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# Driving sustainable innovation through procurement of complex products and systems in construction

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## Abstract

*This paper will explore how procurement of complex products and systems by the demand side may drive sustainable innovation in the construction business system. In recent years, (public) procurement of complex products and systems has increasingly been advocated as a complementary yet powerful strategy to drive innovation for sustainable construction. Such a demand-oriented innovation strategy has been pushed not only by national agencies, but also by international bodies like the United Nations and notably by the European Commission through its Lead Market Initiative. Based on an on-going case study of procuring a complex construction project, this paper emphasize the complex and emergent character of the demand side in construction and argues for a stronger analytical sensitivity towards the various actors and activities on the demand side of construction. Further, this paper makes a preliminary investigation of the various types of constituents of construction. In particular, this paper argues for a distinction between building owners and users in an analytical model of innovation in complex products and systems like construction. Finally, this paper argues that procurement of complex products and systems may reshape the linkages between the various constituents of construction through policy processes, business processes, and learning processes, and the paper hypothesises on the dominant character of these linkages.*

**Keywords:** Innovation, Construction business system, Procurement, Complex products and systems (CoPS), Sustainability

# 1. Introduction

Public policies and public procurement have played an important role regarding innovation in the construction industry (see e.g. Manseau & Seaden (eds.), 2001 and Edler & Georghiou, 2007). In recent years, (public) procurement of complex products and systems has increasingly been advocated as a complementary yet powerful strategy to drive innovation for sustainable construction (see e.g. SCI-network, 2011).

Clients – and in particular public clients – play a crucial role in these demand-oriented innovation strategies, and clients have been called upon to become change agents of the construction industry. Various national building policies, the establishment by CIB of the International Construction Clients Forum (ICCF) and increased research interest (see e.g. Brown et al. 2005 & 2006) have tried to mobilise clients to encourage innovation.

Such a demand-oriented innovation strategy has been pushed not only by national agencies and research institutions, but also by international bodies like the United Nations and notably by the European Commission through its Lead Market Initiative. While more ordinary projects may maintain and sustain existing practices and principles, procurement of complex products and systems potentially opens up the black box of construction and provide an avenue for studying the fundamentals guiding the practices and principles of construction actors and activities. Thus, this paper is based on a case study of procuring a complex construction project by an international construction client.

## 2. Research methodology

### 2.1 Complex products and systems

Hobday (1998, 2000a) has introduced the term complex products and systems (CoPS) and emphasizes CoPS as the chief unit of analysis for innovation, management and competition analysis rather than the single firm. Hobday (1998: 689) argues that the dynamics of innovation in CoPS are likely to differ from mass produced commodity goods due to its distinctive characteristics. CoPS are characterised by being highly customised, engineering-intensive goods, which often require several producers to work together simultaneously. Hobday (2000a: 691-693) identifies a set of indicators of critical factors, which defines the complexity of a CoPS. These include among others the quantity of tailored components and sub-systems, the hierarchical manner in which they are integrated together, the degree of technological novelty of the CoPS in question, and the variety of knowledge bases included in the CoPS. Further, user involvement in innovation tends to be high, and suppliers, regulators and professional bodies tend to work together with users ex-ante to negotiate new product designs, methods of production and post-delivery innovations. Markets are often bureaucratically administered, and contestability is low in contrast to commodity goods, which are characterised by arms-length market transactions. Examples of CoPS include a range of buildings and constructions,

aircrafts, ships, telecommunications networks and a range of military equipment like missile systems and battle tanks.

In another paper, Hobday (2000b) examines if a project-based organisation is the most appropriate delivery mechanism for complex products and systems compared to a more functional matrix organisation. Based on a case study of a large manufacturer of a wide range of advanced, high-cost scientific, industrial, and medical equipment, the paper illustrates the wide variety of organisational choices involved in producing CoPS and points out that the nature, composition, and scale of the CoPS in question is important for the appropriate choice of organisational form.

Hobday (2000b) identifies some of the strengths and weaknesses of the two organisational forms for CoPS production. The project-based organisation is capable of:

- Creating and recreating new organisational structure around each CoPS and customer.
- Coping with emerging properties in production and respond flexibly to changing client needs.
- Integrating different types of knowledge and skills and coping with the project risks and uncertainties common in CoPS projects.

