CHALMERS

Benchmarking production method for self-contained timber houses

Master of Science Thesis in the Masterôs Programme Design and Construction Project Management

JOHAN LINDOW, FREDRIK NYMAN

Department of Civil and Environmental Engineering
Division of Construction Management
CHALMERS UNIVERSITY OF TECHNOLOGY
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Department of Civil and Environmental Engineering
Division of Construction Management
Chalmers University of Technology
SE-412 96 Göteborg
Sweden
Telephone: + 46 (0)31-772 1000

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ABSTRACT

Purpose ï This paper seeks to find a foundation for the selection of different production methods when constructing self-contained timber houses.

Design/methodology/approach ï The study was performed in a deductive manner in the approach of finding important factors in the decision-making process. Commonalities and differences among the reviewed articles were studied. Three field studies were made to observe and retrieve information. This data was used as a base for the development of a model to select production method.

Findings ï There is an interesting field of research in how to rationalize the process of selecting production methods of self-contained timber houses. Indication in the study clearly shows which production method that are most gainful related to the project size and location.

Limitations ï It is recommended to regard this thesis as a preliminary study for further research.

Keywords ï Production methods, Knowledge paradox, Self-contained houses

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Preface

This master thesis were carried out during the period of January 2011 to July 2011 as concluding part of the master programme Design and Construction Project Management, Chalmers University of Technology, Sweden.

The work was initiated by the management belonging to one group within a major contractor in Sweden. The purpose of the paper were to find a foundation for the selection of different production methods when constructing self-contained timber houses

During the proceeding of the thesis we have received much help from the personnel working at the contractor and for that we are most grateful, especially the support given from Site M. Joakim Green and Project M. Magnus Johansson. Also the supervision from Prof. Per-Erik Josephson has been to the greatest help for accomplishing this paper.

Finally we would also like to seize the opportunity to thank our respective families for all support and encouragement during our years of study.

Göteborg March 2011

Johan Lindow & Fredrik Nyman

1 Introduction

This paper focuses on the selection of production methods when constructing self-contained houses with timber structures. By exploring the possibilities to develop a tool for supporting the decision concerning which production method is best to use. The paper is based on a study made in cooperation with the management belonging to one group within a major contractor in Sweden. The group wants to explore the opportunity to produce self-contained houses in their own factory and seeks the knowledge of when it is most cost-effective to use which of the following methods:

- industrial manner on site (field factory),
- purchasing house from subcontractor (subcontractor),
- in-door fabrication in own facility (factory).

Whether a construction project will be successful or not is largely dependent on the decisions made in the early stage of the project. It is also in early stages of the project lifecycle when the uncertainties are high and knowledge of the result is low (e.g. Maylor 2010). The construction and production of self-contained houses is no exception and also faces this dilemma. One aspect among many other is the importance of deciding the most suitable production method.

In the last decadeôs prefabrication has been incorporated into conventional construction methods for producing more favorable results (Hsieh 1997). Prefabrication has made the industry go from project based to a more manufacture based production (Gann 2000). This phenomenon makes it easier to transfer knowledge between projects and to create a base for models to use in decision-making. With increased data from previous projects there is a good chance of making better decision in the start-up phase of next project.

The purpose of this paper is to benchmark production methods for self-contained timber houses in order to identify under what circumstances one method is better than another. A preliminary tool, developed as a part of the analysis, is suggested to be used by managers for supporting their decision of production method.

There are several factors to consider when deciding which production method that is most appropriate. The review will look into and explain why this phase in a construction project is important and then apply it on a specific case. Decision making is an ongoing process over the whole projects lifecycle. The time span, which this study focuses on, is when the contractor makes his calculus and plans for the production. The study seeks its base in the aspects of transfer of knowledge, standardized processes and risk management. Several key factors affect the process of decision, all of them cannot be considered in a single study. Still, the belief is that adapting a tool of this type will improve the base of decision in self-contained housing projects.

