

THE SIGNIFICANCE OF DIVERSE ECONOMIC LOGICS FOR INNOVATION IN THE CONSTRUCTION INDUSTRY

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In the production of the built environment, construction, planning and design are ongoing problem-solving efforts involving fragmented, multi-tier supply chains. The complexity of operations entails multiple actors with disparate responsibilities and diverse operating modes and economic logics. Each actor has only partial involvement in a project, and often operates in several different projects at the same time. Technological improvements and creative, economical solutions to complex problems in design and in construction are rarely commercialised and reused in subsequent projects. Even if ingenious, many solutions are not institutionalised or do not become part of daily routine. Furthermore, innovative technologies often presuppose that one or more actors take on risks that they are ill-equipped to handle, while those who choose to invest in innovative technologies often experience that they are unable to harness any revenue from their new ideas. This contributes to innovation efforts in construction evolving within one particular situation having outcomes not being generalised, not being created in a form that makes it transferrable, and not being learned. Problem-solving and technological change, therefore, may happen without actually leading to innovation. We seek to understand this aspect of innovation in the construction industry by examining the economic logics of different actors in construction projects. The objective is to understand how diverse logics alone and together influence the outcomes of efforts to innovate. By characterising and contrasting logics, it is possible to understand how the attractiveness of various types of innovation will vary systematically between the actors, and how liaising and interactions between them may influence innovation patterns. By discussing specific empirical examples of attempted innovations, we will understand better why it is that resources such as solutions to intricate and novel problems and innovative technologies are not routinely seen as assets and brought forth as successful and consequential innovation in the industry.

Keywords: innovation, economic logics, improvement, technology.

INTRODUCTION

The specific characteristics of any industry influence the innovation processes going on there (Malerba, 2004). The construction industry, which is responsible for planning, designing and physically producing the built environment, encompasses

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complex, multi-tier supply chains, large and heterogeneous sets of firms, whose value-creating activities are organised very differently (Bygballe and Jahre, 2009). These actors are all engaged in on-going problem-solving efforts both on-site and off-site. Temporary organisational structures – construction projects – bind more permanent organisations together for some time, but in constellations that are typically both fragmented and fluid (Dubois and Gadde, 2002). Responsibilities for design, specification, installation, maintenance and operation are generally separated between many different firms (Gann and Salter, 2000). Operations are carried out at different times and under different contractual arrangements. Each company has its own specific, negotiated and contractually recorded responsibility. Contracts are never fully comprehensive, however, and project success depends on commitment from participants not only to do their part, but also to be willing and able to collaborate with other stakeholders (Bresnen, 1990). For most firms, involvement in a specific project can only be partial. First, because responsibilities in the project are divided, and second, because every firm has several contractual obligations and commitments running concurrently in a number of different projects. The complexity of the temporary organization is multi-dimensional; projects are made into a whole by way of complicated legal and economic, as well as informal arrangements that serve to produce a certain level of transparency and predictability in the collaborative set-up. We might argue that there is a certain economic logic of the construction industry, which reflects the economising process within and across projects, in which economic benefits are pursued and distributed among the parties in the construction process, with diverse economic logics (Bygballe, Håkansson and Jahre, 2013).

The way the construction production processes are organised and the diverse economic logics are likely to influence innovation, whether positively or negatively. Projects are arenas for learning and problem-solving since new project objectives trigger search activities that are needed for identifying new solutions (Slaughter, 2000). However, new solutions are risky and introducing change in construction can create unanticipated effects. Since construction projects are inter-organisational, new solutions must be negotiated with one or more actors within the project coalitions (Winch, 1998). As a result, the perception of degree of change and links to other systems can differ among involved parties (Slaughter, 2000). Given the different interests involved, it is likely that some solutions that are good and economically beneficial for one party or a group of the involved firms may not be good for others. Proper incentive systems must therefore be in place, where the benefits from innovations are split between the clients and the actors in the project coalition (Winch, 1998). In other words, innovative solutions are not simply risky; they impact on particular participants in specific ways. The project coalition involves a complex network of contracts, along with rights and liabilities that flow from the contracts.