The matrix organisation has its strengths where the project as organisational form has its weaknesses: in performing routine tasks, achieving economies of scale, coordinating cross-project resources, facilitating company-wide technical development, and promoting organisation-wide learning. Further, project interests and incentives can work against the wider interests of corporate strategy and business coordination.

In line with the work on CoPS, Gann & Salter (2000) provides an analytical framework for understanding the construction industry as embedded in a context of both policy-making (regulatory and institutional framework) and knowledge production (technical support infrastructure). The model recognises not only the actors, but also the activities taking place. Further, the model acknowledges not only the construction industry in a traditional sense – namely contractors and consultants – but it also includes the clients of construction as well as the manufacturing industry delivering products for construction. Based on this resource-based perspective, Gann & Salter (2000) frame the links between different actors and activities as knowledge flows (see Figure 1).

As pointed out by Gann & Salter (2000), a major challenge for project-based firms is to link the project-based processes with the business processes of the firm. The project-based nature of construction implies that the interdependencies are primarily linked to the rather fluently, changing and ad-hoc patterns of cooperation with a rather great number of external firms. These links are important due to the relative high degree of autonomy of the individual project, while the individual projects to a large extent determine the overall performance of a firm.

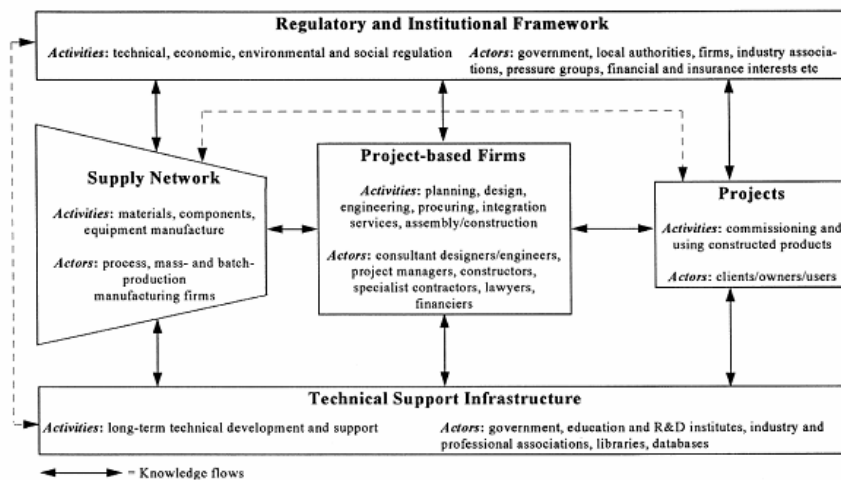


Figure 1: Knowledge, information flows and actors in project based processes. Source: (Gann & Salter, 2000: 960).

What is less clear is the character of these linkages. Haugbølle & Forman (2011) have identified a number of theoretical perspectives on these linkages in construction as: 1) knowledge flows (e.g. Gann & Salter, 2000), 2) functions and regulation (e.g. Carassus (ed.), 2004), 3) governance processes (e.g. Winch, 2000 & 2002), 4) a loosely coupled system (e.g. Orton & Weick, 1990; Dubois & Gadde, 2002), and 5) strong/weak ties (e.g. Granovetter, 1973; Pryke, 2004 and Chinowsky et al., 2008). Haugbølle & Forman (2011) propose an alternative perspective on these linkages as being constitutive rather than being fixed and taken-for-granted, which in turn explores and challenges the very ontologies at play (explanans/explanandum) when it comes to analytical units (project/firm), relations (couplings) and effects (performance/innovation).

## 2.2 Case study design

This study is based on a case study design (Yin, 2009). It should be noted that this article presents preliminary observations and conclusions from an on-going research project. The case is considered to be an exemplary case due to its characteristics:

- The case represents state-of-the-art when it comes to diminishing the need for use of car transportation to get to the office and its energy performance requirements both in relation to building regulation and environmental certification.
- The building represents a complex product and systems due to among others its size, geometry, location and extensive safety protocols.
- The project represents complexity not only in relation to the product but also the process, in particular when it comes to the organisational setup on the client side.