2 Theoretical frame of reference

One of todayĝs great challenges for the contractors is to meet the globalized market and become more competitive. This both opens new markets and increases the competition on the home market. For the contractors this means that the productivity and efficiency must remain high and increase to be competitive in opposition to low cost labor enterprises (Bertelsen 2004). The construction project has a number of uncertainties and risks that influence whether the project will be successful or not. Examples are the condition on site, the political environment, the market conditions and even the weather. Each construction project means new working locations, new project teams creating loss of knowledge and the need for acquire new knowledge (Schaefer 1993). This result in a permanent dislocation of knowledge on the construction site, the knowledge is only available in a limited extent (ibid.). This can be hurdled in different ways, one of them can be to learn from past mistakes by standardize procedures (Cottrell 2006). In general, there is no formal insight of the experience acquired in a construction project, resulting in the practice of re-inventing the wheel. This is done even though the general view of the sector express a great economical importance when dealing with experience (Schaefer 1993). According to Landaeta (2008), the multifaceted and changeable nature of projects creates serious challengers for the managers of projects and project based organizations. As a part of selecting production method it is vital to understand how decisions are made. This paragraph brings up theory regarding decision making in an early phase of the project. Several different instruments can be used to improve the reliability in selection of production method. This study mentions risk management, transfer of knowledge and standardized processes as means of accomplishing trustworthiness in these decisions.

In the early stage of a project the knowledge about the project and its result is abstract and uncertain, in the same time where many important decisions have to be made. When the project is complete the knowledge is well defined and clear, the consequences from the decisions made in the early stage are costly to change (Maylor 2010). This phenomenon can be described with the ñknowledge paradoxò (Figure 1) and by learning from the idea behind the paradox the organization can use the gained information from previous projects and adopt it into new ones, giving less uncertainty in the early stages of the project and benefit from decisions made in earlier projects (Aniander et. al. 1998).

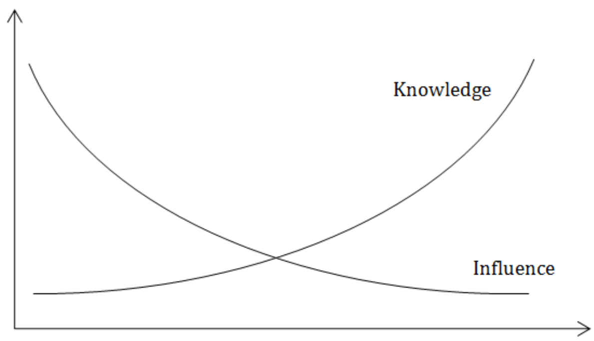

Figure 1. The knowledge paradox (Aniander et al. 1998)

This is also strengthened by Grönhaug & Kollveits (2004), who present that key personnel from the industry believe that better executed decisions in the early phase of a project will increase the project value. The major part of projects studied in their research falls within the traditional way to execute projects, little initiative is taken to exploit the opportunities to improve decision-making. This is seen as a big paradox since most of the key personnel promote its importance (ibid.). Soetanto et al. (2006) establishes the importance of a key decision point within the construction project and lightens the need of a transparent decision methodology. During the early phase should various needs and requirements be captured and considered to increase the chance of making appropriate decisions (ibid.). A challenge in the early stage of the project is to develop the ñtechnical conceptò, meaning that technical solution needs to be decided upon that satisfies function, quality and capacity (Grönhaug & Kollveit 2004). This is important if a project will be perceived as successful or not. It further implies that the quality of the conceptual decisions have a major impact on future value generation (effective production). Strategic choices need to be effective to fully exploit the potential success of a project. Studies have also shown that ineffective decisions in the early stages can lead to conceptual changes during the execution phase, thereby radically increase risk in the project (ibid.). A structured decision-making process will increase the chances of projects success. Chances are that a good methodology stimulates communication and feedback which leads to improved service to the client (Soetanto et. al. 2006). The finding in Grönhaug & Kollveits (2004) studies shows that all of the observations indicated that an effective execution in early phase of a project gives a value generation later in the project. A methodology to manage the decision-making process in a more open and reasonable manner creates a constructive dialogue between different parties in the project (Soetanto et. al. 2006).

