Value Delivery through *Product Offers*: A Lean Leap in Multi-Storey Timber Housing Construction

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Abstract

Among large Swedish contractors there is currently a specialization trend towards an increased use of prefabrication and complete systems in housing construction. The Lean Construction development up to date has focused on the management of value delivery for complex construction projects. Typical Swedish housing projects do not experience this broad complexity; instead the main challenge seems to be to better specify and deliver customer value. Currently, the Lean Construction methods available are not by themselves enough for the generation of value in Swedish multi-storey housing construction. The aim of this paper is to examine the potential of the *product offer* (a well-defined and highly standardized building system developed from the value views of specific customers) as an aid in the generation and delivery of value for multi-storey timber housing construction.

From the point of view of manufacturing and customer value, the *product offer* is considered a Lean strategy for integrated consideration of internal and external value. Case study experiences indicate that the *product offer* strategy provides stability and continuity for producers that in turn provides with Lean practices in marketing, design and manufacturing. Approaching Lean, small- to medium-sized Swedish producers should focus on improvements through Lean Manufacturing. However, since an emerging demand from the Swedish construction industry forces these producers to take a larger role in the construction process, more construction related Lean improvements must also be considered. In this regard, the *product offer* is demonstrated to be a promising Lean strategy for the Swedish housing industry.

Keywords: Lean thinking, Multi-storey timber housing, Value delivery.

Introduction

In Sweden, there are an increasing number of small to medium sized companies that have specialized in multi-storey housing construction by utilizing extensive prefabrication strategies (Björnfot and Sardén 2006). Among the large contractors, who mainly work in a traditional manner which involves large project organizations and on-site work, a similar trend in specialization is observable. This specialization does mainly concern an increased use of prefabricated construction products as well as long-term stable client relations. Drivers for this specialization trend are a demand for reduced construction costs but also a

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pure business perspective where the higher profitability experienced by specialized companies is sought (10 % compared to about 2 % profitability for the large contractors).

The amount of pure waste in traditional construction projects is striking; a Swedish study reports that only about 20 % of performed work is directly value adding (Josephson and Saukkoriipi 2005). Lean Construction takes on this challenge by striving to better meet customer demands and to improve the construction process as well as its product (Howell 1999). Lean has proved to be a valuable philosophy for construction; Ballard and Howell (2004) and Emmitt *et al* (2005) report on successful implementations. However, positive experiences are mainly related to an application of Lean practices on complex construction projects through the use of methods such as the Last Planner System of production control (Ballard and Howell 2003). Typical Swedish housing projects do not experience this broad complexity; instead the main concern seems to be a lack of knowledge of the customer value generation process (Olofsson *et al* 2004, Björnfot and Sardén 2006, Höök 2006).

Based on empirical results from three Swedish multi-storey timber housing producers, Björnfot and Sardén (2006) identified the application of product based technical platforms, called *product offers*, as means for the producers to create stable production systems and supply chains for efficient management of customer value and improved profitability. For these producers, the *product offer* seems to represent a strategic change where the organization is gradually becoming Leaner and ready for an implementation of specific Lean practices. According to Green and May (2005) such an organizational change represents a first stage of Leanness. As such, a strategic change through *product offers* ties in well with the principles of Lean Thinking (Womack and Jones, 2003), i.e., the key is to specify customer value by specific products and then to never lose sight of this value as the value stream is reformed and none-value adding activities are removed.

The aim of this paper is to evaluate the potential of the *product offer* as a means of facilitating the delivery of value in housing construction. First, a basic understanding of value and value delivery through Lean Construction is provided after which the *product offer* is defined through experiences from Swedish timber housing construction emphasized by volume prefabrication. Through the principles of Lean Thinking the *product offer* is then argued as a strategic application of Lean Construction which aids in the generation of internal (own) and external (customer) value. Finally, empirical results from a fresh Swedish development initiative in multi-storey timber housing construction are presented that provides a deeper understanding of how value is delivered through *product offers*.

