Construction Innovation Systems - a Sector Approach

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Abstract

Recent studies depict the general need to increase and improve innovation in the construction industry. Innovation processes are traditionally described and analysed either on a macro level or a micro level. Production in construction is basically project oriented, as opposed to manufacturing industries for which most of these theories are developed. It is not fully sufficient to study innovation from a micro or a macro level due to the effects of the project orientation and the large number of actors in the construction industry. The objective of this paper is to present a model of the construction innovation systems from a sector systems approach. The study rests upon findings in the area of innovation systems in general and construction innovation systems in particular on one hand and construction sector systems analysis on the other. This paper presents arguments for the development of activity based innovation systems at a construction sector level.

Keywords: Construction Innovation, Innovation, Innovation Systems, Construction Sector, Sector Analysis

1. Introduction

The construction industry, as well as any other type of industry, develops continuously. The momentum and impact of construction development is influenced by a complex system of different elements [1]. Knowledge about the characteristics of the industry, its driving forces and external influences, are of basic importance when to understand the development of construction [2], i.e. when to understand the construction innovation systems [3]. Recent studies depict the general need to increase and improve innovation in the construction industry and the need for better understanding of the innovation processes of construction as to gain construction innovation [4][5][6].

Innovation processes are traditionally described and analysed either on a macro (national) level or a micro (company) level [7]. Existing theories of National Systems of Innovation are used on the macro level [8] while Firm Centred Knowledge Networks or Complex Product Systems are examples of innovation theories applied on the micro level [3].

Production in construction is basically project oriented, as opposed to manufacturing industries for which most of these theories are developed, and involves a large number of specialised actors from different branches of industries. Further, construction is closely connected to the national social structure and consequently, is highly influenced by local, governmental and other institutional actors [9]. Due to the effects of the project orientation together with the large number of actors in the construction industry is that in many cases it is not sufficient to study innovation from a micro level as a single company is depending on the actions of their collaborators. The effects on a macro level are that the relations between the actors of the industry are not static but varies from project to project, thus the national systems of innovation has more of an occasional character in construction than national systems of innovation in traditional manufacturing industries. Thus, a comprehensive approach is needed to understand the wide and complex characteristics of construction and its innovation systems.

The objective of this paper is to present a model of the construction innovation systems from a sector systems approach, i.e. a comprehensive approach to construction that includes the actors involved in the whole lifecycle of construction as well as institutional actors at the international, national, regional and local level. The purpose of the study is to induce a discussion about construction innovation systems at a sector level as a complement to identified shortcomings of established approaches of national innovation systems and micro level systems. The study rests upon findings in the area of innovation systems in general and construction innovation systems in particular on one hand and construction sector systems analysis on the other. The study constitutes a theoretical approach to construction innovation systems based on literature.

2. Characteristics of Construction

The specific characteristics of construction is frequently described in literature, e.g. the physical nature of the product of construction and the structure of industry [10], the production of single/unique structures and the diversity of clients [11], the importance of maintenance works [12], itinerant production and the derived nature of demand [13], the long term use of structures [14], diversified client categories such as households, firms and government [15]. The construction process is inherently complex and to a large extent fragmented with many actors working together in ever changing project organisations [16].

Describing innovation systems of construction requires a thorough understanding of the characteristics of construction. The construction sector covers a wide scope of activities, it involves a great variety of actors and it is externally influenced by its market and institutional environment. Construction includes such diverse economic activities as new production and repair/maintenance, itinerant production and stationary manufacture, the production of buildings and constructions, and it involves a large number of actors representing different professions and types, e.g. companies, public utilities and private persons.

3. Innovation

The definition of innovation is some what unclear, many different exist. OECD defines it as "A technological product innovation is the implementation/commercialisation of a product with improved characteristics such as to deliver objectively new or improved services to the customer. A technological process innovation is the implementation/adoption of new or significantly improved production or delivery methods. It may involve changes in equipment, human resources, working methods or a combination of these"[17]paragraph 24. The similarity between most of the definitions is that they include creating a new product or process, and putting it to use [18]. It does not however state that it has to be new for everyone since it is enough to be new for those adopting it. Innovation is not the same as invention; invention is the new idea that may lead to an innovation through the innovation process, see fig. 1.

