SUPPLY CHAIN IMPLICATIONS OF PLATFORM STRATEGIES IN CONSTRUCTION

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ABSTRACT: Platform strategies and modular product development have been applied in manufacturing to achieve goals of agile and lean production, and mass customisation. These strategies have had consequences for manufacturing supply chains. This paper explores the basic characteristics of platform strategies as applied in manufacturing, including the concepts of postponement, decoupling and modularisation. As in manufacturing, application of platform strategies to construction requires reconfiguration of the supply chain. Characteristics of the construction supply chain are converging logistics, make-to-order, many distributed production between separate firms, and delivering complex products with long life cycles. For platform strategies to be applied, inter-organisational multi-project arrangements must be introduced between firms that produce and deliver an integrated product to the marketplace as a “factory without walls”. For this the concepts of the extended enterprise and the modular production network are introduced. This is illustrated through two case studies of open building. Based on its specific product and process co-ordination principles, open building can be explained and typified as a platform strategy that promotes flexibility and agility by delayed differentiation. From the case studies, the supply chain implications of platform strategies in construction are indicated and discussed. In conclusion, further directions are indicated for research of platform strategies and extended enterprises in construction supply chains.

Keywords: Construction supply chain, mass customisation, modularity, platform strategy, postponement

INTRODUCTION

The concepts of design for manufacturing and concurrent engineering seek to improve manufacturing performance by co-ordinating the engineering of products with the actual production system. These concepts are closely tied to that of platform strategies and product modularisation (Wheelwright & Clark 1992). A platform can broadly be defined as ‘a relatively large set of product components that are physically connected as a stable sub-assembly and are common to different final models’ (Meyer & Lehnerd 1997). The platform concept not only embraces product components but also manufacturing technologies and processes employed in production. A platform makes it possible to share production tools, machines and assembly lines. This paper focuses on the supply chain management (SCM) implications of platform strategies in construction. The first major question to be answered is how platform strategies can be characterized for the construction industry. When this question is answered the implications of these strategies for SCM can be analysed.

PLATFORM CONCEPT

The platform concept has received increasing attention in product development and operations management (Wheelwright & Clark 1992, Meyer & Lehnerd 1997, Nobeoka & Cusumano 1997, Robertson & Ulrich 1998). By using a platform approach, a company can
develop a set of differentiated products or derivatives (Wheelwright & Clark 1992). In particular, from the production and assembly perspectives, a platform makes it possible to share production tools, machines and assembly lines. Integrated product development and integrated production planning are essential (Koufteros et al. 2002, Lai & Huang 2003). The platform concept is closely tied to concepts of product architecture, modularisation and standardisation (Muffatto 1999a). Product architecture is the arrangement of the functional elements of a product into physical blocks, which are defined in terms of both what they do and what their interfaces are with the rest of the product (Ulrich 1995). A module can be described as a large group of components that is physically coherent as a sub-assembly and which often has standardised interface designs. Modules can be shared among different products or be specific to any one model. The platform concept offers significant advantages in new product development, such as lead-time reduction, cost reduction, increase in flexibility (Muffatto 1999b). In addition, platform strategies are particularly suitable for new product development in uncertain and equivocal environments (Koufteros et al. 2002).

**SUPPLY CHAIN MANAGEMENT**

Christopher (1992) observes that ‘supply chain management covers the flow of goods from supplier through manufacturing and distribution chains to the end user’. The concept of SCM (SCM) means that independent firms agree upon the way in which production and information flows are organized. The consequence of this agreement is an integrated organization of logistical activities within a chain or group of firms. Fundamental to the theory of SCM is the notion of interlinking and exercising control of an identified sequence of interdependent activities or firms.

In several industries, two basic concepts are applied to support the integrated production control and improvement of the supply chain: the decoupling of different production channels and postponement (Van Hoek 1997, 1999). Both concepts will be discussed here.

**Decoupling of the supply chain structure**

The decoupling point plays an important role in defining the supply chain. The decoupling point has been defined as the point in the supply chain that separates the part of the supply chain oriented towards customer orders from the part of the supply chain based on planning (Hoekstra & Romme 1992). In manufacturing, it is commonly associated with the strategic stock that buffers the supply chain from changes in customer demand, in terms of both volume and variety.