The nature of value in Lean Construction

The concept of value

In traditional housing construction projects it is common to initiate the design process using a vague conceptualization of the end structure which leads to an inefficient design process where extensive customer involvement only increases complexity (Bertelsen and Emmitt 2005), i.e., design changes become a frequent occurrence as the perception of value for the client changes. An additional effect of the fragmented construction process is waste during the production phase which in Swedish housing accounts for up to 35% of the production costs (Josephson and Saukkoriipi 2005) and adverse participant relations (Sardén 2005) leading to even more waste in a business perspective as prices are continuously

negotiated. It seems that a lack of consideration for the value generation process can have dire consequences for all project stakeholders.

Value, as defined in *Lean Thinking* (Womack and Jones 2003), refers to materials, parts or products – something materialistic which is possible to understand and to specify (Koskela 2004). Construction is a process of delivering this value to the client through a temporary production system (Bertelsen and Emmitt 2005). The client is often an organization representing owners, users and society who values different things at different times during the life of the building, e.g., durability, usefulness, beauty, flexibility, environmental aspects, etc. (Bertelsen & Emmit 2005). The other construction team members also have values to fulfil, but their main concern should be to deliver the best possible value to the client whom otherwise would look elsewhere (Emmitt *et al* 2005).

Value may be divided into external and internal value (Emmitt *et al* 2005) – external value is the clients' value and the value which the project should end up with, while internal value is the value that is generated by and between the participants of the project delivery team (contractor, architects, designers etc.). In this paper internal value is synonymous with profitability and independence (Cuperus and Napolitano 2005). Independence provides stakeholders with increased control over the internal value generation process through the shielding of their production systems from external sources of variety, such as late unforeseen design changes.

Even though the project delivery team tries very hard to design and produce a product to suit the specific wishes of the customer, the result of this value generation process is often a building different from the initial customer conceptualization. It seems that the way value is currently generated in construction projects leads to increased complexity and commonly results in waste generation at the expense of providing value for stakeholders. As a result, project stakeholders inevitably end up salvaging as much as they can out of construction projects through claims (Sardén 2005).

Value delivery through Lean Construction

A fundamental aim of Lean Construction is to aid in the delivery of external value by managing the internal value generation process. To aid in internal value generation, the most commonly referred to Lean techniques in construction are work flow control through the Last Planner system (Ballard and Howell 2003), value stream mapping (Rother and Shook 2001, Arbulu and Tommelein 2002), just-in-time production and supply-chain management (Low and Mok 1999), and pokayoke or the five why's technique (Tsao *et al* 2004). Another development effort in Lean Construction is target costing which aims to decrease costs so that a required profit level can be assured (Granja *et al* 2005), i.e. an integrated internal/external value view.

Other interesting and increasingly popular development efforts aiding in the delivery of external value are improved planning tools such as Line-of-Balance (Kenley 2005) and computer-aided design using 4D CAD (Rischmoller *et al* 2006). Another Lean Construction advance is Lean Design (see e.g. Freire and Alarcón 2002) which makes late design changes possible. However, if changes are made too late in the process they may still contribute to waste, especially in stable production systems (Stehn and Bergström 2002).

In Lean Construction, the project is in itself considered a fundamental feature of construction and the production system is designed with the project as its core. In traditional construction projects, external value is generated in the design phase through

negotiations. Even if there are no Lean Construction methods available to specify external value there are accepted methods which aid in the value generation process; examples of such methods are partnering and concurrent engineering (Cheng and Li 2004) with incentives for team work in design and the facilitation of value generation throughout the iterative design process.

Based on experiences from the implementation of Lean in manufacturing, Oliver *et al* (1996) conclude that Lean practices are effective at fine-tuning a system which is already basically under control - it seems that implementation of practices alone are not enough for Lean. Ideally, the development of Lean Construction theory and applications should include an understanding of the Lean Thinking principles (Value, Value stream, Flow, Pull and Perfection) advising producers on how their production systems should be transformed so that value can be maximized and waste minimized (Womack and Jones 2003). In terms of a Lean thinking, production should be aimed at satisfying customer value by specific products (external value), while value for project participants (internal value) should come from waste reduction activities and continuous improvements within value streams.