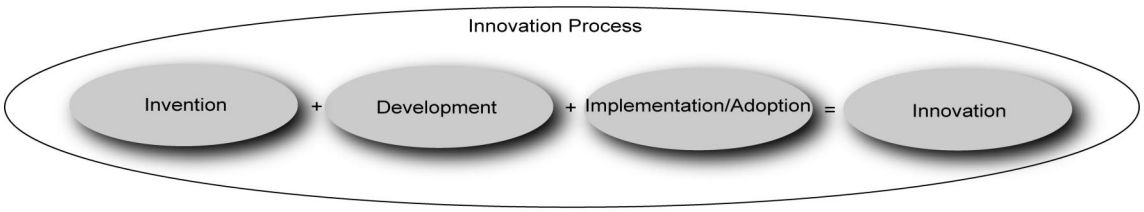

Figure 1. The relation between invention and innovation in the innovation process. (adapted from [19]).

3.1.1 Innovation from a macro-level perspective

In the last decades there has been a great interest in using National Systems of Innovation (NSI) to explain differences in the ability of countries to foster and develop innovative capabilities. Early on, the concept of NSI was defined as the set of institutional actors that plays a major role in influencing innovative performance nationally [20]. According to Edquist [8] p 182 "systems of innovation = the determinants of innovation processes = all important economic, social, political, organizational, institutional, and other factors that influence the development, diffusion, and use of innovations. With a national perspective SI consists of two main components, organisations are actors and institutions are the rules of the game; laws, common habits, norms etc [8].

On the macro level there has been some resent research on national systems of innovation or related areas for the construction industry, e.g. [21], [3], [2]. Much of the work has not been on national systems of innovation as such, but on national construction business systems [2]. In these studies the relationships between institutional factors, companies, education etc. are studied. National patterns and characteristics are used to understand and explain the business capabilities. Regulation is one aspect of national innovation systems that has been studied [22]. In one international study on national systems of innovation the focus was on public policies, and their link to political systems, and their influence on the national systems of innovation [3]. In Sweden a national innovation system has been described [21] identifying six important groups of actors;

clients, service providers, suppliers, universities and colleges, research institutions, and research financers.

Together these different studies do cover a large part of the different parameters within national systems of innovation. One part that is not covered in any particular way is the effects of the project-based situation on national systems of innovation. When using the national systems of innovation on a manufacturing sector the relations between the actors are rather fixed making the systems static. The project focus together with that some actors can play different roles in different projects alters the construction sector systems continuously. The systems are unstable and it is inappropriate to use for general analyses.

3.1.2 Innovation from a micro-level perspective

Brown and Eisenhart [7] have identified three streams in literature regarding the organization-oriented tradition; rational plan, communication web and disciplined problem solving. The rational plan is that a well planned and implemented product that has the right support will be a success. The communication web is that the better members are connected with each other and with key outsiders the better the development process. The disciplined problem solving is a balancing act between autonomous problem solving project teams and the discipline of a heavy weight leader.

Regardless of how the innovation approach is described there are many factors which influence a company's ability to innovate, important examples are competence and knowledge [23], communication [24], learning [23][25], relationship and co-operation with other actors [23][26], and risk capital and reward [23][27].

The theories of innovation steams to a large extent from manufacturing and most often assume that work in support of innovation takes place within the same company. One theory that contrasts with traditional innovation theories and models is CoPS (Complex Product Systems). These are defined as "High cost, technology-intensive, customised, capital goods, systems, networks, control units, software packages, constructs and services" [28] p.793.

There has been some research done on the innovation in the construction firm ([16]). The research is very dispersed, issues concerning, specific parts of the construction sector [29][30], specific actors or groups of actors [31][32] small businesses [33][34], some work on construction material and equipment providers [20], learning [35], teaching [36]. This research covers many of the different areas thought to be important in traditional innovation theory. The aspect that is missing is the contextualisation needed to fit it into the project-based construction process.