Research into construction project practices shows that technological innovations and creative, economical solutions to complex problems in design and in construction are difficult to commercialise effectively and to reuse in other projects (Ozorhon, Dikmen and Birgonul, 2005). Creative solutions to challenging problems tend not to be assimilated into routine practices and diffused across the construction sector. This indicates that diffusion of innovation in construction is difficult. There are several reasons for this, among others that the introduction of non-standard methods and construction products also require those involved to cope with increased risk (Slaughter, 2000). Actors may not be equipped to handle this additional risk. Nor may they be interested in facing more risk, even if they know how to. Indeed, the risks and

responsibilities set out in contracts may inhibit the uptake of innovation. Clearly, shrewd business people will only choose innovative solutions over well-trying solutions if there is a good reason to do so, typically a real economic benefit. If those committing to use novel technologies cannot harness additional revenues from innovation, there is one significant reason less to expect wide diffusion of innovations. Furthermore, if incentives are weak, then what may appear to be a viable innovation in one particular situation in one project might still not be diffused.

If it is true that specificities of construction generate incentive structures that explain why problem-solving and technological innovation do not lead to innovation across projects and firms, then it should be urgently important to understand better what these specificities are, and what mechanisms are at work. Previous research has suggested that a key innovation barrier is the construction industry's inability to create long-term connections and network effects (Dubois and Gadde, 2002; Miozzo and Dewick, 2004). The lack of connections hinders the learning loops from the project to the company and industry levels, which are necessary for innovation (Bygballe and Ingemansson, 2014). The economic logics (as well as institutional) of the industry and its key contributors in construction projects have to be better understood, to make it possible to explain why the potential benefits of innovations are not harnessed, and why there is a lack of connection and the implications thereof. We seek to understand this aspect of innovation in the construction industry by examining the economic logics of different actors in construction projects. The objective is to understand how such diverse logics influence the outcomes of efforts to innovate. The aim is to conceptualise patterns of economic logics springing out of the diverse institutional contexts that actors are typically embedded in. By characterising and contrasting logics, it is argued below that it becomes possible to understand how the attractiveness of various types of innovation will vary systematically between the actors, and how liaising and interactions between them influence innovation patterns. By way of a discussion, empirical illustrations of attempted innovations from previous research are provided to demonstrate how it is that resources such as solutions to intricate and novel problems and innovative technologies are not routinely seen as assets and brought forth as successful and consequential innovation in the industry. We seek to understand the economic logics that motivate firms' behaviour and their employees' decision-making in the context of the network of contracts that constitutes the project coalition or temporary organisation. This involves laying bare the key economic incentives that drive or hinder the take-up and diffusion of innovative technologies.

UNDERSTANDING THE ECONOMIC LOGIC(S) OF CONSTRUCTION (ACTORS) AND ITS IMPACT ON INNOVATION

In this paper, we see innovation as sticky change of established value creation practices (Orstavik, Dainty and Abbott, 2015). Value creation is often synonymous with production. However, we use the term value creation, as activities in construction are not only physical creation and assembly, but very often consist in service provisioning of various kinds. The idea that changes are sticky entails that they have an aspect of irreversibility, and that they are sustained in value creation efforts over time. Innovation is not simply the creation of novelty; it entails a lasting change in the established ways of value creation.

Considering innovation in this way as nothing but transformation of established modes of production, encompasses all the different forms of innovation in the

Schumpeterian tradition. That is to say products and processes, as well an organisation, raw materials and markets (Schumpeter, 1934). When considering innovation in construction, what is of interest is all organised value creation efforts going on as part of designing and producing the built environment. Hence, the whole of the complex set of value creation chains is of concern to the analysis. Innovation potentially occurs along these chains, and may affect other parts of a chain, and other related value creation chains. In this respect, we are in line with Roger's (2003) diffusion theory, which concerns positive and negative incentives for adopting innovations and the way diffusion is patterned by way of such factors. Innovation in this perspective is taken as given novelties that rational actors have the choice to adopt, or not to adopt. However, this perspective has been criticised for overlooking the important transformation processes often associated with diffusion. Generally, innovations find their form in a process where creation of the new and the diffusion of novelty is closely intertwined (Hall, 2005; Rosenberg, 1982).