The methods for collecting and analysing data include analysis of documentary material, a visit to building site, public presentations of the project and seven designated student reports following a course on construction management.

### **3. Case: UN City in Copenhagen**

#### **3.1 Background – city development and Nordhavnen**

The capitol area of Copenhagen is growing quite rapidly. The number of inhabitants is expected to increase by 100,000 people or 18 % by 2025. At the same time the business structure is changing rapidly. Heavy industry is disappearing from for example the harbour of Copenhagen. These changes free up new areas for urban development. One of the most prominent areas is Nordhavnen, the Northern Harbour of Copenhagen (BY & HAVN, 2009).

In December 2005, the Danish government and the City of Copenhagen agreed on the principles that would govern urban development in Nordhavnen. This agreement was turned into an act of parliament that was adopted on 22 May 2007. In May 2008, an open international ideas competition on the sustainable city of the future was launched. The competition attracted some 180 proposals, and in March 2009 the results were announced. The winning proposal titled “Nordholmene – Urban Delta” was developed by a team of COBE, SLETH MODERNISM, Polyform and Rambøll. During the summer of 2009, the winning proposal was reviewed, and its development strategies were further detailed and specified. The six themes of the winning proposal are 1) Islets and canals, 2) Identity and history, 3) Five-minute city, 4) Blue and green city, 5) CO<sub>2</sub> friendly city, and 6) Intelligent grid. During 2010-11, the Municipality of Copenhagen developed a Municipal Plan supplement and local plan for Nordhavnen (BY & HAVN, 2009).

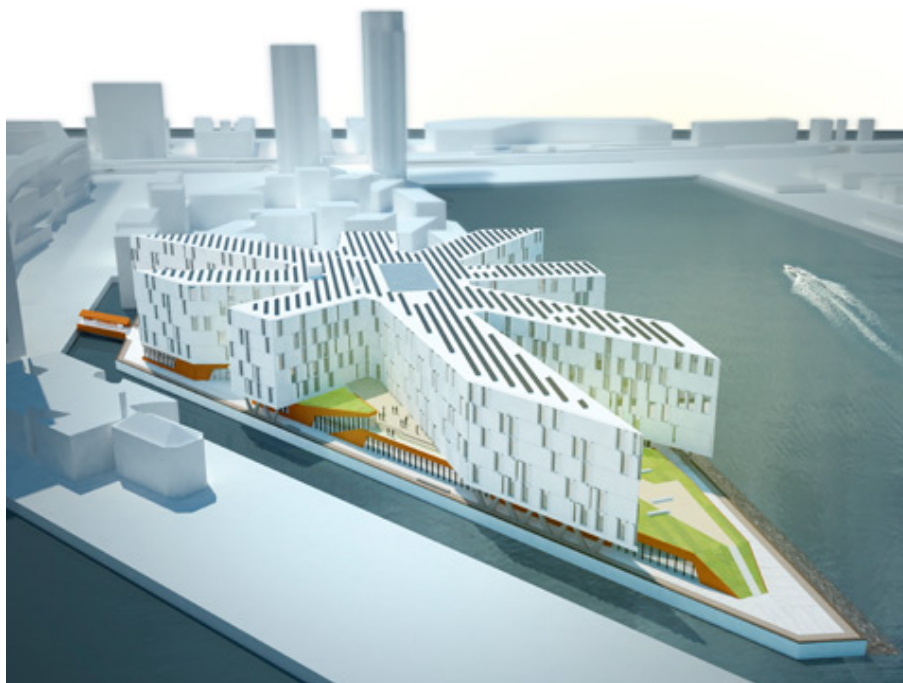
Nordhavnen is expected to be developed over the next 40 years to house 40,000 inhabitants and 40,000 employees. The development of Nordhavnen is divided into three stages. In the first stage, the inner Nordhavn (the so-called Århusgade Quarter) comprise some 350,000 m<sup>2</sup> of new gross floor area and the preservation of existing buildings with a gross floor area of 70,000 m<sup>2</sup>. The Municipality of Copenhagen has recently adopted the urban plan for this stage to be initiated. In the second stage scheduled to start in 2018, additional 200,000 m<sup>2</sup> may be developed. In a third stage not yet detailed, the entire Nordhavnen may eventually be developed to include buildings with a gross floor area of 3-4 million m<sup>2</sup> (BY & HAVN, 2009).

