ACCELERATING CHANGES IN THE CONSTRUCTION INDUSTRY: EXERCISES AND LESSONS

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Abstract: The economic and social importance of the Construction Industry (CI) and its impacts caused on the environment demand search for models that can accelerate changes. The aim of this paper is to share lessons which can contribute to a technological paradigm shift in the CI. A paradigm shift requires the development and testing of specific models which imply: first, the identification of the influence vectors of the process of change; second, the application of the identified vectors in an integrated and interconnected manner, learning how to enable the acceleration of change. The complexity of the CI, added to the complexity of the analysis of the innovation process, together with the aim of introducing changes can result in an equation with complex variables. The complexity of this equation compared to the complexity of living beings naturally leads to the application of concepts of systems thinking. The exercises presented in this paper allow the identification of a few factors which should be to be considered by similar experiences, so they can have more chances of succeeding. The integration of agents, actions and instruments (legal, economic and social) in a collaborative network strengthen the rationalization of economic and natural resources use and can be identified as the main influence vector to the innovation process of the CI.

Keywords: Construction industry**;** Innovation; Integration of agents, actions and instruments.

INTRODUCTION

The construction industry productive chain can be understood as the “activities articulated progressively from the basic raw material to the final product”, including: 1) The raw material and component industry; 2) The main industry (responsible for the construction process); 3) The auxiliary industry (which includes consultants,

academy and specialists), (Blumenschein, 2004). It's main product is the built environment.

Although the construction industry is responsible for meeting society's demand for infrastructure and contributes to the social and economic development, its environmental impacts add to climate change, raw material scarcity, pollution and consequently to the roll of challenges for the 21st century as listed by the United Nations Environment Programme (UNEP) including: climate change, disasters and conflicts, ecosystem management, environmental governance, hazardous materials and efficiency in the use of natural resources (UNEP, 2011).

The construction industry in Brazil is experiencing an increase in production with the Growth Acceleration Program (PAC) from the Brazilian Government, together with the preparation for the United Nations Conference on Sustainability in 2012 (Rio +20), the FIFA World Cup in 2014, and the Olympic Games in 2016, which conduce to the regional development and to the construction of structural projects. This scenario fosters the economic development and the materialisation of "great investments in infrastructure" (CBIC, 2011). This is also an opportunity to strengthen the emergence of innovation and accelerate the paradigm shift in production and management of buildings and urban spaces.

With a workforce with below average education (Ghinis, 2011) and outdated construction methods, the Brazilian construction industry needs to improve its productivity and to raise investments in research and development. The industry is labour intensive and has presented an average added value per worker 27.8% below the Brazilian average (Ghinis, 2011). Only one public investment fund dedicated to the construction industry, called Habitare, which has an investment which represents 0.00078% of the industry GDP. The average for public investment in R&D in Brazil was 0.84% of the GDP in 2009, while private investments amounted to 0.78% of the GDP (MCTI, 2012). Considering the figure of 0.00078% mentioned above, the construction industry has received two thousand times less R&D investments than average, taking only public funding into account.

The Brazilian challenges, such as reducing the housing deficit of 5.5 million houses (MCidades, 2008) and the upcoming high profile international events, demand an update of national infrastructure, particularly concerning transportation, and require a shift in the paradigm of the constructive systems which negatively impact the environment. This will require the diffusion of Modern Methods of Construction (MMC), which according to the British Government, are more efficient, offer better control of environmental impacts and higher quality (Parliamentary Office of Science and Technology, post notes number 209, 2003).

The acceleration of a paradigm shift in Brazil is a challenge which demands the search for models and exercises which may prepare a road ahead. The study of drivers of changes in the production and management of the built environment is directly linked to the research on the process of innovation, models of technological evolution, collaborative networks and environmental management instruments (the latter two may consider behaviour changes).