In construction there is still undoubtedly a large variety originating from poor process control and unforeseen and uncontrollable external factors such as weather and traffic. Swedish prefabrication initiatives are structurally changing the multi-storey housing industry towards a kind of manufacturing; one of the main strategies for the implementation of a Lean thinking in construction (Bertelsen 2004). A fundamental aspect of this transformation is the *product offer* which aids producers in the delivery of external value by stabilizing their internal value generation processes.

Value delivery through *product offers*

The large majority of Swedish producers of detached housing (single occupancy) have well developed production systems where the product (the house) is prefabricated and targeted at specific customers who enjoy great flexibility within the constraints of the production system, e.g., architectural and floor-plan customization are partly limited. As an example, the largest Swedish detached housing producer offer limited flexibility through a fixed set of options (much like a car manufacturer). Through these options their customers (private home owners) are provided a sense of great flexibility at a very competitive price. There are also detached housing producers who offer their customers more flexibility - their prices are generally higher due to a more complex product and production system. The detached housing producers have realized that specialization is a condition for profitability and ultimately survival and that it is very difficult to be profitable by approaching the requirements of every possible customer. As such, these producers pursuit of value delivery for specific customers is similar to companies within the manufacturing industry.

Even considering the long-term success of the detached housing producers, the Swedish multi-storey housing industry has been slow to adapt; the industry is still in an era of traditional production where construction companies generally compete for their customers with production systems suitable for numerous different customers. As a consequence, the construction process is prone to waste generation for both customers and construction process participants (Björnfot and Sardén 2006). Furthermore, Josephson and Saukkoriipi (2005) argued that construction companies who try to be best at everything by pursuing every possible project create further waste since much resource are spent without any result in extensive and frequently unsuccessful bidding competitions.

Volume prefabrication – an example of a *product offer*!

In the Swedish multi-storey timber housing market, there are a number of small- to mid-sized producers who have realized that it is possible to gain benefits from specialization. A key aspect of this specialization trend is a clear identification of the customer and the development of a technical platform, a *product offer* (similar to detached housing) based on the values of the targeted customers. As such, the *product offer* is a well-defined and highly standardized building system (including design, manufacturing, assembly, and supporting services such as long-term quality assurance, financial aid, etc.) allowing for the design of a stable and efficient long-term production system. To understand the *product offer* as an *alternative* Lean Construction strategy for value delivery in multi-storey housing construction, volume prefabrication is used to further define its core characteristics.

The volumes are produced in a standardized manufacturing process where wall and floor elements are assembled to three-dimensional volumes (see Olofsson *et al* 2004, Björnfot and Sardén 2006, Höök 2006). Before delivery to the construction site, the volumes are finished with installations, façade, interior surfaces and finishing forming ready-to-use living space. Value delivery for volume production (condensed from the literature cited above) is for each project performed through four parallel processes (project management, design management, purchasing and production) illustrated in Figure 1.

