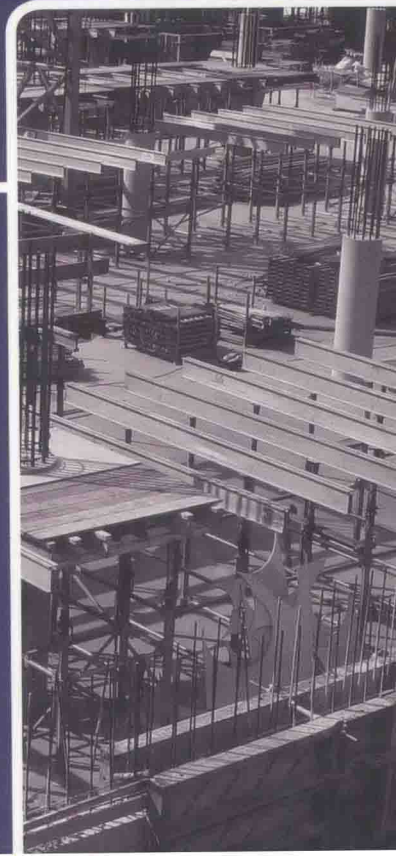


Supply chain integration in the building industry

The emergence of integrated and
repetitive strategies in a fragmented
and project-driven industry

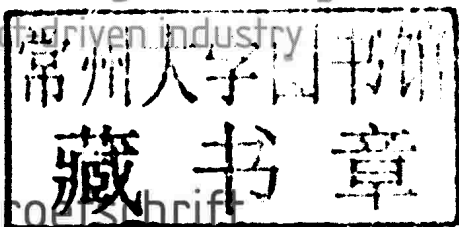


Ruben Vrijhoef



Supply chain integration in the building industry

The emergence of integrated and
repetitive strategies in a fragmented
and project driven industry



ter verkrijging van de graad van doctor
aan de Technische Universiteit Delft,
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prof. ir. K.C.A.M Luyben,
voorzitter van het College voor Promoties,
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Preface

The building industry is one of the oldest industries around. The ways of working within the industry have developed at their own pace over the years. The industry has been applauded for furnishing great works, providing populations with accommodations and infrastructures, and substantially contributing to economic growth and prosperity worldwide. However, the industry has also been criticised extensively for being wasteful, not innovative and unproductive. In those criticisms, reference is often made to other sectors of industry, particularly manufacturing, that functions and produces its products in more effective and efficient ways than the building industry does apparently. One of the major differences observed between building and manufacturing, among other things, has been the organisation and coordination of the supply chain. Such differences call for a careful consideration of the possibilities and impossibilities of transferring supply chain approaches from manufacturing to building.

The organisation and coordination of supply chains have been observed and conceptualised in different ways in building and manufacturing based on the specifically characteristic differences between those sectors. In building, the organisational approaches of supply chains have particularly been influenced by the one-off, temporal nature of projects; the large number of firms involved in the definition, design, manufacture and assembly of built objects involving many relatively small firms; the dispersed power and governance regimes; and the initiating

role of clients. These characteristics and other specific aspects of building have influenced how firms in the building industry operate, how they manage their inter-firm relationships, and in essence, how the industry as a whole is organised. In order to address improvements of this situation, managerial and organisational arrangements between firms in the building supply chain need to be reconsidered.

A more integrated approach to the supply chain has been suggested as a solution to the many problems and deficiencies existing in building. On the other hand, the restrictions on increasing the level of integration in building also need to be taken into account. The approach's underlying principle would be that the supply chain that is delivering a single product should not be fragmented nor consist of disconnected functions. Instead, supply chain integration would lead to a more stable and repetitive production environment, similar to what is common in manufacturing. The premise here is that the building supply chain would function better when approached and reconceptualised as a single entity, an extended enterprise. In a way, the deeper issue here is whether the building industry could or should develop itself towards the standards and practices of a more integrated and repetitively operating industry, such as manufacturing.

This thesis represents an exploration of that idea, and marks the end of a longer journey in that direction that has been ongoing for some years. A selection of parts of previous writings produced during this journey has become an integrated part of this thesis. The aspiration of the thesis is that it will contribute to the theoretical and practical development of the concept of supply chain integration and the positive effects it may yield for the building industry.

Ruben Vrijhoef

Delft

November 2011



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Doing a doctoral study and writing up the thesis is a lonely task. It is actually meant as a test for the researcher, to prove whether he or she is competent to perform such a task individually. However, it cannot really be done without the help of many. In fact, it is thanks to the support of many that this thesis is now finally lying before you. First, my thanks go to my supervisors, Hennes de Ridder, Hans de Jonge and Bart Bossink, for their continual support, criticism and patience. I want to thank Bart in particular for his help in getting me through the final process of writing up the thesis. I could not have done it without him. In addition, I want to thank Hans Wamelink for being so generous in allowing me to take some time off to write up the thesis. I want to thank Jelle Koolwijk for taking over my activities at the university and the centre during my absence. Thanks also to other colleagues at the university, clients and industry partners for their expressions of interest in my work and the thesis. In particular, I want to thank the PSIBouw innovation programme, Delft University of Technology and the Centre for Process Innovation in Building and Construction for their financial support of this thesis.