#### **3.2 The UN City**

The UN City is the first of a number of new buildings to be constructed in the inner part of Nordhavnen. The intention of the UN City is to have all of the representations of the United Nations in Denmark gathered in one location. Today, United Nations have six agencies in Denmark located in different locations with some 1,100-1,200 employees. The six agencies include the Nordic Office of

UNDP (UN Development Programme), the European headquarters of WHO (World Health Organization), the headquarters of the Supply Division of UNICEF (UN Children’s Fund), one of the Liaison Offices of WFP (World Food Programme), one of the Liaison Offices of UNFPA (UN Population Fund) and the headquarters of UNOPS (UN Office for Project Service).

Although the intention was to gather all UN activities in one place the UN City now actually consists of two campuses at the inner part of the Northern Harbour of Copenhagen (Nordhavnen). Campus 1 encompasses the domicile of UN and is situated on the Marble Pier (Marmormolen) in the port of Copenhagen, immediately adjacent to the existing UNICEF warehouse. Campus 2 include a fully automated high bay warehouse for UNICEF with a capacity of close to 40,000 cubic meters, which is being built in the Free Port at the outer part of the Northern Harbour of Copenhagen and ready for moving in at the beginning of 2012. The warehouse will handle goods for development and emergency projects around the world.



*Figure 2: The star-shaped UN City. Architects: 3XN A/S.*

The new domicile of UN at Campus 1 will be constructed in two phases. The first phase covers the construction of some 28,000 m<sup>2</sup> gross floor area and some 5,000 m<sup>2</sup> basement in one storey for technical installations and storage. This phase is expected to be finished in the beginning of 2013. The building will be constructed as a star-formed building with 8 “arms”, of which phase 1 consists of the central and Eastern part of the star making up the first five “arms” (E. Pihl & Søn A/S, 2012).

In the beginning of 2014, the second phase will complete the star by adding the last three “fingers”, when the existing UNICEF warehouse has been demolished. This will increase the gross floor area with 17,000 m<sup>2</sup> to a total of 45,000 m<sup>2</sup> and add some 3,000 m<sup>2</sup> extra to the basement. The building will be constructed as low-energy class 1 building according to the Danish Building Regulation

(energy consumption below 50 kWh/m<sup>2</sup>/year). Further, the building has been designed to be certified according to the American certification scheme LEED (Leadership in Energy and Environmental Design) with the goal of achieving a minimum score of LEED Gold and reaching at least 73 LEED points according to Version 3 of the LEED scheme. The building will be using recycled rainwater for toilet flush, cooling will take place with sea water, all lighting will be automatically controlled, and photo-voltaic cells will be installed. Due to strict security reasons, the building is being constructed at an isolated island linked to mainland through one bridge accessible only by foot and with small vehicles. In addition, the developer FN-BYEN P/S became a Green Building Partner as one of the first Danish organisations. The main requirement of the European Union's Green Building scheme is to reduce the energy consumption with 25 % compared to national regulation (European Commission – Joint Research Centre – Institute for Energy and Transport, 2006).

### **3.3 Procuring a new headquarters**

The development of Nordhavnen is carried out by the developer CPH City Port and Development I/S in collaboration with the Municipality of Copenhagen. CPH City Port and Development was established in October 2007 and is owned 55 % by the Municipality of Copenhagen and 45 % by the Danish government (ownership exercised through the Ministry of Transport). CPH City Port and Development is responsible for the development of the properties owned in Ørestad and the harbour of Copenhagen along with the operation of the port activities through the subsidiary Copenhagen Malmö Port (CMP). The company is required to carry out its activities on ordinary commercial grounds, for example through the sale of building rights.