Many of the different authors have stated that collaboration between different actors is important especially as the construction process is so project focused as it is. Construction innovation on the part of the primary actors – designers and contractors – outside projects appears to be rare [37]. How to understand this innovation collaboration and how to develop it long-term are rather

unstudied areas. As a result ideas that occur on a daily basis on the construction site and in research and development environments normally, literally, have no place to go [38].

As much innovation takes place within the daily projects, the ability to implement innovations is often not depending on one company, thus a micro-level focus will not be fully sufficient to explain implementation success or failure in construction.

4. Construction Sector Systems Analyses

A traditional way to approach construction is by the construction process model that describes the main phases of a general construction project, i.e. development, design, construction and operation. The phases of the process model of construction are independent of project type and scale, procurement systems, numbers of actors involved or where the project is located. For example, Bonke [39] presented a construction process model with the aim to provide a general model applicable in an international context and of course other outlines of the process model are available in literature (e.g. [40][41]). A general construction process model, standardised even on an international level, provides a basis for analysis of construction, such as information and knowledge management, business relations, risk mitigation, productivity, benchmarking analyses, etc. An organisation can position itself relative to other actors and apply the analysis specifically focussed on topical targets or core areas based on the general model [41]. However, the construction process model basically describes the creation process of a construction product and as such it emphasizes the production phase. Thus, the construction process model is too narrow to describe and understand the full scope of actors and activities in the construction sector [42], and consequently, a more comprehensive approach is needed when to analyse construction innovation systems.

In this paper, a construction sector systems analysis, established by [41], will provide a model describing construction innovation systems applied at a sector level. The construction sector systems analysis, referred to as the sector model, aligns with the structure of a systems analysis, with specific emphasis on a comprehensive aggregation level and consideration of the influences of the institutional environment. Thus, the sector model describes the construction sector as an open system, composed of interacting components that carry out economic activities ranging from manufacture, production, to asset management.

The construction sector systems include not only on-site production activities but also the operation and maintenance of existing structures, the manufacture of building materials and equipment, real estate management etc. The system environment consists of external elements that in one way or another influence the system. The construction sector systems model specifically considers the institutional environment, as an important aspect that influences the sector. In the case of construction, the role of institutional actors is twofold, as they constitute part of the system's environment in their role as policy makers, but also as components of the systems, principally as clients or as public companies competing at the market. Another external influence

on the construction sector systems comes from the state of the market, the interest rate level, etc. This external influence is referred to as the market environment, or simply the market.

The economic activities of the sector model are divided into three main activities of construction, namely manufacture and distribution, project-related activities and, asset management, i.e. real estate and property management etc. In the sector model, these three activities are described along the vertical axis, dividing the model into three sections, see figure 2. The type of construction works for each of the main activities are described along the horizontal axis and are divided into new construction, management of service and demolition. Consequently, the overall horizontal direction describes the life cycle of the building or construction while the more detailed, horizontal level represents the different phases of the construction process. The vertical direction correspondingly indicates the value chain of construction, from the initial manufacture and distribution to the onsite production in which the new construction is prepared and on to the maintenance of the completed structure.