For our purposes, this means the following reasoning: different firms are engaged in various value creation activities. For example, in the building sector, architects develop designs in dialogue with clients and produce documents to communicate this to others in the process; consultant engineers make calculations of loads and specify construction dimensions; technical subcontractors create and assemble systems for electricity, ventilation, plumbing, etc.; main contractors procure and coordinate everything on site and clients fund the work. Each organisation makes decisions of different kinds, in relation to their contractual duties and professional obligations. Clearly, the different actors entertain different kinds of production skills, deal with diverse input materials and tools, create different outputs, are assessed against diverse quality criteria, etc. Furthermore, different actors employ different remuneration principles, have diverse sets of "*significant others*" (different business environments), and they are subject to various legal and contractual frameworks that influence, among other things, the timing and amount of payment they may receive for their work. Even culture is different across firms in projects, as firms have different value orientations, senses of identity, etc. This, essentially, is what we mean by the notion that institutional and economic logics of stakeholders in construction projects are diverse. This diversity is important when trying to understand the nature of innovation in construction and the barriers to successful creation and diffusion of innovation. The diversity is multidimensional, and subjecting it to systematic analysis entails an effort to simplify and to distinguish more important from less important factors. If we take the different actors involved in the construction process, how could we understand their economic logics? Table 1 illustrates a "*simplified*" outline of key features of the economic logics of different parties.

The "*owner/client*" in construction tends to take on many different forms. Sometimes a client is both owner and user of what is being built, but often this is not the case (for example, property developers who develop real estate for sale). Nevertheless, the client plays a vital role with respect to innovation in setting the project objectives and choose the project team. The question is, what incentives are there for clients who build for their own purposes versus clients who build for others, and do public and private clients differ? There are characteristic differences between key groups of participant:

- Architects and consulting engineers could innovate, but the legal aspects of their professional indemnity insurance policies specifically exclude them from employing untried technologies. So, what are the consequences of this risk

avoidance, which is likely to characterise the consulting part of the industry? Is this the key barrier to innovation in the industry?

- Main contractors could innovate, but their contract typically centres on only bringing resources to site, in order to build what has been designed. This is the essence of what is usually known as general contracting, which is not as traditional as some people make out, since it is only something that happened as a result of the industrial revolution (Hughes, Champion and Murdoch, 2015). This also means that contractors often operate as coordinators rather than technology or competence providers. What are the consequences for the type of innovation that this type of actor is interested in pursuing?
- Sub-contractors and suppliers could innovate, but no architect would specify an untried technology. Sub-contractors are paid for installing things, but traditionally not for running them after they are installed. Thus they have no “*skin in the game*” when it comes to innovative buildings helping to improve client processes in a building in use. (These are, essentially, the technology providers as far as a client is concerned, the sub-contractors as far as designers and contractors are concerned). This type of actor is also often involved “*late*” in the process and usually has a delimited role in the project as a whole – how can an actor that is not part of the process nor project as a whole know what needs to be changed/innovated as well as how?

Material suppliers are often not even defined within the construction industry, which is one reason why many of the traditional innovation measurements show that construction scores low on innovation (Winch, 2003). Material suppliers are often highly research-intensive. In many segments, such as concrete, any new solution must be thoroughly tested, as the implications of failure can be fatal. Material suppliers are therefore often large, multinational companies, since being in the forefront is highly resource-demanding. Given that much of the innovation in the construction industry comes from this part of the value chain, what are their innovation logics? In other words, what is it that enables these to be so innovative?

