Innovation and construction management in Brazil: Challenges of companies in times of quality and productivity

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Abstract. Considering the efforts to optimize productivity and quality in the construction through the potential existing in the respective companies, this study presents an approach for identification, management and priorities of improvements actions at construction sites focusing status on productivity, added value and innovation in the socioeconomic context and scenario of construction industry in Brazil. Technological advances in recent years have made the Brazilian construction industry gradually incorporate technologies and forms of management, despite its traditionally conservative character. In current days, the innovations are pursued with the quest for greater quality, productivity, safety and customer satisfaction, which have been increasingly competitive and global. Construction in Brazil occupies an important role in the economy, directly contributing to GDP and acting on an extensive productive chain of suppliers, commercialization services and maintenance. The Brazilian construction sector has undergone major changes in recent years, facilitated by factors such as the resumption of public investments, the creation of laws that facilitate real estate, investments and funding of external resources, and the efforts of the Brazilian Quality and Productivity Program - PBQP H. However, the sector faces problems of a lack of skilled labour to meet the growth needs of the sector. There are still problems and challenges of quality and productivity that prevent full sector development. The aspects of nonconformity, low quality, high tax burden, outsourcing and informality of the workforce have not been adequately addressed and resolved. Through the use of indicators of productivity and growth, the challenges of the Brazilian construction industry are discussed and the possible paths for the sector that allow its full development and to reduce the distance between the Brazilian construction industry and that of the developed countries.

1. Introduction

1.1. Introductory Concepts about Brazil

The Federative Republic of Brazil was proclaimed in 1889, from the then "terra brazilis" discovered in the fifteenth century by European expeditions. From colonization and Portuguese language, the country currently has a regime of Presidential government, formed by the union of 26 states and 5,570 municipalities. It is the largest country in South America (Fig. 1), being the fifth largest in the world in territorial area, 8,516,000 km² (47% of the South American territory) with a population of 200 million inhabitants. It is one of the most multicultural and ethnically diverse nations, due to strong immigration from various countries, where 81.25% of the population live in urban areas [1].
The main economic region of the country, the cities of Sao Paulo and Rio de Janeiro are located in the Southeast (Fig. 2), where 55% of national GDP is generated and 80.35 million people live [2].

With its extensive territory and characteristics, crossed in the north by the Equator and to the south by the Tropic of Capricorn, Brazil is located in the inter-tropical zone, where hot and humid climates prevail, with average temperatures around 20ºC. Historically, has recorded low rates of natural disasters from earthquakes, volcanoes and hurricanes due to geological and climatic factors [2]. Brazil's economy has a nominal Gross Domestic Product (GDP) of 2.39 trillion dollars, ranked by the IMF as the seventh largest economy in the world, the country is ranked 62nd in the world in the GBP per capita ranking. The country is an active member of economic blocs, targeting Mercosur, G-20 and BRICS. It has hundreds of trading partners, and about 60% of the country’s exports relate to manufactured and semi-manufactured products. Brazil's main trade partners in 2011 were: Mercosur (25.9% of trade), Europe (23.4%), Asia (18.9%), United States (14.0%) and 17.8% others [1].

2. Brazilian Construction Scenario

2.1. Economic growth of the sector

Civil construction in Brazil, starting in 2000, once again plays a leading role in the national economy and is on the road to a new and important virtuous cycle of growth. Construction as a development lever has important socio-economic standpoints, helping to cope with the housing shortage, as well as contributing to infrastructure solutions, which constrain the country's rapid growth. The industry continues to be one of the leaders of the current pattern of economic growth in the country [3]. Fig. 3 shows the evolution of cement consumption in construction in Brazil in the last years. The number of jobs generated in recent years (Fig 4) illustrates the growth of the sector [3].

The construction sector has a significant socio-economic role in Brazil, with a formal participation of 5.6% of total salaries paid to workers in the Brazilian economy and 9% of employed persons. The building industry needs more growth. In 2010, the Brazilian housing shortage was estimated at 6,273 million households, of which 82.6% are concentrated in urban areas [2]. Data on the expansion of construction indicates that there is robust growth in the sector. Between 2006 and 2013, construction investments totalled more than 39.3% of the country's gross fixed capital formation [4]. However, in comparison with the growth of the country, it can be seen that Brazilian construction has not been following the real growth of its GDP in relation to National GDP (Fig. 5).
2.2. Construction Productivity in the Brazilian Economy

The use of a productivity measurement of a process is similar to the evaluation of the performance of a work model, for a later analysis before other similar processes. Productivity indicators are present in most organizations that are active in several activities, since the measurement and control of this indicator is a guiding factor for the achievement of high performance results, continuous improvement, cost reduction, quality improvement and maintenance of the organization's sustainability. An analysis of industry productivity in Brazilian economy identifies the low levels of productivity of the workers in relation to other countries (Fig. 6).

