 0.293 units in the performance factor.

The most representative obtained regarding the performance was observed in wages value that means in this research, the value of salaries, management fees, withdrawals of partners and owners, fees, commissions, allowances, 13th salary, vacation, bonuses and profit sharing of employees and management of all employed persons (Neves & Fernandes, 2002; Silva et al, 2014).

The study highlights that human capital is the main guiding the performance of a company (Silva et al., 2014) and that the process of identifying, developing and retaining people in organizations is a reliable strategy that can provide competitive advantage in organizations or sectors in a competitive context. This analysis may help explain the fact that wages influence more strongly sectoral performance, for each added unit to the standard indicator gives an increase of 0,697 units in performance.

Conclusions

Innovation can be understood as a strategy of organizations, sectors and countries in the search for market positioning and sustainability. The performance can be understood as a method of measuring the efficiency and effectiveness of the organization.

The Brazilian construction industry is considered strategic for the development of the Brazilian economy and accounts for over 50% of the Gross domestic fixed capital, 5.2% of GDP, 24.4% of the industry's GDP (2017), more than 2 million direct workers (2017) in 215,000 establishments (2016). From 2007 to 2013 the construction industry grew in its production (61.72%) against 30.72% of the Brazilian economy, this is because this period has ease of families in getting the home from the expansion financing. In the period from 2014 to 2016 was a decrease of 13.22% in its GDP and even a shutdown of one million direct employees. Given this scenario of high and low in their activities, this research project intended to better understand: What factors generating innovation and performance in the Brazilian Construction? And therefore, the overall objective of the research: analyzes which innovation and performance, generating factors in the Brazilian civil construction, from 2007 to 2015.

Innovation and performance can be confirmed as innovation: gross fixed capital formation (representing investment) causes an increase of 0.924 units in innovation; the cost of the labor causes an increase of 0.187 units in innovation; the cost of the material causes a reduction of 0,178 units on innovation. The results of canonical correlation also show that the cost of the workforce has a strong influence on innovation. The types of innovation can explain this process.

From the analysis of the proposed model can be confirmed for performance: The value added of construction, is the amount that the industry adds to the GDP of Brazil, causes an increase of 0,293 units on their performance; Wages cause an increase of 0,697 units in performance.

Considering the studied theory, indicators and variables chosen to compose the model and tested from the canonical correlation analysis returned a high explanatory power (98.08%) which reinforces the relevance of the study and alignment the specific sector.

As a work limitation the canonical model does not allow to measure how much the independent latent variables affect its dependent counterparts, and also is another limitation availability of data.

As a new research, it is suggested to carry out new studies that seek the expansion of data and new analytical methodologies base where you can measure the impact of innovation in performance.

Thus, it is understood that the focus of the study has been met and contributes to academic and organization studies.

It is expected to instigate further studies about the relationship between innovation and performance using the variables validated in the construction sector using, for example, a structural equation modeling. Still can suggest a new study to compare the innovation and performance factors with other sectors or country empirical analysis with this model.

International and Managerial Implications

We sought to advance from an empirical study on the understanding of innovation and performance (Andreassi & Sbragia, 2004; Brito, Brito, & Morganti, 2009; Santos & Popadiuk, 2011; La Falce, De Muylder, & Toivanen, 2014) and the adapted model from studies Muylder (2004) and La Falce (2015) focused on the Brazilian construction adapting the variables that represent innovation and performance investigating the dependence between variables using the canonical correlation technique which is an multivariate analysis as proposed by Johnson and Wichern (1998) and thus a quantitative descriptive study.

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