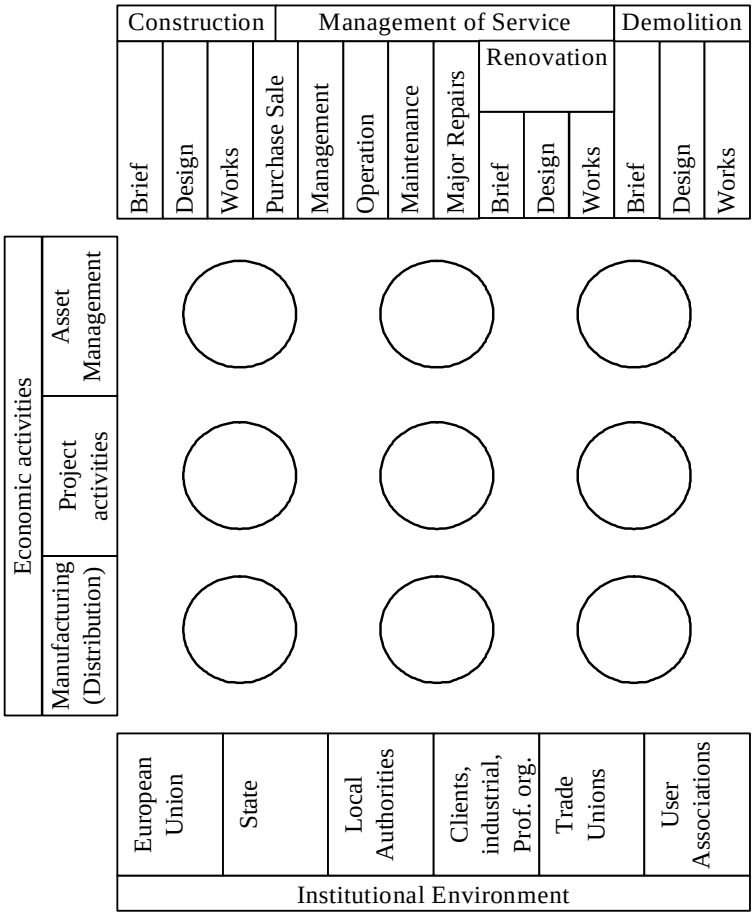

Figure 2. The construction sector systems model [41]

The various actors constitute the components of the systems, those actors are grouped together in boxes according to the construction activities they perform, and the phases of the life cycle they support. One category of actor, e.g. contractor or architect, can be represented in more than one construction activity.

As the sector systems of construction are described as open systems, they are influenced by the external environment, i.e. the surrounding market and the institutional environment, which is specifically emphasized. Thus, in the sector model, the institutional environment is represented by different institutional actors, which are graded from left to right, with the most comprehensive institutional actors to the left, starting with the European Union, down to trade unions and tenants' associations.

5. Activity Based Innovation Systems

The principal suggestion in this study is to use the sector systems model presented above as a framework for an innovation system at a construction sector level. This implies an innovation system that is established at a construction sector level in which the components of the system are constituted by the economic activities of the system. The argument for such a system rests upon the earlier deficiencies described for macro- and micro innovation systems in the case of construction.

The activity based construction innovation systems includes the temporary and itinerant project related activities as well as long-term manufacturing. National innovation systems are traditionally designed for manufacturing industries and, according the discussion earlier, has difficulties in describing project oriented industries as is the case for construction.

The activity based construction innovation systems captures the whole lifecycle of construction, including the early stages of manufacturing through to the final demolition, and thus, does not solely concentrate on the short-term production phase. Consequently, the effect of innovations in one phase of the lifecycle can be analysed in a long term perspective. This is of course of specific interest in construction due to the long-term nature of construction products. Neither the macro- nor micro-level innovation systems handle the specific requirements of construction regarding the time aspect.

The national innovation systems include the aspects of institutional actors, which has great influence on construction. Accordingly, institutional actors are identified as an important part of the sector system model.

The basic argument for the activity based innovation system is, however, the way it handles the great variety of actors that are involved in construction. A specific characteristic of actors involved in construction is that their roles change from project to project. For example, a subcontractor in a large project can be a main contractor in a smaller project. A manufacturer generally produces building material but can also transport and assembly its components on site.

A contractor either produces and delivers a building to the client or acts as both client and producer when using a direct labour approach. Thus, the fundamental principal of the sector systems model is that its components are not constituted by its actors, but by its economic activities. These activities ought to be the same regardless of procurement system, size or type of a building project, location etc., which makes the activity based innovation systems stable.

6. Conclusions

This paper presents arguments for the development of activity based innovation systems at a construction sector level. The argument is solely based on literature about established innovation systems as well as construction sector analysis and consequently, the suggested innovation system is not tested. The purpose of the paper is namely to contribute to and open up for a critical discussion about activity based innovation systems at a sector approach.

As the innovation systems are based on activities, it is obvious that the definition of activities, i.e. the detailed level at which the activities are described, are crucial to the applicability of the system. However, the outline of the sector systems model remains intact and thus, the breakdown of activities into smaller units can adjust the required detail level of a specific analysis while the outline of the sector systems model remains the same.

Another difficulty about the activity based innovation systems ought to be the identification and analysis of the relations between the components, i.e. the activities. This problem is, however, not unique to the activity based innovation systems, but occurs in any systems analysis.

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