![Figure 6. Productivity of each worker in the countries (US$ / year [5].](image)

From the point of view of the growth of production and the economy, Brazil's productivity in relation to other developing countries in the last decades (Fig.7), And the construction productivity compared to other industrial sectors in Brazil are illustrated below (Fig 8).

![Figure 7. Productivity Growth - Average rates by selected countries (%) [6].](image)

![Figure 8. Productivity Growth in Brazil - Average rates by sectors (%) [2].](image)

2.3. Quality development in construction sites

The introduction of new management models by the construction companies, which consider quality from a strategic perspective, is the result of a series of factors that characterize the current market situation of Brazilian civil construction, especially the subsector dedicated to building.
ISO quality standards have not been developed focused on the construction industry; it is fundamental to undertake a discussion of their requirements in order to enable their implementation in the sector. An efficient construction site project, in addition to ensuring the safety of its workers, brings in its core qualities that reflect in the total performance of the enterprise, such as:

- Better use of the energy expended by the worker;
- Rational use of equipment;
- Optimization of time (human and material resources);
- Rationalization of activities and use of spaces;
- Minimizing interference that can cause waste.

In Brazil, a growing increase has been observed in the introduction of improvements in the search for quality in construction sites. More companies have developed checklists, work orders, logistics and material storage, accessibility, quality tools, compliance with safety standards in workplaces, implementation of ISO certifications, Integrated Management System and the implementation of the Brazilian Program of Quality and Productivity (PBQP-H).

Even though initially the awareness and training reside in the top management of the companies, through the directors and managers in search of a lean model, it is perceived that the demand for productivity is essential for development of the sector.

2.4. Brazilian Program of Quality and Productivity (PBQP-H)

There was a challenge for Brazilian managers and authorities in creating mechanisms that would make it possible to increase the competitiveness of the construction industry. In response to this challenge, the Brazilian Federal Government instituted the "Brazilian Program of Quality and Productivity in Habitat" – PBQP-H, in the quest to improve the quality and productivity of Brazilian organizations linked to the sector. Together with ISO quality certifications, construction companies adopted the PBQP-H seal, relating to planning, projects, materials, labour and specifications on sites.

The PBQP-H aims to support the Brazilian modernization effort, by improving quality, increasing productivity and reducing costs in housing construction. It has targeted various segments of the production chain, ranging from the materials industry to construction companies, as well as other governmental bodies, financing agents and promoters, universities, research centres and non-governmental organizations for the development of diverse actions foreseen by the programme [7].

The main objectives of PBQP-H are:

- For companies – an opportunity to increase their competitiveness, through the reduction of waste, better training of professionals, access to projects, materials and components of better quality and adaptation to technical standards. It also complies with the provisions of the Consumer Protection Code, avoiding penalties for companies and suppliers that make products that are non-compliant with Brazilian standards.
- Public sector contractors – an opportunity to use the public sector’s purchasing power as a way to select suppliers with the highest quality, optimizing the use of public resources.
- For the consumer – an opportunity to use their buying power, giving preference to companies that produce with quality.

2.5. Profile of workers at Brazilian construction sites

The civil construction industry, due to its characteristics, requires the performance of heavy, changing, varied and repetitive activities by its workers. In Brazil, most construction workers have little schooling, little or no technical training, low wages, are poor and largely outsourced. It is associated with demotivation, poor nutrition, and lack of environmental awareness and job security.

On the part of the companies, it is observed that the monitoring of worker productivity and safety is deficient. Investments in training and improvement plans in this area are not sufficient, regardless of the size of the company or demand of the sector. It is also possible to observe the high turnover, works has been redone and high absenteeism of its employees.
The construction industry in Brazil ranks highest in relation to labour accidents registered with official Brazilian government bodies. Besides, with the informal working conditions may means that accidents are under-reported, and could increase these existent registers.

It is important to highlight the great social loss that is linked to the occurrence of occupational accidents and diseases inherent in the working environment of the Brazilian construction industry in the present day, which has a direct impact on the quality of life of the workers and the productivity results obtained by the company [8].

3. The role of Productivity and Innovation in the growth of the construction industry

Productivity in the construction industry has long been a focus for industry and academia alike, because the construction industry is a leading sector, with a key role in growing and sustaining general economic activity [5] [9].