2.1 Risk management

Future opportunities and risks are hard to predict but it is manageable by using experience and retrieved knowledge to create a vision of the future. A factor of success is to actively identify, analyze and treat risks in an appropriate manner (Blomé 2004). The nature of a construction project is commonly related to high degree of risk. It is involved in several aspects of a project, such as business activities, processes, environment and organization (Akintoye & Macleod 1997). With time have the growing complexity and dynamics of construction overwhelmed the industry creating considerable hazards and losses. Consequently, project risk management has been acknowledged as critical for the construction industry to improve their performance and secure the process (An et. al. 2007). It is complicated especially in the early stages to do analysis of risks since risks usually are affected by numerous factors. It can be problematic to judge risks associated to a specific project when there is a great uncertainty involved. Many techniques used today are relatively mature tools and the application of them might not give a result that can be considered satisfactory. An et al. (2007) implies the essential in developing new risk analysis methods that are able to identify key factors and to asses related risks in an acceptable way.

Contractors have a tendency to transfer risks to the sub-contractors and to insurance companies. Despite this, it is recognized that risk should be transferred to the part that has the best potential to handle them. Akintoye and Macleod (1997) warn for how the impact of risk transfer can influence innovation initiative within the industry. However Al-Bahar & Crandall (1990) state that contractors develop series rules of thumb that they apply when dealing with risk. These rules often rely on the contractorôs knowledge and judgments. Working with risk management and risk analysis can be summarized in following paragraphs:

- What experience does the organization have of similar projects? Did they go well? Has any other organization done something similar? What were their experiences?
- Are the knowledge and resources available at the right time to make the schedule become reality? What other projects or activities will compete for resources?
- What are the general risks can be identified from the customerθs perspective and their businesses?
- Which ability has the organization and project to assess risks?
- Are there buffers in the calculations and schedule to manage risk?

(Blomé 2004)

Added to above, risk management has to be a continuing activity all the way through the project lifecycle (Akintoye & Macleod 1997). From beginning to the end, the construction process is characterized by many uncertainties that involve a variety of unknown, unexpected, frequently undesirable and unpredictable situations. (Al-Bahar & Crandall 1990) Manage risks is relevant for all parts in a construction project and it also have to be a concern for the contractor (Akintoye & Macleod 1997).

2.2 Transfer of knowledge

Landaeta (2008) define knowledge transfer as flow from project sources to project recipients, aiming to improve performance and capabilities. He further states that knowledge is one of the strongest competitive advantages in the modern market, consequently is the management of organizational knowledge a vital organizational capability. Not having key knowledge in a project makes the project incapable of accomplish its objectives without running into problems and even crisis (ibid.). Repenning et al. (2001) make it clear that lack of knowledge capability also can create problem at the project-based organizational level. An example mentioned is the emergence of persistence of firefighting in project-based organizations. Project managers, site managers and senior managers have to focus on making projects more skilled in eradicate uncertainty and reduce ambiguity. It is a contradiction for the project organization that they face knowledge needs in their projects, and not being able enhances the opportunity to use existing knowledge of their other projects (Landaeta 2008). Many questions remain unanswered in how to promote learning by managing knowledge in the project-based organization. Much has been written in the subject but there few empirical data of knowledge transfer across different projects (Landaeta 2008). Blomé (2004), states that problem with gaining a good transfer of knowledge is linked with mistakes made and personal prestige of the employees. Landaeta (2008) also states problems and pitfalls with transfer of knowledge, one is that the transfer of knowledge can become huge and not possible to overlook. This can be done by assigning a small group of project members to put forth a high effort of knowledge transfer from other projects.