In the wider community, I want to thank my many colleagues around the globe for our inspiring debates at the many occasions and conferences where we met and discussed the subject of the thesis. Within this community, I want to thank

a few distinguished people in particular. Thanks go to my first academic mentor and supervisor, Lauri Koskela, for introducing me in 1997 to this intriguing realm of research while I was finishing my master thesis in Finland, and selling me on the idea of embarking on a doctoral study in the first place. Parts of this thesis are based on previous papers I wrote that have now shown to be part of the longer journey of writing this thesis bit by bit during the last couple of years. In a few cases, the papers were co-written with colleagues around the globe, notably Kerry London, William O'Brien, Carlos Formoso, Hans Voordijk and Lauri Koskela. Thanks to you all for the collaborative writing and being able to reuse and adapt a few parts of the texts, particularly in the first part of the thesis. With respect to the empirical part of the thesis, particularly the building case studies, I want to thank all respondents and informants involved for contributing their input and time so generously. I would like to thank Roberta Hardy for her valuable corrections of the English, and Corien Smit for doing a wonderful job on the design and the layout of the thesis.

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1 | Introduction

The building industry can be typified as a project-based industry with specific characteristics such as location-bound design, one-off production, changing production coalitions per project, outdoor and environmental circumstances, multiple clients and multiple suppliers involved in a single project. In comparison to many other industries, the production environment in building is relatively complex and unstable. This generally leads to negative effects, such as low levels of effectiveness and efficiency, low rates of innovation and impediments to knowledge sharing and learning. The performance level of the building sector is considered to be lower and lagging behind other industrial sectors. The introduction of more integrated and multi-project ways of working and collaboration such as those seen in other industrial sectors would seem logical and beneficial. One pathway towards these kinds of solutions is provided by the *concept of supply chain integration*. In manufacturing, supply chains have typically been integrated by focal companies, linking and synchronising suppliers' processes to their own business processes through applications of supply chain integration. This thesis represents a quest to construct a concept for supply chain integration in the building industry.

1.1 Background: understanding the building industry as a project-driven industry

In previous research as well as in practice, the building industry has been criticised for its supposed low level of performance and backwardness in many respects

(Woudhuysen & Abley 2004). The causes of the problematic character of building apparently lie in the very *nature of building*, and have been sought at the level of the product, the production in projects, and the industry as a whole. The nature of building has been blamed for contributing to waste and value loss, and it has been claimed that it is necessary to transform this or at least to mitigate the impact on the level of production (Koskela 2000). However, to achieve 'full resolution', it often seems that a particular characteristic has to be mastered at multiple levels of the production system. The industry's characteristics on the production level are related to characteristics on both the product and industry levels (Figure 1). The three levels of characteristics reinforce each other in a complex interaction, which contributes to the difficulty of reducing the problems of building and thus also to the persistence of the *problematic character of building* (Koskela 2000).

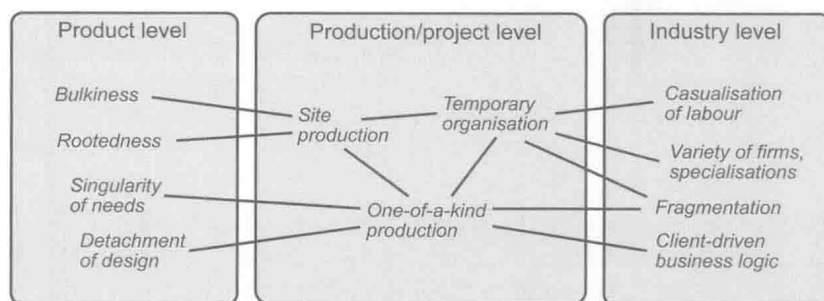


Figure 1: Three characteristics of building on product, production and industry level.
Adapted from (Vrijhoef & Koskela 2005b)

The *basic characteristics* of built objects have been viewed as causing limitations to technology and problems in the management of building projects (Nam & Tatum 1988). In this context, various features have been mentioned, such as immobility, complexity, long product life cycle, capital intensity and impact on the environment. In addition, built objects are often unique with additional specific features, and they are built in a specific institutional and socio-economic context. At the industry level, there are high levels of *fragmentation*, a wide variety of firms of different specialisation and size, and high levels of casualisation of labour. In some cases it has even been questioned whether building can be regarded as an actual industry (Groák 1994), or more properly as a 'loosely coupled system' of projects (Dubois & Gadde 2002). Paradoxically, however, fragmentation of the industry must not be seen as strictly problematic. The involvement of many different specialised firms in projects does not necessarily cause low levels of efficiency. On the contrary, it has been claimed that this could just as well increase the efficiency of resource allocation and speed of information exchange between parties (Pryke 2002).