This was driven in part by government, through productivity reports [9] [10] [11] [12] [13] and partly through collaborative industry initiatives and corporate sector initiatives [3] [5] [14]. In early strategies, the aims were simplistic. For example, Latham (1994) called for efficiency savings of 30% over five years [11] and Egan (1998) set per year targets of 10% reduction in both cost and time [12]. Aspirational targets (20%) remain in many cases [14] [15]. Companies increasingly use strategies to drive productivity improvement through efficiency and elimination of waste in targeted industry practices, such as procurement, integrated design: BIM [7] [11] [16], project management [17] [18] and innovation in the construction [19] [20].

Within this context, it can be argued that productivity improvement, or at least innovations and the process efficiency should be an important focus in construction research. However, productivity in construction has multiple meanings grounded in discipline perspectives, especially in developing countries such as Brazil.

3.1. Productivity in Latin America in relation to developed nations

Differences in growth rates of labour participation or the accumulation of capital (human in the form of labour skills and physical in the form of capital per worker) typically pale in comparison with the gap opened by lagging productivity improvements, or reversals, in the typical Latin American country [9] [21] [22]. In many cases, such as Brazil and Peru in Latin America, the relative inefficiency of the services sector when compared with the developed nations - and the low growth rates of the sector in recent years - contributed significantly to the reversal of the productivity convergence and the technology innovations [9] [19] [22].

The productivity failure can be traced to distortions in the workings of the economy that drive aggregate efficiency below the technological frontier [14] [22] [24] [25].

3.2. Challenges of construction companies in Brazil

In view of the literature, the size of the Brazilian challenge in the pursuit of higher productivity is clear, and that it incorporates the necessary innovation, both effective and lasting, since success depends on changes to the main structural problems of Brazil, such as social and cultural limitations due to the low quality of Brazilian education, lack of infrastructure, excessive bureaucracy, levels of informality in the workforce, high tax rates and little investment in technologies.

In addition, it is not only the government that needs to leave its comfort zone and seek new actions to promote efficiency, companies must invest in the renewal of their productive processes and in the development of really effective management processes, but such actions derive from increased competition. Therefore, there will only be productivity growth if we work seamlessly.

A construction company’s success can be basically defined in terms of its profitability and project success. However, long-term goals, strategies and competitiveness in the industrial environment force companies to measure their success with some strategic indicators such as innovation and technology transfer which also provide competitive advantage [5].
4. Importance of innovation in strengthening competitiveness

4.1. Innovation and its scope

The act of innovating means the need to develop different models to achieve a certain goal. It is when an idea meets the needs and expectations of the market, is economically viable and offers financial returns to companies. In other words, every innovation must generate results. Innovation is neither invention nor discovery, although it may often require these concepts. However, its focus is not on knowledge, but on economic performance. The first application of an innovation should be the strategy, bringing the maximum to its ideal.

But for an invention to be considered an innovation, your customers need to recognize the value of the investment. Some contemporary concepts of innovation suggest that innovation has the ability to add value to the products and services of a company.

Although there is a huge potential for innovation, companies still use these technologies very narrowly in their projects. Most of the time, they simply acquire and train the team, and the discussion about their use does not occur. The exchange of experiences among the various professionals also acts as a trigger for the creative process in the field of innovation.

A common question raised is: How much can construction be innovated in the construction industry? The question of the extent of innovation in construction is very different from other industries. Since it is necessary to consider in the application of innovative models in the construction industry, the economic, social organization, cultural and regional context in which it is inserted. Therefore, builders have a great challenge ahead of them: harnessing the innovative potential of all available information and technologies to deploy value-adding enhancements in the process. Today, they cannot be seen merely as something that automates or expedites the execution of the tasks on the construction site. They also represent a great qualitative leap for companies and professionals operating in a market characterized by productivity demand, reduced profit margins and competition.

4.2. Innovations: one of the main drivers of development

There is broad consensus on the role of innovation as a major source for countries' economic growth. The relationship between innovation and economic growth has been demonstrated by several studies over several decades that have found positive correlations between various measures of innovative performance and economic growth. It is through innovation that productive knowledge and creative ideas are transformed by companies into products and services with greater added value and novelty. It is not by chance that several governments have recognized that innovation has been playing an increasing role in the growth of their countries. For example, over the last 25 years, innovation has accounted for more than 60% of UK economic growth. Innovation appears as one of the main drivers of development and main motivation for the need for industrial policy. Precisely because of this, the competitiveness indicators try to capture this dimension of countries' economic development processes. The Index of Industrial Competitiveness Development released by the United Nations Industrial Development Organization measures industrial competitiveness as the capacity of countries to increase their presence in international and domestic markets – including indicators that seek to measure the success of nations in diverting their productive structure towards sectors that would be more innovation-intensive.