Table 1: A “simplified” and generalised outline of the economic logics of construction industry actors

	Clients/Owners	Architects	Consulting engineers	Building contractors	Technical sub-contractors/specialist	Materials suppliers
Role	A decision-maker in the overall process.	Design – concept/design process.	Calculation – planning process.	Production and assembly – primarily construction, but sometimes in design.	Developing and assembly of technical installations – construction process (possibly design).	Production – supplying from permanent production site to construction site.
Primary activities	Fulfilling the project needs through setting project objectives, selecting the team and following up.	Interpreting and (re)solving client problems and needs through problem finding, acquisition solving, choice, execution, control/evaluation, within the context of urban planning and other legal constraints.	Interpreting and (re)solving customer problems and needs through problem finding, acquisition solving, choice, execution, control/evaluation, within legal constraints.	Transforming input into output - assembly and coordination.	Transforming input into output - assembly and coordination.	Transforming input into output – production.
Key value and cost drivers	Fulfillment of project objectives – time, cost and quality. Costs related to coordination and control.	Reputation and knowledge (success, linkages and learning across projects and client problems). Costs related to man hours.	Reputation and knowledge (success, linkages and learning across projects and client problems). Costs related to man hours.	Man hours, skills, capacity utilization, economies of scale/ productivity.	Man hours, skills, equipment and functionality.	Man hours, skills, capacity utilization of equipment, economies of scale/productivity, product development.
Coordination modes	Contracts, planning and supervision	Contract, planning and mutual adjustment/interaction	Contract, standardisation, planning and mutual adjustment/interaction	Contract, standardisation, planning, and mutual adjustment/interaction	Contract, standardisation, planning, and mutual adjustment/interaction	Contract, standardisation and planning

Even if simplified and generalised, spelling out these characteristics of key actors in the construction industry and their economic logics allows us to start discussing the

implications of this diversity for innovation. Furthermore, the institutional logic needs to be taken into consideration. In our view, any understanding of how innovation happens in construction needs to consider its project-based character. A construction project consists of (1) a legal and economic framework in terms of contractual agreements, statutory controls, resource availability and budget(s), (2) several, overlapping sequential phases in which specific decisions and activities take place regarding design, specification, purchasing, assembly/production, delivery, commissioning, maintenance etc., (3) the different actors that need to adapt to the two former type of structures – economic/legal and institutional. Based on these structures, what are the incentives to introduce new solutions vs. using known solutions?

Empirical illustrations

Vignette 1. Innovation in technology and processes - the use of BIM

The first illustration concerns process innovation and the use of Building Information Modelling (BIM) in the design and construction process. The example is taken from the Skandion Clinic project in Uppsala, Sweden, the first facility offering proton-radiation treatment for cancer patients in the Nordic countries. The project was operated as a formal partnering agreement between a large public property developer (AH) and the Uppsala unit of one of Sweden's largest contractors (NCC).

Due to the complexity and risk level of constructing a new type of radiation facility, the property developer took several initiatives to facilitate the construction process, the project coordination and the future management of the clinic. One such initiative was a wide implementation and integration of BIM from planning to production and delivery. This was a new way of working for the developer and to most of the project organisation: the main contractor, a set of subcontractors, and the planning coordinator used BIM for designing, planning and producing the facility. The architect, a local unit of a Norwegian architect firm, was also a driver in this process as BIM was common practice to them. The use of BIM necessitated new meeting forums where the actors could discuss progress and particular adjustments during the entire project. The entire project staff, including all the production workers on site, was “*BIM-trained*” in using it as a communication tool and to detect any potential organisational and technical “*clashes*” beforehand on site. Production staff struggled, however, and often hard copy was used instead of the digital format. Another complicating factor was that in Sweden, a BIM model cannot be used as a legal document. Thus, its use becomes limited in formal communication between actors.

During the project, the property developer initiated the development of a “*BIM manual*” with the purpose of standardising the way BIM was used in future projects. The manual was to guide any future project manager in how to use BIM and, ideally, develop this use further. Thus far, this manual has been used in a subsequent large public property project and is further developed within a forum for public property developers in Sweden.

In this illustration, innovation relates to the way that BIM was used by the entire project organisation, and the development of a standardised BIM manual. Yet a short description, diverse interests, roles and incentives for the actors to drive the development are indicated. The actor responsible for managing the project and the future facility had clear economic incentive to initiate solutions facilitating the project and the maintenance of the facility. The architect was also a main driver as large customers in Norway demand BIM and thus this was their normal practice. BIM allows for the type of iterative problem solving that architects as well as consulting