The contractors often deal with maintaining a stable organization which can be hard since construction jobs are short term projects. This undermines the possibility to improve productivity by learning from earlier mistakes (Cottrell 2006). A part of a report written by Josephson et al. (2008) concerns the unfamiliarity of talking about learning in the construction sector. The difficulty seems to be mostly with the contractors on the field. In their report the question was asked if there is some transfer of knowledge from the past projects and the consistently answer was that they couldnõt bear in mind something specific. From the report also emerge quotes on project uniqueness, this is interpreted by Josephson et al. (2008) to be used as an excuse why the transfer of knowledge is underdeveloped.

Landaeta (2008) concludes that the body of knowledge obtained from other projects is positively associated with project performance. Further results verify that the level of knowledge transfer across projects is connected with increase in the capabilities and performance, if it is effective. Kotnour (2000) suggests creating a framework for project learning that can help project-based organizations to benefit from their knowledge.

2.3 Standardized decision process

The first thing to embark on in management practice is personnel functions and personnel information needs. This is because of a manager will not be able to perform his or her functions effective if there is no information to base decisions on(Kwaku & Tenah 1986). Even though this is well known in the sector it is still not emphasized, leading to lack of information regarding functions, responsibilities and information needs to construction management (ibid.). The construction industry constantly search for higher quality requirements, tighten schedules and pressured labor shortages. One way to achieve this is to standardize processes to achieve a higher control over the production process (Hsieh, 1997). As in all standardization there is several opportunities for cost savings, this also includes the process of decision-making (Gibb 1999).

Artificial intelligence is one way of standardize the process of decisions and it has been considered to offer many benefits in progress of reaching the project aim. Examples that Al-Jibouri and Mawdesley (2000) bring up is the importance to know how the information flows and what dependencies exist when striving towards the project goals. If the information flow is understood and monitored, it can be assured that right people receive the right information at the right time. Schaefer (1993) has in his research developed methods to inventory experiences. It is based on a guide to create discussion on who learned what and to who it might be of importance to. Laufer & Tucker (1987) conclude that one of the major flaws is when all attention is put on making proper decision-making instead of controlling the necessary steps prior. If planning, is to become more effective should methods change and assumptions be modified. With todayõs possibilities to construct advanced computerized knowledge-based systems creates opportunities to take action against repeating past mistakes (ibid.).

3 Method

The result and conclusion reported in this study are drawn from a benchmarking of three methods of producing self-contained timber houses. All these methods are considered being among the focal ways of producing these type of products. Three projects are chosen as cases for the analysis. They demonstrate similarities in attribute and are produced by the same company and during the same time period.

The field of subject in the literature review focuses on the importance of making good decisions in the early project phase, this involves selecting production process. Decision making includes several different aspects, this review look into how transfer of knowledge, standardization of decision and risk management can affect and improve this process. When the literature study was completed, three field studies were performed on sites where the investigated production methods were used. Each visit lasted from three to five days. During the site visits formal interviews, informal interviews and informal meetings were performed. When all data was collected and mapped, started a process of finding a method to analyze and compare the production methods. A conclusion was drawn that the best way was to develop a model that data and aspects regarding risks could be assembled in. Finally, an analysis was made of where and when these three production methods are most suitable to use.

In the literature review was the theory that affects the process of selecting production methods studied. Before the review, the field of subjects was chosen, based on the knowledge paradox. Both literature and articles has been used in the study. The review took its base in exploring how the effects of the knowledge paradox can be mitigated.

Six formal interviews were made, two on each project. These were done with the site managers and project managers. The questions concerned the process of risk assessment and were intended to uncover how risks were handled. The interviews were performed with the ñstructured methodò, according to Lantz (2007), meaning that the questions take aim in to seize the intervieweeôs opinion and experience of known phenomenaôs and getting answers that is easy to compare. All formal interviews were tape recorded in order to reassure that all information is captured and interpreted correctly. Five informal interviews were made, these interviews included question about costs to consider and the processes of the production methods. They can be seen as semi structured interviews with a precise question followed by discussions regarding the mention subjects (Lantz 2007). When visiting the construction sites we met craftsmen and the subcontractors and took the chance to talk to them about their views on the projects. This data made it possible to analyze and compare different answer to locate positive and negative aspects of the three production processes.