There are two extreme positions (Figure 1). The first is the ‘buy to order’ supply chain in which the product is configured from the outset, that is, from raw materials. In this supply chain all businesses respond to changing customer requirements. This supply chain works well as long as the customer is willing to accept long lead-times. The other extreme is the ‘ship to order’ structure in which a standard product is provided from a defined range. Although lead-times of products may be very short or even ‘off the shelf’, the risk of obsolescence has to be considered.
Related to the family of supply chain structures is the typology of Lin and Shaw (1998). They define three types of supply chain networks, from the perspective of the assembling firm in the supply chain, including three types of strategies towards the order fulfilment process, order management, manufacturing and distribution. The first type is the *convergent supply chain* implying that the assembling firm performs the final manufacturing processes and the assembly of the final product with a long life cycle, applying just-in-time approaches and early differentiation strategies, involving relatively many suppliers per product delivered to a relatively small number of clients, e.g. in the aerospace industry. The second type is the *divergent supply chain* implying that the firm performs the final assembly and distribution of products with a medium life cycle, applying a make-to-order strategy serving mass-customisation purposes and delayed differentiation at the assembly stage (divergent assembly), e.g. in the computer industry. The third type is also a *divergent supply chain*, but this type implies a build-to-forecast strategy and differentiation at the manufacturing stage (divergent differentiation) of products with a short life cycle focussed at achieving responsiveness, e.g. in the textile industry. Applying modularity to the product design, the outsourcing of components, and the organisation of production and supplies, is viewed as an improvement strategy of the order fulfilment process and supply chain networks structure (Lin & Shaw 1998).

**Postponement**

Associated with the decoupling point is the issue of postponement and late configuration. The postponement concept has been identified as an important characteristic of modern and competitive supply chains. Implementation of the postponement concept requires a reconfiguration of the supply chain. According to Bowersox and Closs (1996), the principle of postponement can be subdivided into three generic types: form, time and place postponement:

- Form postponement entails delaying activities that determine the form and function of products in the chain until customer orders have been received.
- Time postponement means delaying the forward movement of goods until customer orders have been received.
- Place postponement refers to the positioning of inventories upstream in centralized manufacturing or distribution operations, to postpone the forward or downstream movement of goods.
Postponed manufacturing combines these three types of postponement. In other words: final processing and manufacturing activities are postponed until customer orders have been received (time postponement) and are performed from central locations in the supply chain (place postponement) to include customer and country specific characteristics in the finished product based on final manufacturing (form postponement), frequently followed by direct shipment to retailers or customers. This operating system is diametrically opposed to push systems in which goods are entirely manufactured in anticipation of future customer orders and stored downstream in the supply chain, even though the company does not know whether a customer will actually buy the product (Van Hoek 1999).

Modularity

Product modularity is a complementary concept of platform strategy because it allows the product to be differentiated to a high degree, meeting varied customer requirements, i.e. multi-objective optimisation (Rai & Allada 2003) within a reconfigurable manufacturing system (Yigit & Allahverdi 2003). Among many advantages are the possibility of producing product variations that have only a limited impact on production and assembly processes, limited proliferation of parts, reduction of lead-times and higher productivity levels (Baldwin & Clark 1997, Watanabe & Ane 2003). In general, modularity increases a firm’s strategic flexibility, performance and therefore competitiveness (Worren et al. 2002). On an industry level modularity increases the overall performance of firms, for instance in the electronics industry. The establishment of industry standards has played a major role in the widespread adoption of modularity principles (Baldwin & Clark 1997, Gadde & Jellbo 2002).

The modular system of the product is the basis for purchasing and outsourcing policies, i.e. system sourcing (Gadde & Jellbo 2002). Modularity is important for company-supplier relationships as it implies suppliers’ involvement in production and product development. A number of issues play a role including the strong reliance on suppliers, distributed control, organisation and information capabilities of the focal firm, innovation capabilities of suppliers (Gadde & Jellbo 2002). Particularly the role of the first-tier suppliers in the supply chain increases (Doran 2003). Similarly, Sturgeon (2002) introduces the concept of the modular production network where turnkey suppliers play an essential role.

CONSTRUCTION SUPPLY CHAINS

Construction supply chains have been associated to make-to-order supply chains (e.g. Vrijhoef & Koskela 2000). Typically, a make-to-order construction delivery process begins at the customer, through the entire supply chain from initiative to hand-over, back to the customer. In contrast to most manufacturing supply chains, a construction make-to-order supply chain is converging to the construction site where the one-off final product is assembled. According to the typology of Lin and Shaw (1998) construction supply chain must be categorized as a type 1 converging supply chain (Table 1).

Table 1: Construction supply chain characteristics (Adapted from: Luhtala et al. 1994)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Construction supply chains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of business</td>
<td>Project deliveries</td>
</tr>
<tr>
<td>Production</td>
<td>Make-to-order</td>
</tr>
<tr>
<td>Control</td>
<td>Pull</td>
</tr>
<tr>
<td>Volumes</td>
<td>Low</td>
</tr>
</tbody>
</table>
Luhtala et al. (1994) argue that pure converging chains occur in one-of-kind production and in project delivery business, such as construction. In addition, the competence in make-to-order supply chains is merely based on technical know-how, and managerial issues like information exchange and co-operation between units in the supply chain.