Still, the product, process and industry characteristics of building do have an impact on the *production situation* and the way in which building projects are organised. Building projects have been described as *coalitions of firms*; i.e. 'a number of independent firms coming together for the purpose of undertaking a single building project and that coalition of firms having to work as if it were a single firm, for the purposes of the project' (Winch 1989). The parties involved in building projects have been interpreted as 'organisational units joining and operating together as a single production organisation when it is advantageous' (Harland et al. 1999); a 'temporary multiple organisation' (Cherns & Bryant 1984); or a 'quasi-firm' (Eccles 1981). The production system has been regarded as 'capability-oriented production' (Wortmann 1992), and is always locally bound and thus dependent on physical factors such as soil and weather conditions.

The *organisation of production* and the supply chains is strongly aimed at the convergence of logistics to a particular site, and delivery of the one-off, customised and capital-intensive product to a single end customer (Lin & Shaw 1998). This has previously been identified as the 'prototype nature' of building (Koskela 2000), reflected most characteristically by the predominant one-off approach in discrete building projects, i.e. 'unique-product production' (Drucker 1963). These characteristics of the production organisation in the building industry are not unique as such and can also be found in other sectors of industry, but it is the specific *combination of characteristics*, which apparently makes the building situation unique. This implies that *concepts from other industries* could be applicable to the building industry if the combined characteristics of building and their causal relationships are addressed (Figure 2). The characteristics of building could be overcome or resolved in practice by *adapting* those concepts and *translating* them into a building context.

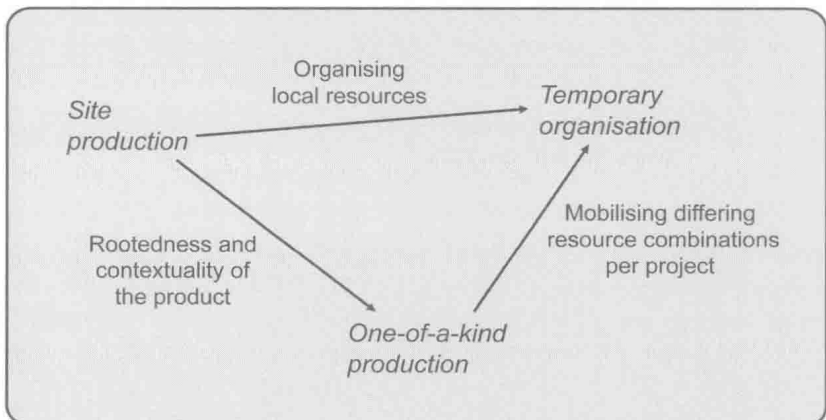


Figure 2: Characteristics of building and their causal relations (Vrijhoef & Koskela 2005b)

1.2 Research problem: fragmentation and lack of repetition in the building supply chain

Because of its project-based approach, the production system of the building industry is highly flexible and fragmented, consisting of many different subsectors (residential, commercial, etc.), many different disciplines (developers, builders, engineers, architects, etc.), and a wide spectrum of firm sizes with a relatively high share of SMEs. This has led to relatively high levels of *fragmentation* of the building supply chain from supplier to end user. Building projects are usually initiated by a client organisation, such as a housing corporation. On both the demand and the supply side, many parties play a role, including a large number of stakeholders on the demand side as well as a large number of co-producers on the supply side (Figure 3).

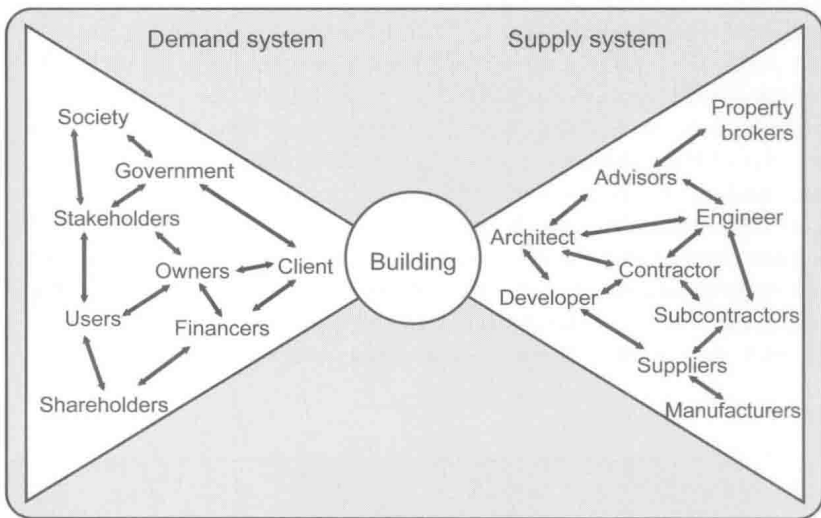


Figure 3: Schematic representation of the demand and supply system around a built object (Vrijhoef & De Ridder 2005)

Firms in the building industry work together in constantly changing coalitions on different building projects (O'Brien et al. 1995). This is particularly true in a traditional building setting, where multiple bilateral contracts are negotiated between individual parties who are involved in a temporary coalition until the completion of the project. As a result, the constructed product is seldom predefined, but instead the delivery of built products can be typified as assemble-to-order, make-to-order, design-to-order or even concept-to-order (Luhtala et al. 1994, Winch 2003) (Figure 4). This makes building essentially a demand-driven process that is