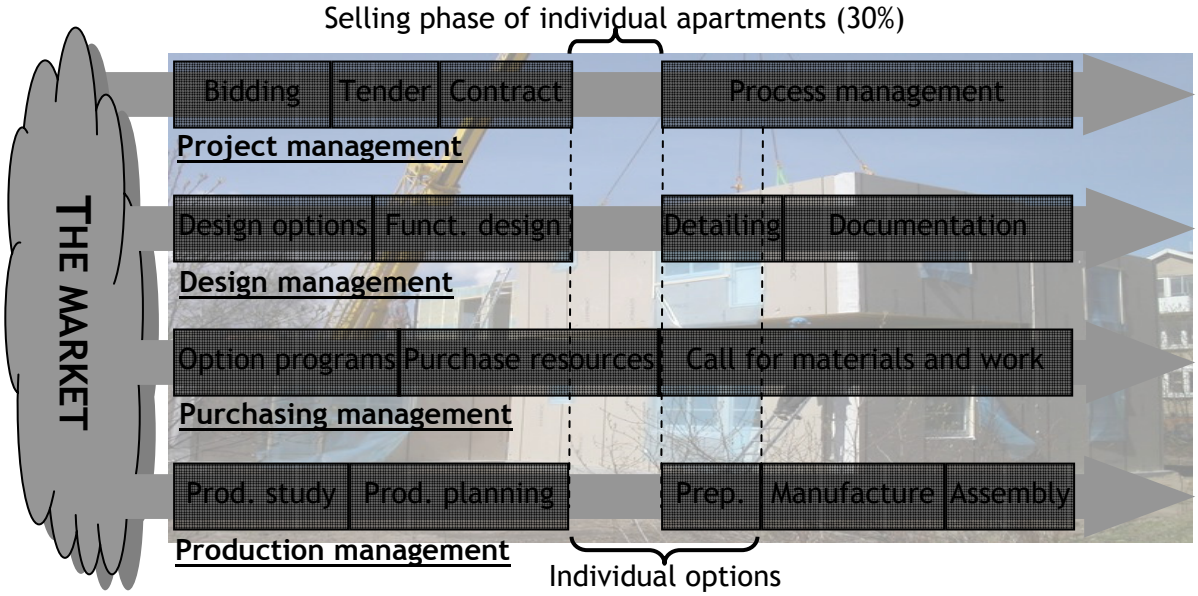

Figure 1: Schematic illustration of value delivery through volume prefabrication.

What drives these four processes is the volume system (a *product offer* as defined above) which is designed according to the requirements from the market. Adopting the *product offer* strategy has supported the volume producer in designing their production system:

- **Project management.** The case company prefer to, and most often, offer their standardized volume system to landlords through general long-term agreements that roughly specifies both client options and individual options for the client's customers – the tenants. Through these general agreements, customer value is adapted to the needs of individual clients. Adopting the *product offer* allows the volume producer to utilize a "simplified" tendering process that adapts the house

layout to the project in question, negotiates price and date of delivery, and sets up a list of options for the clients' tenants. After initiating the manufacturing process, the production process is thoroughly managed for increased control and stability.

- **Design management.** The volume system is specifically adapted to the project in question by specifying for example individual tenant options and site characteristics for the current project. Often only minor changes of the principle design (interior and façade design, and add-ons such as balconies) are allowed to keep a high production-to-cost efficiency. When the contract has been signed, the client initiates the sales and customization process of the houses (certain individual options are even possible after manufacturing has been initiated). When 30% of the apartments are sold, the start order is given for detailed design to commence after which documentation is supplied to the manufacturing process.
- **Purchasing management.** Through the adoption of a long-term *product offer* the volume producer is in control of the whole value stream which consists of long-term general agreements with subcontractors (carpentry, electricity, ventilation, etc.) who are brought in-house to perform their work, with assembly teams for on-site construction and with suppliers for a stable long-term supply chain for reliable material deliveries. For each individual project, contracts are signed for the required resources. When manufacturing is initiated the volume producer is then able to call on the pre-purchased resource so that production can be performed smoothly and without delays.
- **Production management.** For each individual project, and based on the individual customer options, the volume production system is prepared to allow for manufacturing to begin. From the detailed design phase, design drawings are delivered to the manufacturing process. When manufacturing is initiated, information of selected customer options from the customization process is passed to the production process so that the individually customized tenant-owned purchased apartments can be manufactured. The manufacturing process uses automation in conjunction with traditional construction work to produce volumes in a cost-efficient manner with short lead times.

The *product offer*: an application of Lean principles?

The *product offer* strategy seems to be a new way of thinking, a Lean thinking, in the delivery of value for the multi-storey housing industry rather than an implementation of specific Lean practices. Garnett *et al* (1998) argued that delivering customer value means organising around a product and/or service which provides continuity and stability. The *product offer* strategy takes on this challenge by controlling the inherent variety of construction through continuity (long-term thinking) and stability (reduced production system variability). Understanding the *product offer* through the Lean Thinking principles promotes the adoption of the *product offer* as a strategic application of a Lean thinking for value delivery in multi-storey housing construction. Lean characteristics (as viewed from Swedish timber housing industry practices) introduced into the production system by producers adopting *product offers* are outlined in Table 1.

From Table 1, the *product offer* is specified and detailed from customer requirements (**Value**) but managing customer value through the *product offer* forces the customer to lock their options to a specific technical platform (building system) offered by the producer.