Although there are tools available for analysing technological change and innovation, which may be used to study the construction industry, none applies fully to the context, especially in Brazil. Firstly, because they refer to technologically advanced manufacturing which are mostly foreign to Brazil. Secondly, because of the characteristics of the construction final product, which can be a building or an urban environment, both with peculiarities in the production process (Turin, Ive and Groak, 1968. 1986; Ive and Gruneberg, 2000). Thirdly, because Brazil is a country with a high social inequality and weak institutional framework. Furthermore, the number of stakeholders in the construction process highlights the relevance of the social dimension in any analysis (Bowley; Ive; Turin; 1966; 1968; 1986; Ive and Gruneberg, 2000).

The studies specific to the construction industry seek the integration of technical, economic, institutional and political factors, taking local peculiarities into account. In the European context studies tend to focus on the role of public policy and the relevance of integration among the agents co-ordinating the industry (CIB, TG-35, 1999; TG-71, 2010).

The goal of this article is to present some of the results obtained in the exercises co-ordinated by Lacis/FAU/CDS/FGA-UnB with the development of applied research for strengthening built environment innovation and sustainability, including processes and products. The design of a method to carry out the proposed exercises is based on the research methods used by Blumenschein from 1998 to 2004, which were developed from studies in the Bartlett School in London, the Schumacher College in Devon and the Centre for Sustainable Development in UnB. From 2005 this experience has been applied in research and developed by the Lacis team.

1. CONCEPTS AND THEORETICAL PRINCIPLES

Studies specific to the construction industry point to drivers of innovation and change, such as: behaviour of leaders, search for new markets, technological development, change in the production processes, strengthening of the learning and innovation systems, introduction of command and control instruments, both via incentives and persuasion, and the establishment of collaborative networks.

In studies focused on change in the construction industry some definitions of innovation converge to improvements and incremental change (CIB, TG35, 2000). The definitions referring to the construction industry, identified by CIB Work Groups (UK TG35, 2000, and TG71-73, 2010), illustrate the trend of departing from the Schumpeterian innovation concept as something new, patentable and lucrative, towards Freeman's (1994) incremental innovation concept.

Among the drivers for accelerating the paradigm shift the strengthening of National Learning Systems dedicated to the construction industry may be highlighted, which have been used in different approaches. Countries with a more centralised governmental structure and with ministries specific to the construction industry (such as Japan, France and England) have benefited from greater industrial collaboration and a change of focus from products to processes (CIB, TG-35, 1999). This approach is characterised by the relations and responses which group together organisations (for profit and non-profit organisations) and emerges from conscious efforts of public and

private agents which may share targets for improvement and development (Ludvall, cited by Viotti, 1997).

The concept of National Innovation System, defined by Freeman (1995) as “the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies” is an indispensable tool for structuring the analysis of national institutions and its relations in support of the capacity and ability of technological development of nations and industries.

In the neo Schumpeterian evolutionary approach, the indigenous learning literature emphasises the possibility of technological change based in the long term learning along the technological trajectory (Viotti, 1997). This trajectory is possible due to opportunities created by the accumulation of technologies introduced by the many processes of technological transfer and the continuous introduction of incremental change.

Late industrialised countries are characterised by the absorption and diffusion of incremental changes through what Viotti (1997) called the National Learning System (NLS). The acceleration in the paradigm shift gathers momentum in the set up of a NLS considering national standards of environmental education, technical and economic capacity for acquiring technology and national efforts in research and development (Blumenschein, 2004).

The application of the principles from the theory of innovation and the systems theory in testing and developing methods and accelerating the paradigm shift allow advances in the analytical framework supporting the strengthening of the organisations’ learning systems (Blumenschein, 2004). Maturana (2002) makes it clear that without an environment a system does not exist. It is through interactions with the environment that the main metabolic processes are possible, allowing a system to grow and change. Johnson (2010) offers an approach that emphasizes the complexity of the interconnection among vectors that influence the emergence of innovations and his analogy of coral bank confirms the importance of collaborative networks.

In applying this analogy to the context of organisational learning, the sharing of resources, expertise and responsibilities may be considered as a preponderant factor in the innovation process. The challenge then is in testing and learning different ways of carrying out this integration.