Naim et al. (1999) highlight the potential for applying standard components and the importance of the location of the decoupling point in house building supply chains in order to develop “lean” house building supply chains, and postponement strategy that enables to respond to changing customer requirements in an efficient way. In the lean supply chain, components flow from the supply base through supplier tiers towards the assembler. The components are delivered to fit exactly to the structure of the product system and production process of the assembler. This is based on cooperative and intensive relationships between the assembler and suppliers (Womack et al. 1991, Lamming 1993, Ohno 1988).

Applying lean concepts to construction requires a fundamental supply chain reorganization and increase of the level of customisation. Barriers to these developments include institutional factors, implications for internal business processes, fragmentation of the supply chain, low innovative capacity, and low technological competence (Naim et al. 1999).

**PLATFORM STRATEGY IN CONSTRUCTION: OPEN BUILDING**

The open building concept represents an initial example of platform strategies in construction (Vrijhoef et al. 2002). The concept of open building identifies the conflict between the inertia of the building industry and the volatile customer demand. According to Dekker (1998) open building is based on the principle of organizing the building process along independent levels of decision-making, in order to decouple building parts with different life cycles, controlled by different parties, built by different trades. These decoupled building parts correspond to the structure of technical subsystems in order to create maximal flexibility and variety of the object, while keeping the process systematically organized. In this way, it enables relatively free choice of design of one level, independently from the underlying level, i.e. the infill level (fit-out, interior) and the support level (base-building, structure) of a house.

The fit-out is a modular system prefabricated and supplied by a single supplier. Supplier is often also the fit-out contractor assembling and installing the fit-out on site into the base building. The modular system is developed and pre-engineered in such a way that it can be assembled and installed fast and simply. The customers can often select and order there fit-out directly from the fit-out supplier/contractor. The modular system allows finishing according to the customers’ wishes. The customer is involved in an interactive decision process to design the fit-out. Next the fit-out supplier/contractor start the engineering, prefabrication and supply process, towards site assembly and installation (Tarpio & Tiuri 2001).

Typically, the decoupling of subsystems allows independent decision-making regarding the base building and the fit-out, and thus supports delaying decisions on the fit-out, while the base building can already be built. In addition, it allows residents to easily refurbish and restyle their houses during occupation, or in case of change of residents. The pre-engineered building system is the basis for a systematic building process with predefined interfaces.
between activities. This promotes the transformation of the building process into an “assembly process” dominated by manufacturing principles (Cuperus 2001).

Case studies

Below two case studies are briefly analysed to find indications of SCM implications of open building. The SCM implications will be analysed in relation to the three postponement aspects: form, time and place postponement (Table 2 & 3):

- Form postponement (delayed differentiation): the final shape of the end product is determined downstream in the supply chain,
- Time postponement: the customer can make modifications to the design of the end product in a late stage of the supply chain,
- Place postponement: the assembly of the end product is located in a late stage in the supply chain, components are prefabricated, and stocks are located upstream in the supply chain.

The Matura case

The Matura system is a pre-engineered infill system of parts and components for the finishing of new built housing and refurbishment of existing houses. It provides an integrated concept for the flooring and interior walls, with integrated plumbing and wiring, enabling the layout and finishing of the interior according to client wishes, and application of industrial production techniques (Tarpio & Tiuri 2001).

Figure 1: Matura decoupling system (Taken from: Tarpio & Tiuri 2001)
### Table 2: Postponement aspects of the Matura system

| Time postponement | Since the structure and the infill of the house or apartment are separated the structure can be built independently from the specifications of the infill. The customer is leading in the design of the layout and the floor plans that are directly drawn in a CAD system. The system calculates the costs of the design, and defines the components and materials needed, including the bills of materials and working drawings. The customer can decide on the infill during the construction work of the structure, or even after the completion of the structure. For instance in an apartment block all residents can decide independently in time from each other. When the occupation changes during the life cycle of the house or apartment the infill can be modified relatively easy. So in this sense the Matura system promotes the time postponement beyond the delivery of the house or apartment. |
| Place postponement | The Matura system enables to keep stocks of materials upstream in the supply chain. According to the customer’s design the materials are pre-cut and coded in the factory and components are pre-assembled. This pre-assembly of components is performed in a short period of time and close to the installation stage on site to enable the customer to have enough time to finish the design. The materials and equipment are packed in a systematic way in a container and transported to site. |
| Form postponement | The Matura system enables the customer to take relatively long time to determine the final plan and design of the house or apartment. The system assures that the assembly is performed in a fast mode by a three-man multi-skilled work crew performs site installation of a standard apartment up to 10 days average. These lead times are possible while the materials and components exactly fit together due to the pre-assembly, the wiring is provided with easy (“foolproof”) connections, and other facilities to support fast installation. |