When the data collection was done, we began to develop a tool for calculating which production method is best under certain circumstances. The tool was set up in Microsoft excel with spreadsheets. First the data was formatted and organized, in the form of tables containing the calculus and matrices of the risks associated with each of the production methods. When the data was mapped, differences and similarities of the production methods were attributed to make it the comparison more accurate.

Features of the tool step by step:

1. *Define the project*
   Number of houses and the distance to the fabric were defined.
2. *Collecting and mapping economical data* ï
   Organizing and formatting data in matrices.
3. *Defining differences and similarities*
   Make the methods comparable.
4. *Risk analysis*
   Foresee risks and plan actions if problems occur.
5. *Decision based on model*
   All parameters is summarized and presented

4 Three production methods

Three ways of producing prefabricated residential buildings is the foundation of this study. All production methods are houses based on timber structures that are produced as elements. The methods are the most common when projects are carried out by large construction companies in Sweden. Other methods, such as framing is not encapsulated in the study.

Purchasing product from subcontractor. There are several companies specialized in prefabrication of elements for housing projects. These companies already have methods and organizations to produce elements in a competitive price and with a high standard. The specialized company will gain profit from the job and this will become a cost for the contractor, in other hand the method can save time and decrease risks. There is a political issue to purchase complete elements from another company regarding allocation of manpower. If the workload is high the organization can increase productivity by outsourcing and in financial recessions more work-hours need to stay in the organization. In this production method the contractor has the lowest risk because the risk is transferred to the subcontractor. In many regions this method is regarded as the best one and many managers like it because of practical reasons but craftsman generally disagree because they seek the chance for imbedding when producing the elements themselves.

In-door fabrication presents a unique situation. Some of the large construction companies already own facilities used to prefabricate residential houses in the 70-80s. Using this method creates a chance of control over the process and quality of the product. The climate and the working environment in a factory have the possibility to be optimal, which creates opportunities to increase the quality of the elements and the health of the workers. The down sides are the cost linked to owner of and maintain a factory. Transportation plays a bigger part in the estimation of the projects overall budget and the location of the factory to a wider range of possible projects with cost benefits. A startup of a factory is a risky procedure. However, the risks will decrease along time when the method is developed and the craftsmen are getting more familiar with the process. It will always be a more risky method than purchasing product from subcontractor since more operations are included in the own organization (transportation etc.).

Industrial manner on site often occurs as tents that work as a shelter from bad weather conditions. The method implies that the elements are produced on site in a close range to the place for assembly. Tools and methods used can be compared with the production in an indoor factoy. Benefits of manufacturing on site are literally the short distance of communication which creates a better flexibility and control of the production. The size of the elements is limited due to the regulations for transportation. This creates the opportunity to optimize the size of the elements compared to in-door manufacturing. Transportation of elements is dealt with on site and manages by the site managers which creates control but also a higher workload. This method is common in lager housing projects due to the cost for assembling the factory. The risk can defines as high because of the many uncertainties. The weather shelter is not optimal and the new startup phase can affect the productivity in the beginning.

5 Result

The result summarized in Figure 2 reflects an average house project carried out by one of the major contractors in Sweden. It is based on a tool that was developed from data collected during formal and informal interviews as well as informal conversations with project participants. The base of information used in the tool is within the economical domain and were perceived from the contractor. In addition to the process of making decision are aspects of risk management, transfer of knowledge and standardized decision processes included. Results based on these aspects were gained by interviews. Based on the figure, contractors can chose the most appropriate production method. The figure gives information of when it is most favorable to use a certain method depending on the number of houses and the distance from the factory to the site. The Y-axle represents the relative cost. Complementary to the graph has a table been set out to clarify the break-even point on the graph (Table 1). The maximum distance to transport the elements presented is 150 km. This is because long transportation creates dilemmas like drivers need for rest, therefore the transportation is limited to be done during one day.