engineers are involved in and offers a balance between standardisation and adaptation, which architects and consultancy firms need to create value (see Table 1). From a production point of view, benefits of BIM are harder to recognise. In traditional projects where activities of design and construction are split, the way that risks and rewards are specified in contracts will reinforce traditional practices, where designers detail the project and leave the contractors to build what is already decided and modelled in the BIM, leaving few incentives for either of them to innovate. Another interesting question that has arisen in relation to BIM is who owns the data and what are the risks in supplying the model with technical information and new solutions? Architects, engineering firms and technical contractors all supply the model with a large amount of data, which the client ultimately owns. What hampers the client in using this data in new projects with new partners? How would a sub-contractor's intellectual property in an innovative technology be protected? This is likely to influence the incentives to engage in BIM, and the development of technological innovations in general. Indeed, as long as technical subcontractors are paid only for installation, and appointed after the main contractor, the opportunities for them to influence the design decisions with innovative technologies are severely limited.

Vignette 2. Innovation in wet-room products

Industrial building products embody a significant share of research-based innovation in the construction sector (Hauknes and Knell, 2009). However, building product innovation is intimately related to institutional factors such as standards and technical certification. Orstavik (2014) shows how broad innovation processes in housebuilding after World War II transformed the way houses are constructed in Norway, and opened the way for novel industrial products to become major inputs in the housebuilding sector. The use of boards made of gypsum has become the *de facto* standard in this process.

In spite of being made from materials that are perishable and brittle (paper and gypsum), the mass produced boards have physical properties that make them well suited for building. The use of gypsum has been driven by builders themselves choosing cheap building materials over alternatives that are more expensive. However, the use would not have become an accepted standard without the boards being included in designs and specifications detailed by Byggforsk, the leading construction research institute in Norway in the post-World War II era. The involvement of this institution in development of technical standards was instrumental in establishing gypsum as a basic material in housebuilding.

In 2000, a start-up company introduced a novel building board as a specialised “*wet room board*” and offered it to Norwegian builders. As detailed in Orstavik (2014), the claim of the company was that basic gypsum boards are inadequate for wet room building, since water and humidity easily destroy these boards. The company referred to findings that wet rooms had emerged as a prime area of building faults and damages: the recommended practice of covering gypsum with a liquid waterproof membrane had proved ineffective.

The innovative board is made with a core of extruded polystyrene, in a sandwich structure akin to the gypsum board, but with waterproof and vapour-proof layers instead of paper. These boards are more robust in wet environments, and they do not lead to accelerating degradation in the same way as water-absorbing gypsum boards.

Entrepreneurial ventures are often short-lived, but this company survived. Still, results obtained were mixed. Interestingly, the early adopters of the board tended to be

individual housebuilders and do-it-yourself re-modellers. Building product retailers showed interest, but it proved to be difficult for the company to win over professional builders who opted for gypsum and the established ways of building wet rooms.

How can this pattern of diffusion of an innovative building product be explained? That the novel board is embraced most eagerly by single housebuilders and of those outside the ranks of professional builders can be explained by the fact that these actually profit from choosing the novel and more expensive board. They benefit from this investment over time, by becoming owners of a wet room that has a higher quality and a longer lifetime and avoiding all the negatives associated with a faulty wet room. Professional builders do not have the same incentives, mainly for two reasons: First, lower quality materials in the wet room are largely invisible, and will probably not influence significantly the selling price of what is being built. Second, problems in the wet room tend to occur only after any warranty period is over, and using gypsum is in line with accepted standards. Hence, investing in higher quality does not pay off.

The novel wet room board is certain to increase cost, and can normally not be expected to increase income. Since no other negative effects of choosing the lower quality option is to be expected, professional builders do not consider adopting the innovation a rational choice. This position is reinforced by the fact that gypsum is endorsed by Byggbrosk and in rules and norms for wet room building. Hence, in spite of the facts that the novel board is highly compatible with existing methods of building; few complications for builders and significant benefit for house owners and users over time, adopting this innovation is largely avoided by professionals today.