The local plan of Marmormolen was approved by the Municipality of Copenhagen on 10 December 2009. The local plan includes 23,000 m<sup>2</sup> office buildings, 28,000 m<sup>2</sup> housing, a hotel of 25,000 m<sup>2</sup>, the 45,000 m<sup>2</sup> for the UN City and 58,000 m<sup>2</sup> for the so-called LM Project. The LM Project includes two office towers at Marmormolen and the tip of Langelinie, and connected with a bicycle and footbridge in a height of 65 m (Københavns Kommune, 2010).

The development of Marmormolen (the Marble Pier) was initially handled by the consortium Byggemodningsselskabet Marmormolen P/S owned by CPH City Port and Development (50 % ownership) and the private investor N&S P/S (50 %), which in turn was owned by Nordkranen A/S and SNS Property Finance. During 2011, the ownership rates were changed to 90 % for CPH City Port and Development and 10 % for N&S P/S. In December 2011, a new consortium called Harbour P/S owned by CPH City Port and Development (8.5 % ownership) and the two pension funds ATP (45.75 % ownership) and PensionDanmark (45.75 % ownership) bought for 2.1 billion DKK the UN City along with the building rights for the so-called LM Project. CPH City Port and Development put up the concluded UN City and part of the LM Project as investment and hold a minor share of ownership. The agreement will be effective by the middle of 2013.

The UN City was developed by the company FN-Byen P/S with the associated limited partnership company. The company was owned by CPH City Port and Development (99.2 % ownership) and



Nordkranen A/S (0.8 % ownership). The purpose of the company is to prepare the area for construction, to construct and let properties at Marmormolen.

While the ownership of the UN City is with the consortium, CPH City Port and Development is the building client and the letting office of the property. The Ministry of Foreign Affairs will be the leaseholder on a long-term lease contract, while the UN representations are the actual users of the UN City. On behalf of the UN representations, the Ministry of Foreign Affairs has hired Alectia and PLH Arkitekter as consultants for the user organisations. As is customary for UN representations, the nation hosting the UN representation will make properties available to the UN representations and pay the lease. As The Ministry of Foreign Affairs does not in itself have the necessary skills and organisation to manage building projects, the ministry is obliged by law to have the Danish Palace and Property Agency of the Ministry of Finance as construction and facility manager.

The new UN City has been designed by one of the leading Danish architectural firms 3XN A/S, who were also involved in creating the master plan for the Marble Pier together with architect Kim Utzon (for the hotel), SCHØNHERR LANDSKAB (the landscape) and Steven Holl Architects (the LM Project), which formed the backdrop for the local plan. The consulting engineers are Leif Hansen Rådgivende Ingeniører A/S, who merged with Orbicon during the project.

The land development was undertaken by the contractor Aarsleff A/S as a turnkey contract and with Tscherning as sub-contractor. The detailed design and construction work is also undertaken as design-build contract. After a pre-qualification round, six contractors were selected for participation in the limited tender in the period 15 March 2010 – 17 May 2010, which was based on economically most advantageous tender and followed the European regulation on public tendering (Public Sector Procurement Directive, Council Directive 2004/18/EC). The contractor E. Pihl & Søn A/S won the tender. Part of the tendering requirement was the obligation of the contractor to take over the consultancy team of 3XN A/S and Orbicon/Leif Hansen Rådgivende Ingeniører A/S. Later the contractor Pihl & Søn A/S also won the tender for the phase 2 extension of the UN City.

## **4. Discussion**

As examined in the research methodology, Gann & Salter (2000) provides a framework that understands the project with its actors and activities as a central constituent in the development of complex products and systems within construction. Below, we will critically discuss this central constituent of the model by Gann & Salter (2000) and propose a somewhat different perspective.

First, this case study has illustrated the complex and emergent character of the demand side in construction. As has been emphasised by the Swedish Engineering Academy (IVA, 1997) the client side of construction can be understood as a nodal point having relations to four groups of actors: the construction industry, the regulatory system, the users and the building owner. The case study has illustrated how the demand side of construction may be very complex with multiple user organisations (in this case six UN organisations), extensive role separation (as owner of building rights, developer, construction client, building owner, financier, user, tenant, leaseholder and letting office) along with

overlapping roles between the regulatory system and the business (the double role of the municipality as both authority and part owner of the developing company), and repeatedly changes in the ownership structure over time. Thus, we would like to challenge the rather monolithic perspective on the demand side of construction as expressed in Gann & Salter (2000).