Locking customer options allows the producers to be in control of a stable value generation process where customers are allowed flexibility through selected add-ons and options such as façades, apartment layouts and interior finishing. Consequently, value is specified by specific product for specific customers, which enables stability.

Table 1: The Lean characteristics of the product offer

Lean principle	The product offer implies…
Value	…detailed product specifications developed from customer requirements captured on the market where the product is intended.
Value stream	…definition of the specific resources and activities required for supply chain management and product realization.
Flow	…control of a stable value stream so that value adding activities can be better managed and so that waste can be eliminated or reduced.
Pull	…flexibility and adaptability to current and future customer demands and the ability to find ways of reducing lead times.
Perfection	…stable and transparent processes and operations allowing for continuous improvements by experience feedback.

In production system design, the stability conferred by the *product offer* is discerned through the specification of activities and resources required for product realization (**Value stream**). Continuity provides a steady foundation (process stability) for continual improvement through identification and elimination of non-value adding activities (**Flow**) (Table 1). Working with *product offers* provides a foundation for successful supply chain management which is facilitated by lower variability in delivery (quality, time and amount) and continuity for suppliers who are provided with a stable base from which to facilitate their own profitability through improvement programs (**Perfection**). In a sense, a transparent production system where everyone can see everything and where everyone is working towards the same goal is both facilitated by and a requirement for a *product offer* strategy since stability and continuity cannot be reached without a stable supply chain.

If customization is of value to the customer then enough flexibility must be incorporated in the design of the *product offer* so that value is delivered (**Pull**). According to Naim and Barlow (2003), profitable customization requires a robust supply chain for changes in both product volume and product variety. Ensuring enough flexibility is a continuous struggle for housing producers relying on prefabrication strategies (Stehn and Bergström 2002) since the customers' perception of value does change over time. Hence, the *product offer* must continuously be developed so it can be adapted to the changing market (Table 1).

To conclude, an adoption of the *product offer* strategy provides construction practitioner with Lean characteristics throughout their production system; its stability creates a stable value stream which results in a stable production system with activities which can be continuously improved upon so that flow can be established and internal value updated.

Specification of value through *product offers*

Looking back at the volume prefabrication example it can be argued that as a result of working with *product offers* Lean characteristics (Table 1) can be observed throughout the volume producer's production system. Examples include:

- a stable and continuous value stream and supply chain,
- a well developed manufacturing and site assembly process,
- customer pull through flexibility and adaptability and
- a shared process design with suppliers and academics to facilitate improvements.

However, the volume producer can still not be considered Lean since no specific Lean Manufacturing practices, such as visual control or work smoothing, can be discerned in their everyday work. But it seems that the stability and continuity incurred by the *product offer* presents a good opportunity to implement these Lean practices.

Experiences from volume prefabrication provide insights into successful *product offer* design. Successful development of a *product offer* requires clear specification of the product and associated services (**product specification**) that are related to customer requirements so that the value asked for is what is produced and delivered. Consequently, close relations with current and future customers (**external relations**) are important so that the product offered can be adapted to changes in what customers want. To facilitate work in a changing market, stability within the production system is required (**internal relations**) as well as control over the delivery from external suppliers (**supply chain management**). In the next section, empirical data from a Swedish initiative at *product offer* development is provided. In this initiative, the above mentioned aspects are used to describe how value is specified during a *product offer* development effort.

A Swedish *product offer* development initiative

The initiative reported on involves three Swedish timber component producers and one firm of architects. The volume producer described in relation to Figure 1 is part of this initiative. The aim is to increase the producers' share of the multi-storey housing market. As of now, the *product offer* has not been seen in practice, yet a discussion of how the *product offer* has been developed is of interest to deepen the understanding of its application as a Lean strategy for housing construction. The presented results are based on data collected over a one year period including interviews with managers and production personnel, participation at design meetings and documentation relating to the initiative.