2. METHODOLOGY: STRATEGIC INTEGRATION

The method developed for analysing and implementation of innovation in the Brazilian construction industry presented in this article was developed during the maturing of Lacis. Initially, an analogy which was inspired in biology, ecology, theory of evolution, and in the Schumpeterian theory of innovation, has guided the efforts to understand the process of change in the construction industry, taking into account external and internal factors, as well as economic, technical and social ones, which influence the decisions and helped to obtain results.

Further research, including new dimensions influenced by the Schumacher College through contacts with Satish Kumar, Viktor Papanek and Fritjof Capra, has led to the

understanding that environmental impacts from the construction process should be considered part of the quality of the process. Besides, the integration of agents in a structured platform is an important innovation driver when seeking the introduction of a change within a system.

Through this process, a few questions arose: How to contribute to improvements in the construction industry? How to make it more adequate to society today, which is asking for greater care in the use of natural resources, as well as higher quality and efficiency methods?

These questions were taken to the Centre for Sustainable Development in UnB as part of a doctorate project, where different research methods were used to adequately handle the extent of the matter and the complexity of relations, both internal and external to the construction industry.

The results indicated that the goal of accelerating a paradigm shift may be reached by "strengthening the innovation and learning systems that can potentiate a new way of knowledge, one which values the sustainable way of delivering the built environment for all agents involved in the productive chain of the construction industry, sharing responsibilities and resources and integrating actions and instruments" (Blumenschein, 2004). The process of strengthen learning systems require, then, a well-structured platform which allows the integration and exchange of knowledge, expertise and resources.

The results from this maturation process are being applied in Lacis through pilot research projects, which consider that the innovation process is supported by the integration of agents, actions and instruments structured in a context which works like an ecosystem particularly designed to enhance the strengthening of the learning system, at all levels, gathering momentum and sharing resources, making the development, testing and demonstration of solutions viable.

The number of agents acting in the productive chain of the construction industry, and the number of internal and external factors influencing it, is comparable to that of living systems. In applying the definition of living systems from Capra (1996) we identify analogies in the organisation pattern, the process and meaning, which are useful to compare change in the living and the cultural systems. The change, adaptation and evolution are promoted by information systems, such as the genetic code for living systems. The focus of the method applied in Lacis is the planning of modification to be introduced via drivers of change.

For the conception and test of methods for accelerating the paradigm shift, the objectives and the scope were defined according to the change to be introduced, the identified stakeholders and the drivers considered and analysed, in three stages:

- **Definition of the goals**: The modification to be introduced may involve the mitigation of negative impacts, the introduction of a specific technology or testing of new methods. The definition of change leads to the identification of agents which should integrate the network for the implementation of the project.
- **Construction of the network of relevant agents**: Considering the availability and preparedness of the agents (or the potential for preparedness) to participate

in the project. The institutions and organisations to be integrated must share a common goal and be aware of the importance of teamwork, sharing responsibilities, resources and actions. The co-ordinating agents from the private and public sectors, academy and NGOs, are integrated in a process which allows new methods to be proposed and or developed to be absorbed.

- **Preparation of the context – an engineered ecosystem**: In order to assure that the necessary network will allow knowledge, information, methods and technologies to be generated and applied together with legal, economic, educational, institutional, communication and operation instruments, a well-designed and structured process is implemented, which is strategically monitored in order to strengthen the change of values and strategies, allowing the consolidation of a desirable technological trajectory.

3. RESULTS

In the development of the pilot projects focused on the construction industry, Lacis has consolidated three connected areas of activity:

- The productive chain of the construction industry
- The urban solid waste productive chain
- Urban and social regenerative processes

The main pilot projects are listed in table 1.