Figure 9. R&D investments in relation to GDP by selected countries (%) [26].
Figure 9 compares Research and Development (R&D) spending in some countries. Typically, more developed countries have relatively higher expenditures as a proportion of GDP. South Korea, with an R&D expenditure of 3.6% in 2014, is larger than the developed countries selected in the sample. Another highlight is the substantial increase of this variable for China. Brazil has made little progress in the last decade and it is small compared to emerging countries like Russia.

However, innovation should not be related only to R&D or patents. For companies in emerging countries, although R&D labs are rarer, many innovative activities can be found in the practical and commercial application of ideas not necessarily linked to cutting-edge technology.

At the same time, significant innovations can emerge not only from sophisticated labs, but also from engineering areas. Therefore, a broad concept of innovation encompasses the implementation of changes in products and services, processes and organizational systems. In emerging countries, innovative activities often lie in engineering and design. In a second step, they can form the foundation and preconditions for achieving world-class R&D activities.

It is impoverishing to classify countries (and companies) in a binary manner as ‘innovators’ or ‘non-innovators’. Enterprises from the emerging high-tech world have begun their trajectory with duplicative imitation. Imitation practices can be preconditions for the implementation of more sophisticated engineering and R&D activities, including the expressive generation of patents (Fig. 10). Much of the innovation does not depend on science, and the recombination of existing technologies accounts for a large part of innovative activity over the past 50 years.

In the longer term, rather than focusing on innovative activities, it is important to strengthen the technological capabilities that allow companies to move from innovation to an advanced R & D. Technological capabilities are a stock of resources based on human capital, technical-physical systems (software, hardware, labs, databases) and organizational systems, such as routines, procedures, standards, etc. The accumulation of technological capabilities, at the level of companies and industries, is fundamental for economic growth.

4.3. Improvements & productivity beyond projects, planning and management in developing countries

The current dynamic and competitive market makes companies seek continuous improvement, a fundamental factor for an organization that aims to characterize its services and products. For this, the precision, speed and the overview, that facilitates the decisions, are fundamental, what has made the Technology and the Information an important competitive differential. Effective IT and technology management brings benefits to the company's operational and strategic areas by providing data, information and insights to the project consolidation process.
Some successful cases and some index have been identified in managerial practices in offices and construction sites in Colombia, Turkey and Mexico [27] [28] [29]. The indices of productivity in the construction industry in Chile are well above the other countries of Latin America [30]. Although each country has its economic and socio-cultural particularity, it can serve as a guide in the models and practices to be adopted in developing countries.

In the sense of the economic growth of construction in Brazil, there is a constant diffusion of technologies, with competitive advantages of a dynamic market, and demands of flexibility, quality and innovation [17]. New market conditions and increasing competition are driving companies to technological modernization. There is an increasing use of software and applications to monitor the work associated with planning and budgeting, frequent use of digital signatures, integrated calendars, e-mails and corporate clouds by adopting a platform for managing and storing information and projects and Implementation of BIM - Building Information Modelling, shown as the centrepiece of the architecture, engineering and construction (AEC) technology market, to address building information, design, construction and operation aspects. The incorporation of new technologies requires changes in work practice in companies, since the development of an integrated model requires high collaboration and communication among those involved [31, 32].

Standardized processes and protocols will be required to define responsibilities and conduct the review and validation of documents and projects as well as the good practices necessary for data management to be appropriate to the team structure and company requirements [15, 32].

Nevertheless, BIM and associated technologies, currently, is not meant to directly interface with the real world at construction sites, making it more suitable for design than operations. To provide an efficient interface between software and physical data, there is a need to leverage flexible and adaptive data collection systems [33, 34]. It is observed the growth in the studies in the exploration of the potential of existing tools and equipment to answer the above needs for productivity improvements in construction industry through some innovations: (1) Unmanned Aerial Systems (UAV or drones), (2) GPS, (3) Sensors, (3) Imaging, (4) 3D Models / SFM, (5) Robotics, (6) RFID, (7) Lasers and (8) Standardizing and modularizing construction components.

Although small and large companies have started the process of deploying new technologies and information management, there are several difficulties in this process that prevent their complete adoption in the Brazilian construction sector, among them:
- Consciousness of entrepreneurs and managers;
- Equipment, software and training costs;
- Contraction of skilled labour;
- Resistance to change in the organizational culture of traditional production;
- Monitoring focused on the final profit of the works and services;
- Few indices of productivity and profitability of construction teams and stages.