Product offer development & specification

The competitive edge of the developed product was initially stated as offering a "complete package" (from design to assembly) in a cost- and time-efficient industrialized construction process involving the main products of the involved companies; prefabricated timber elements and volumes (Figure 2). The companies all have high expectations of the outcome of the initiative; the volume producer achieves improved flexibility in their *product offer* enabling consideration of new client values while still producing a familiar product. The element producer whose prefabricated element system (Björnfot and Stehn 2005) is lacking in development would gain an increased share of the housing market and the possibility of developing their element system in real applications. As the architectural values of customers change, the long-term involvement of the architect ensures that new architectural forms and layouts can be developed that specifically support the *product offer* without compromising the producers manufacturing processes.

The main customer for the *product offer* was identified as landlords who offer flats to tenants at a price of around 110 €/m^2 (living area) in multiple floors. The calculated total

cost for a regular sized apartment was 1300 €/m^2 (compared to about 1700 €/m^2 per apartment in traditional housing construction). Based on these costs a target *production cost* of 800 €/m^2 was agreed for the development of the *product offer*. The layout of the houses is based on volumes but to achieve a higher degree of layout flexibility than can be accomplished with volumes alone prefabricated timber elements are used. The main idea was to use both volumes and elements where they are best suited. A large and difficult part of on-site production was identified as finishing off "wet areas" such as bathrooms and kitchens. Therefore, it was decided to attempt to prefabricate such areas as volumes and to include as much as possible of the installations since experience has shown that site production of installations is a common source of waste and that higher quality can be maintained inside factories.

Figure 2: The product offer integrating prefabricated timber volumes and elements.

During design development, wall and floor elements were standardized to simplify the manufacturing and site assembly processes. This effort significantly reduced the number of elements used. Standardization was considered an important aspect in promoting a construction process where standard work in manufacturing, delivery and site assembly could be utilized. Surprisingly, it was not until late in the process that standardization became a key aspect. By the end of the development process, a production cost of 900 €/m^2 was achieved which was higher than the targeted cost. However, the delivery team is continuously looking to improve the *product offer* so that the target cost can be achieved.

Relations & supply chain management

Through the *product offer*, the producers are able to use a simplified tendering process similar to the practice already used by the volume supplier (see Figure 1). The simplified tendering process involves relational contracting among the producers so that the customer does business with one delivery team instead of a multitude of independent subcontractors. The main customers for the *product offer* are landlords but the improved flexibility makes the *product offer* attractive to contractors as well. The increased flexibility of the product offer also enables clients to become further involved in the design process without compromising the stability and continuity of the producers manufacturing processes.

The standardization effort resulted in reduced production costs due to cost and time savings in manufacturing and assembly. This allowed the delivery team to pinpoint key component suppliers and to simplify the supply chain by reducing the number of suppliers,

i.e. it was decided on the suppliers who would be able to deliver required components when needed and at the right price and quality. The delivery team has a desire to integrate lower tier component suppliers into their value chains and to engage in long-term relations with suppliers so that stable supply chains can be formed. The aim of this effort is to

- allow the delivery team to be in control of the whole supply chain and
- involve everyone in continuously improving the product and associated processes.

A goal was to develop an on-site assembly process with manufacturing characteristics, i.e. use of automation for material handling and movement. Additionally, a dry site production process was aimed at through the use of a covering tent. Through this effort, the construction site becomes much like a factory in which components are shipped in and assembled as they are delivered. Such an assembly process demands attention on logistics for Just-in-Time delivery of components. To facilitate cooperation within the delivery team and control of the production system, a computer support system is being developed. The aim of the computer system is to

- allow for simultaneous sharing of information between the involved producers to aid in the design process,
- facilitate short lead times with increased customer involvement,
- support the manufacturing processes and
- guide the delivery of components to manufacturing and to the construction site.

Concluding case study remarks

Deciding on a course of action, in this case the combination of elements and volumes provides with stability and continuity – the variety of construction is integrated into the *product offer* which provides with a stable foundation for client negotiations, design development, production system design and continuous improvements of both the product and associated processes. Most of the development efforts in support of the *product offer* either enables Lean practices or are influenced by them, i.e.

- the *product offer* is highly standardized to facilitate *standard work* in manufacturing and assembly,
- internal relations are managed through *target costing* and *relational contracting*,
- external relations are managed through *flexibility* and
- the supply chain is managed through l*ong term supplier relations* to enable *continuous improvements*.