### The Sekisui Heim case

The Sekisui Heim is pre-engineered modular housing concept in a steel variant and a wooden variant by Sekisui Housing, a division of Sekisui Chemical Company. The concept offers a complete prefab housing system made up of modular units, which are assembled in the plant and installed on site. 80% of the labour is executed on the factory, and 20% on site. The lead-time from customer order-taking to move-in in the house is about 40 days, never exceeding 50 days. The actual production of the house takes 3 days: 1 day fabrication of parts, 1-day assembly of modules (modules are transported overnight), and 1-day site installation (Cuperus 2000, Hall & Yamada (unknown)).
Table 3: Postponement aspects of Sekisui Heim

<table>
<thead>
<tr>
<th>Postponement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time postponement</td>
<td>The design of the house is done in interaction with the client into a CAD system that codes materials, estimates the costs of the design, and makes the bill of material. The average lead-time for developing the layout and plans with the customer takes about 1 month. Next the engineers check the plans and finish the drawings and details, and make them ready for production. Information is then directed to suppliers and the factory. Materials are pre-cut, coded and labelled by the suppliers, with easy connections to enable error-free assembly. The suppliers deliver materials and subassemblies to the factory based on a JIT/kanban system.</td>
</tr>
<tr>
<td>Place postponement</td>
<td>Units are assembled in the factory according to client wishes, put down in the design. The modules are finished as far as possible, including walls, flooring, wiring, doors, built-in appliances, windows, finishes, plumbing, fixtures, cabinets, trimming etc. The modules are assembled on multiple assembly lines with a throughput time of about 3 hours, covering all operations, from the welding of the module frames using welding robots to the shipping of the modules.</td>
</tr>
<tr>
<td>Form postponement</td>
<td>Each unit is transported separately to the site. It takes 15 transports for an average house. The units are installed on site, exactly fitting together. Before the installation commences the site is prepared and ready for installation. Site preparation takes about 10 days.</td>
</tr>
</tbody>
</table>

SUPPLY CHAIN IMPLICATIONS OF PLATFORM STRATEGIES IN CONSTRUCTION

As demonstrated in the example of open building, application of platform strategies in construction implies consequences for the construction supply chain and needs adaptation and reconfiguration of the product and process structure to support its postponement strategy of modularity, delayed differentiation, and decoupling of subsystems and decision levels (Dekker 1998). This implies higher levels of standardisation and predefined processes: client interaction in the design phase of the project, engineering and prefabrication of exactly fitting parts according to client demands, order picking and centralized distribution of all parts per object (house), site assembly and installation of subsystems into the object by a multi-disciplinary work crews.

Application of platform strategies in construction involves various aspects of postponement. As mentioned above, the construction supply chain is typically a convergent supply chain implying that the assembling firm performs the final manufacturing processes and the assembly of the final product with a long life cycle. In terms of Lin and Shaw (1998), application of platform strategies results in the move from type 1 (convergent assembly) to type 2 supply chains (divergent assembly), including adoption of make-to-order strategies serving mass-customisation purposes through delayed differentiation.

In terms of clusters and sub-markets, application of platform strategies in construction, again, as demonstrated in the example of open building, the dual concept of two separate types of contractors is often suggested: one contractor for the base-building, and one contractor for the fit-out. Tasks and contracts of both contractors would be separated. In the
supply chain the structural contractor precedes the fit-out contractor. The interface must be supported by standards so that the fit-out corresponds to the base building, and vice versa. The construction supply chain would transform into an “open network system” with a “dispersed control pattern” of making and buying modular parts and components through the supply chain (Kendall 1994, 1990).

CONCLUSIONS

Application of platform strategies and modularity promotes flexibility and agility of the construction supply chain. Platform strategies are supported by a structured system of decoupled yet interconnected parts (units) regarding the product as well as a modular process structure. This enables postponement strategy for delayed differentiation in the order fulfilment to achieve efficient “pulled production” and “value generation”. This is particularly interesting in the sectors of the industry with high levels of demand volatility and speculation, such as housing and office building. These sectors require high levels of product flexibility and adaptability, because the client is often not the end user, and often there are multiple users behind one client organisation, e.g. the renters behind a housing corporation or the house owners behind a project developer. In addition, the ownership and the use of residential and office buildings change relatively often during the life cycle.

Open building represents a platform strategy in construction through a product and process system of separation and decoupling of different levels of decision-making, and modular coordination. Open building supports customized and efficient building through a postponement strategy of delayed differentiation supported by the decoupling and modular coordination of subsystems, the separation of levels of decision-making, application of prefabricated parts, and a predefined process organization. The production technologies developed, such as the application of modular coordination, JIT deliveries and site installation of parts and subsystems are familiar to the realms of manufacturing. With the application of platform strategies construction supply chains will grow to more integrated and constant production organisation formats including product development, instead of mere one-off project delivery in constantly changing project coalitions of firms.

REFERENCES