5. Proposal of actions focusing status on productivity, added value and innovation

A control option is planning is through actions based on productivity and innovation available in the company or in the market, which is known to those involved.

The productivity control associated with the value added in the activity and the innovations available in the company can be managed in the construction through tools and available software, easy to follow and register, or even through spreadsheets. It is a proposal for simplified control of the priority actions to be provided by the company, focusing on productivity optimizations in the most relevant items of high value added, which have process alternatives and / or innovative solutions available, that are known to those involved.

Using existing spreadsheets and individual controls in the company, insert productivity range, added value range and identify action options, knowledge of methods or innovation in the corresponding activity. From these elements and rating, manage the classification of activities.

For analysis and classification of activities will be necessary to know the reference productivity considered in the budget, in addition to the planning and financial values of each activity and stages of construction. The measurement of productivity is rating as low or high, and must be periodic and constant, following the units of measures provided in the worksheets and technical memorials of the
enterprise, making it possible to identify the real quantity produced by the workers and their team in completing the activities. The added value is rating as low or high and considers the value of financial importance through the unit values or critical path of relevant interference of the observed activity and/or other related activities. Based on the previous productivity and value-added results observed in documents and on the construction site, the relevant activities are identified for analysis and discussion of the techniques, materials and processes available and knowledge among those involved in the process, and is classified as Available and unavailable for innovation. From these elements and rating, manage the classification of activities.

Table 1 illustrates the basic classification to be adopted, in relation to the improvement actions in the observed activities, in their priority scale.

**Table 1. Classification of actions based on added value, productivity and innovation.**

| Added Value | Productivity | Innovation | Action |
|-------------|--------------|------------|--------|
| High        | Low          | Available  | Priority |
| Low         | Low          | Unavailable| Important |
| Low         | Low          | Available  | Regular  |
| High        | High         | Dispensable| Needless |
| Low         | High         | Dispensable| Needless |

In the action column, it is observed that activities that have a high aggregate value associated with a low productivity will be understood as relevant, and those that have an innovation available in the company will be a priority to be implemented. The activities with lower impacts on results are denominated as regular, since it represents low added value, in its different productivity and available innovation conditions, but it is applicable actions, in search of better productivity indexes and continuous improvement of the process. While activities with high productivity results will be exempt from improvement actions at the observed construction stage.

Synthesizing the understanding Figure 11 proposes a simplified approach of actions to be provided by the company focusing on productivity, added value and innovation available, as shown.

**Figure 11. Construction productivity, added value and innovation approach proposal.**

The proposed simplified approach must be adequate to the existing management in the company and considers the need to know detailed projects and memorials, reference and measurement units, forecast values, deadlines and critical paths in execution, fines for delay, among others. And, they will be the object of analysis and discussion among all those involved in the process.
It should be noted that the registration and dissemination of productivity (of workers, staff and construction site), priorities of actions, available innovations and results obtained in the implementation of actions are important to be considered in the next projects and constructions, and plan needs, for a search for continuous improvement in the process.

6. Conclusions
The registration and dissemination of productivity (of workers, staff and construction site), priorities of actions, available innovations and results obtained in the implementation of actions are important parameters to be considered in the next projects and constructions, and plan needs, for a search for continuous improvement in the process. It is proposed adoption of decision-making that adopt the productivity and added value associated as parameters and using methodologies already tried by the involved ones. Making the actions available to professionals is a more pleasant beginning and does not change the daily routine of professionals. In Brazil, especially in the construction industry, it is observed that the traditionally high margin of gains and coefficients of safety make the control global, which makes it difficult to act in gaps, failure and waste. And even the identification of these.

With the globalization and advent of information technology expanded today, the construction industry needs innovation and transforming, which is felt especially in times of economic crisis, as today. Improvements must go beyond design technologies and reach construction sites.

From these analyses, it can be observed that the Brazilian construction sector is closely linked to oscillations in national GDP. The figures illustrate that investments and productivity in the sector need to develop further and leverage the growth of other sectors and consequently of national GDP. Since there is market demand to be met, we need to find ways to grow the Brazilian construction industry.

Construction performance needs to be less volatile and susceptible to national change. Although there are crises in the Brazilian and world scenario, the real growth of construction can make this sector become more solid. Without even counting on the urgent demand for improvements in public policies aimed at lower taxes for companies, social security incentives and laws that improve the condition of corporate earnings and consequent social improvement of workers and society.

Brazil needs to overcome difficulties and restore growth in order to converge with the socioeconomic pattern of developed countries. It is of the utmost importance for construction firms to increase competitiveness, which depends on raising productivity and developing innovative technological capabilities.

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