Multiple similar endeavours to this case are currently being developed in Sweden characterised by a stable *product offer* acting as a driving force for improvements - it seems as if the *product offer* strategy provides an initial stimulus towards a Lean thinking in multi-storey housing construction.

Discussion

The aim of this paper was to evaluate the potential of the *product offer* (a well-defined and highly standardized building system developed from the value views of specific customers) as a strategic application of Lean to facilitate the delivery of value in multi-storey timber housing construction. It was argued that producers who adopt *product offers*

approaches Lean Construction on a strategic level; it is a new way of thinking about the delivery of value for the multi-storey housing industry, rather than an implementation of specific Lean practices. Based on the principles of Lean Thinking it was argued that the application of the *product offer* is a Lean strategy for value management. Case study experiences indicate that the *product offer*, through its stability and continuity, provides with Lean practices in marketing, design and manufacturing.

It should be noted that there are critics against the understanding of construction through the principles of Lean Thinking. For example, Koskela (2004) argues that the principles are insufficient for the task of changing construction to Lean. However, this research indicates that the principles can indeed promote a change of perception of production in multi-storey housing construction, particularly of how value is delivered and improved upon. In Lean Thinking, customer value (delivered as a product and/or service) is clearly of primary concern and governs the transformation of the production process so that value can be delivered as efficiently as possible. Since value delivery is what fundamentally drives the development and the use of the *product offer*, this paper proposes that the *product offer* should be considered as an application of a Lean thinking for construction.

Developing a *product offer* requires input from many specialized subcontractors who are often acting independently – they must work together towards a common goal instead of "minding their own business". The *product offer* development initiative described in this paper is an example of teamwork over organizational borders through relational contracting. Relational contracting provides stakeholders with incentives to make their best effort for the project, to use innovative thinking and to continuously improve on their own work (Matthews and Howell 2005). The case study experiences showed that it is possible to work together and deliver value in new ways by breaking the restraining influence of the traditional project oriented construction process.

The view on value differs between industries and even cultures. Therefore, the application of Lean will be different. A contractor of complex industrial projects may for example want improved control of site production through Last Planner while a producer may want manufacturing process improvements through practices such as the *Toyota Way* (Liker 2003). The similarity of these efforts is a new way of thinking, Lean thinking. Approaching Lean, small to medium sized Swedish suppliers should primarily focus on improvements through Lean Manufacturing. However, an emerging demand from Swedish contractors forces these suppliers to take larger responsibility in the construction process. In this regard, the *product offer* is considered a Lean strategy for Swedish producers that, if fully developed and correctly applied, enable them to satisfy external value while being able to pursue profitability through stable production systems and supply chains.

References

Arbulu, R. and Tommelein, I. (2002). "Value Stream Analysis of Construction Supply Chains: Case Study on Pipe Supports Used in Power Plants". Proceedings of the 10th annual conference of the International Group for Lean Construction, Gramado.

Ballard, G. and Howell, G. (2003). "Lean Project Management". *Building Research & Information*, 31 (2) 119-133.

Ballard, G. and Howell, G. (2004). "Competing Construction Management Paradigms". *Lean Construction Journal*, 1 (1) 38-45.

Bertelsen, S. (2004). "Lean Construction: Where are we and how to proceed?" *Lean Construction Journal*, 1 (1) 46-69.

Bertelsen, S. and Emmitt, S. (2005). "The Client as a Complex System". Proceedings of the 13th Annual Conference of the International Group for Lean Construction, Sydney.

Björnfot, A. and Stehn, L. (2005). "Product Design for Improved Material Flow – A Multi-Storey Timber Housing Project". Proceedings of the 13th Annual Conference of the International Group for Lean Construction, Sydney.

Björnfot, A. and Sardén, Y. (2006). "Prefabrication: A Lean Strategy for Value Generation in Construction". Proceedings of the 14th Annual Conference of the International Group for Lean Construction, Santiago de Chile.

Cheng, E. and Li, H. (2004). "Development of a Practical Model of Partnering for Construction Projects". *Construction Engineering and Management*, 130 (6) 790-798.