DISCUSSION AND CONCLUSIONS

In the first vignette, the introduction of BIM was driven by the client. The success of this innovation relied on the involvement of all members of the design and production teams from an early stage in the process. Although it is rather unusual to successfully include subcontractors and suppliers into this process, it was achieved in this project. But even if the contracts that bound each different participant to the project were changed in order to allocate liabilities for decisions to the parties who were taking them, was there any possibility for an innovator to share in the future revenue savings, or contribute to future revenue losses, in the event that an innovative technology failed? Clearly, this project involved a transformation of the usual economic logic because there was early involvement of subcontractors in the decision-making processes. But without the added incentive of future revenue from the operation of the building, innovative ideas depend on good-will and a kind of openness.

The second vignette illustrates how the business model of housebuilders differs significantly from building contractors. Housebuilding involves the development of land, so the housebuilder is acting in the role of a developer, even though they may have technical building skills in-house, especially at the local scale. Indeed, a housebuilder who is a builder/developer can overcome many of the business barriers to innovation, since the housebuilder reaps the rewards from the market for the introduction of new technologies. Such a company carries all the risk and stands to receive all the rewards. In this respect, they are completely unlike the contracting sector of the industry, where responsibility for decisions and choices does not rest with those who could innovate. The local housebuilder has an economic imperative and incentive to develop and maintain a reputation for quality. In larger scale work, where contractors are being used by national housebuilders, there is a distance between the decision-making around specifications, and the responsibility for

delivering and installing the materials. Moreover, the housing developer may not be so dependent on repeat customers, operating in completely different market.

One of the things that makes it difficult to understand the economic logics of innovation in the construction sector is that it is not simply a buyer-seller market. Quite apart from the huge network of contracts and separation of responsibilities that characterise the process, there are other constraints that preclude what might be thought of as typical market behaviour. The professions in the construction sector have a significant impact, especially in places like the UK. Professional liability extends beyond the buyer-seller relationship. Professionals owe a duty of care to anyone who may come into contact with their work. This has to be backed up with professional indemnity insurance. Public authorities make significant decisions that constrain designs, both in terms of aesthetics (planning legislation) and performance aspects (construction regulation). Planning and construction regulation may limit the scope for innovation not by dictating tried and tested solutions but by allocating financial liability for decision-making in a way that distorts the market for innovative technologies. In most countries, it is common for the municipal authority to be the decision-maker for these aspects of control. The politics of municipal decision-making may produce another layer of conservatism into the decision-making processes.

These vignettes show that the theory of economic logics provides explanations for the way that different business models emerge and survive in the construction sector. From just two vignettes, the extent of the diverse economic logics begins to be clear. They suggest that when innovation is successfully introduced in a construction project, it is usually because a central actor has managed to align the right competences and interests at the right time along the construction process. In both our illustrations this has been the clients/owners, and in the second case also the materials suppliers. This suggests that owners/clients are least hampered by the economic logics in the industry, and therefore have the largest opportunities for facilitating the introduction of innovations. The theoretical section suggested that the lack of connections of actors and their resources in the construction process induces particular incentives for how to act and (not) interrelate resources across projects. Together, the theoretical findings and our empirical illustrations indicate that the concept of “*connectivity*” might be a useful next step to understand the impact of diverse economic logics on innovation, and also vice versa. Innovative organisational models, such as partnering, are directed towards aligning the diverse goals and interest of the parties. However, to grasp the full implication of these new ways of organising the construction process, we need to understand the diversity of the firms, and more particularly the diverse economic, as well as institutional logics of the involved actors. Without this understanding, phenomena such as partnering will work in some situations and not others, and it will not be clear why.

Ultimately, the illustrations in this paper provide a clear demonstration that the ownership of the means of production is typically divorced from the ownership of decisions about what to build and how to build, as outlined in Table 1. This suggests that further research into the notion that the installers of technology should also be responsible for maintaining and operating the things they make, as well as ways in which this can be implemented, should be a fruitful line of investigation.

In this paper, we have sought to contribute to the stream of research, which deals with understanding innovation and innovation processes in the construction setting. We have made a first step in scrutinising the implication of diverse economic logics of

construction actors for why solutions to intricate and novel problems and innovative technologies are not routinely seen as assets and brought forth as successful and consequential innovation in the industry. The next step is to delve deeper into the concept of “connectivity”. This concept might help us in better understanding and conceptualising the relationship between economic logics and innovation.

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