Second, we have preliminarily investigated the type of links between the various constituents of construction. Undoubtedly, the links can be perceived as knowledge flows as argued by Gann & Salter (2000), but we would like to hold that there is more than knowledge flows at play. In fact, we may perceive construction as a technological system and ask through which technologies the interactions between the various constituents of construction take place. Technology may be perceived as the sum of artefacts, processes and knowledge. As the case study illustrates, the relations between the various actors are kept in place via a diversity of technologies. These include financial instruments like capital investments, organisational arrangements like competitions, artefacts like drawings and construction equipment etc., contractual arrangements like building rights and many others.

Previous policy analyses of the Danish construction industry as a resource area (Erhvervsfremme Styrelsen, 1993 and 2000) have pointed towards an understanding of the interactions as taking place through three distinctively different yet interrelated markets:

- A product market between the supply network and project-based firms.
- A construction market between the project-based firms and the building owners.
- A property market between building owners and users.

Thus, we would like to propose a somewhat different perspective on the constituents of construction as illustrated below in Figure 3. More specifically, we would like to introduce a clearer distinction between building owners on one hand and users on the other hand. In most cases, the building owner and users will be interacting through a property market either through sales or leases.

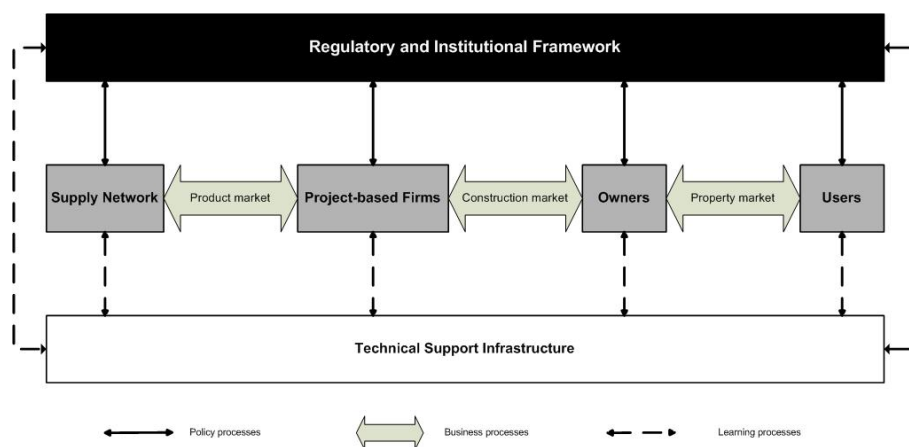


Figure 3: An alternative perspective on the construction system. Source: The author.

Third, we would also like to hypothesise on the dominant character of the links between the various constituents. Thus, we would like to suggest that the interactions between actors take place through policy processes, business processes and learning processes. This is not to say that all processes are at play with the same weight in all situations or between all actors. Business processes seems to be particularly important when it comes to the interactions between the supply network, project-based firms, building owners and users as most of the products and services being exchanged happens in various kinds of markets. The interaction between the regulatory and institutional framework on one hand and business and technical support infrastructure on the other hand may be more dominated by policy processes of policy-making and implementation. The interaction between the technical support infrastructure on one hand and the business and regulatory framework on the other hand may be dominated by learning processes related to the development and transfer of knowledge.

## 5. Conclusion

Based on an on-going case study, this paper has explored how procurement of complex products and systems by the demand side may drive sustainable innovation in the construction business system.

First, this case study has illuminated the complex and emergent character of the demand side in construction and argued for a stronger analytical sensitivity towards the various actors and activities on the demand side of construction.

Second, this paper has made a preliminary investigation of the various types of constituents of construction. In particular, this paper has argued for a distinction between building owners and users in an analytical model of innovation in complex products and systems like construction.

Third, this paper has argued that procurement of complex products and systems may reshape the linkages between the various constituents of construction. The paper suggests that these interactions take place through policy processes, business processes and learning processes, and the paper hypothesises on the dominant character of these linkages.

## 6. Acknowledgements

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