Cuperus, Y. and Napolitano, P. (2005). "Open Building/ Lean Construction Evaluation of a Case in Brazil". Proceedings of the 13th Annual Conference of the International Group for Lean Construction, Sydney.

Emmitt, S., Sander, D. and Christoffersen, A.K. (2005). "The Value Universe: Defining a Value Based Approach to Lean Construction". Proceedings of the 13th Annual Conference of the International Group for Lean Construction, Sydney.

Freire, J. and Alarcón, L. (2002). "Achieving Lean Design Process: Improvement Methodology". *Journal of Construction Engineering and Management*, 128 (3) 248-256.

Garnett, N., Jones, D.T. and Murray, S. (1998). "Strategic Application to Lean Thinking". Proceedings of the 6th Annual Conference of the International Group for Lean Construction, Guaruja.

Green, S. and May, S. (2005). "Lean Construction: Arenas of Enactment, Models of Diffusion and the Meaning of 'Leanness'". *Building Research & Information*, 33 (6) 498-511.

Granja, A., Picchi, F. and Robert, G. (2005). "Target and Kaizen Costing in Construction". Proceedings of the 13th Annual Conference of the International Group for Lean Construction, Sydney.

Howell, G.A. (1999). "What is Lean Construction - 1999". Proceedings of the 7th Annual Conference of the International Group for Lean Construction, Berkeley.

Höök, M. (2006). "Customer Value in Lean Prefabrication of Housing Considering both Construction and Manufacturing". Proceedings of the 14th Annual Conference of the International Group for Lean Construction, Santiago de Chile.

Josephson, P-E. and Saukkoriipi, L. (2005). "*Waste in Construction Projects - Need of a Changed View* (In Swedish)". Fou-väst, report 0507.

Kenley, R. (2005). "Dispelling the Complexity Myth: Founding Lean Construction on Location-Based Planning". Proceedings of the 13th Annual Conference of the International Group for Lean Construction, Sydney.

Koskela, L. (2004). "Moving-on – Beyond Lean Thinking". *Lean Construction Journal*, 1 (1) 24-37.

Liker, J. (2003). "*The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer*". McGraw-Hill, New York.

Low, S.P. and Mok, S.H. (1999). "The Application of JIT Philosophy to Construction: a Case Study in Site Layout". *Construction Management and Economics*, 17 657-668.

Matthews, O. and Howell, G. (2005). "Integrated Project Delivery an Example of Relational Contracting". *Lean Construction Journal*, 2 (1) 46-61.

Naim, M. and Barlow, J. (2003). "An Innovative Supply Chain Strategy for Customized Housing". *Construction Management and Economics*, 21 (6) 593-602.

Oliver, N., Delbridge, R. and Lowe, J. (1996). "Lean Production Practices: International Comparisons in the Auto Components Industry". *British Journal of Management*, 7 529-544.

Olofsson, T., Stehn, L. and Cassel-Engqvist, E. (2004). "Process and Information Flow in Mass Customization of Multi-Story Housing". Proceedings of the 5th European Conference on Product and Process Modeling, Istanbul.

Rischmoller, L., Alarcón, L. and Koskela, L. (2006). "Improving Value Generation in the Design Process of Industrial Projects Using CAVT". *Journal of Management in Engineering*, 22 (2) 52-60.

Rother, M. and Shook, J. (2001). "*Learning to See – Value Stream Mapping to add Value and Eliminate Muda*". The Lean Enterprise Institute, Brookline.

Sardén, Y. (2005). "*Complexity and Learning in Timber Frame Housing*". Ph.D. dissertation 2005:43, Luleå University of Technology, Sweden.

Stehn, L. and Bergström, M. (2002). "Integrated Design and Production of Multi-Storey Timber Frame Houses". *International Journal of Production Economics*, 77 259-269.

Tsao, C., Tommelein, I., Swanlund, E. and Howell, G. (2004). "Work Structuring to Achieve Integrated Product-Process Design". *Construction Engineering and Management*, 130 (6) 780-789.

Womack, J. and Jones, D. (2003). "*Lean Thinking: Banish Waste and Create Wealth in your Corporation*". Revised and updated edition. Simon & Schuster UK Ltd, London.