Table 1: Pilot projects

Materials Management Program (PGM)	With the goal of contributing to the management of materials used in the construction process, aiming to mitigate the environmental impacts from the extraction of raw material to the disposal of waste. It was developed and implemented in partnership with the local Construction Industry Employers' Association (SINDUSCON-DF) and the Brazilian Construction Industry Chamber (CBIC). It has three subprograms: • Rationalisation and Loss Reduction Program; • Materials Lifecycle Analysis Program; • Solid Waste Management Program.
Program for Social and Environmental Responsibility in Construction (PRAS) – Phase 1 – Responsible Procurement	Developed in partnership with developers and SINDUSCON-DF. The main product from PRAS – Phase 1 "Responsible Procurement" is the creation of a Procurement Guide, including principles and criteria for the acquisition of

	materials and services fulfilling environmental and social responsibilities.
Park for Innovation and Sustainability of the Built Environment (Pisac	The Park for Innovation and Sustainability of the Built Environment (Pisac) is the result of a partnership among public and private sector agents from Brazil and the United Kingdom including the Brazilian Ministry for Science, Technology and Innovation (MCTI); the Brazilian Construction Industry Chamber (CBIC), the British Building Research Establishment (BRE); the University of Brasília (UnB) via LACIS. Pisac is a concrete result of the integration of agents (public, productive and academia), actions and different instruments which allows bringing what is most advanced in the world to the national construction industry and to develop local approaches and stimulate investments in Research and Development to advance national Science and Technology, fomenting future innovation and economic development.
The Waste Observatory	The Recyclable Solid Waste Observatory of the Federal District was developed by Lacis with support from the Secretary for Science and Technology for Social Inclusion from the MCTI. The Observatory aims to structure information on Recyclable Solid Waste, integrating them in a single location, strengthening the knowledge management on this theme, including information gathering, storage in many formats (charts, web pages, maps, tables, reports, etc), and dissemination to the public interested in the theme.

The experience of developing these projects has made it clear that to conduce to a paradigm shift is a multi-layered task which depends on some factors, such as:

a) The presence of leaders;
b) Research and Development;
c) Legal framework.

These dimensions are most relevant because of their relations with a few barriers to innovation found during the development of the projects. The cultural divide between

the productive sector and the academia remains an issue in the Brazilian context, where researchers are reluctant of seeing their efforts being oriented to the market mainly for ideological reasons, and the industry is dismissive of elaborated efforts towards research and development. This divergence emphasise the prominent role of leadership, because, in this context, early adoption is an exception. Leaders produce results which are the only real leverage to counter the inertia of the late movers. The public sector also presents its own challenges in lacking a participative approach to policy making. Decisions are often made with no stakeholder consultation which leads to litigation. The judicial system of Brazil is very slow at best and offers many appeals instances, which further complicates the problems. Institutional weakness manifests itself in the constant shifts in policy and reversal of decisions made by public sector organizations with each change in Government. Until a few years ago it was not uncommon for an outgoing administration to wipe out all data from computers before the transition of power.

4. CONCLUDING REMARKS

The change process requires tests and development of methods which allow not only understanding the interdependences of every change, but at the same time to integrate the aspects which act on this process influencing its steps and direction. Once these forces are identified and integrated, it is necessary to exercise the establishment of references and to strengthen the learning process and the natural evolution continuous process, always in search of improvements of production processes and products of the built environment.

The projects carried out in Lacis allow the identification of a few important lessons:

- The potential of partnerships among the academy, productive and government sectors and NGOs to enable complex social systems and organisations, composing collaborative networks with specific goals;
- The capacity of the network to rationalise resources use and to distribute efforts channelled to the strengthening of goal reaching;
- The importance of consolidating shared meanings among the network agents, which allows identifying impacts, responsibilities and ways of integration;
- The enforcement of legal instruments may press for the change in behaviour;
- The weight of the decision of which product to produce and which process to be used, highlighting the influence to be applied by customer groups in favour of the selected targets;
- The role of media in disseminating and monitoring results;
- The importance of making practical methods available for the introduction of new paradigms to enable and accelerate change since learning increase the capacity of changing;
- The recognition of the political and institutional dimension as critical to sustainability.

The results obtained with the development of this research show that it is possible to contribute to the acceleration of the changing process in the productive chain of the construction industry with the structuring of collaborative networks in a planned structure and process. All the participating institutions consolidate results inside their

internal processes, strengthening the learning and the knowledge which, according to Dosi (1988) are requirements for the change process to get moving.

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