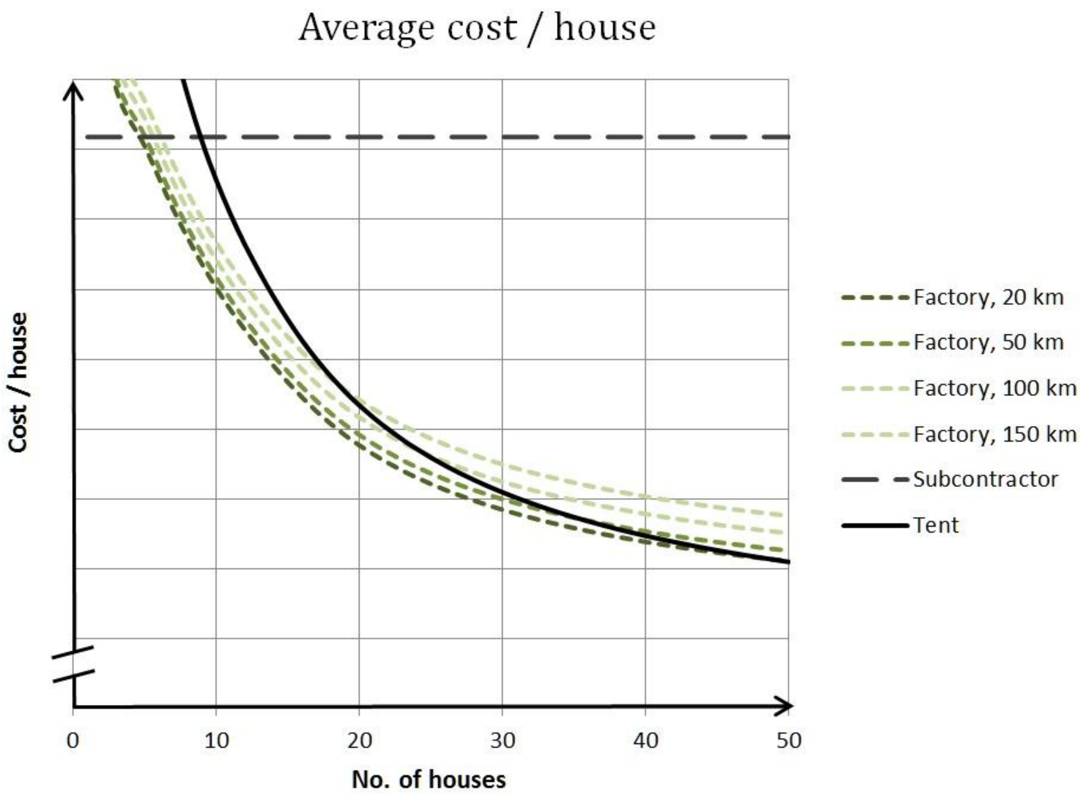

Figure 2. Production costs per house when using different production methods related to distance.

Table 1. Number of houses related to method and distance

	Distance			
Production-method	20 km	50 km	100 km	150km
Purch. from sub-c.	1-4	1-5	1-5	1-6
In-door fabrication	5-48	6-35	6-24	7-18
Ind. manner on site	49-∞	36-∞	25-∞	19-∞

Table 2. Main risks for presented production methods.

	Production methods		
	Purch. from sub-c.	In-door fabrication	Ind. manner on site
Evaluation of major risks	Decreased control over production Contractual risks (Sub.-c. violate contract) Loss of knowledge and development	Ownership and maintenance of factory Complicated transports Communication problem between site and factory	Assembling and demolotion of field factory Influence of Weather conditions Complicated location of constrcution site
Opportunities for Transfer of knowledge	Incompleted chain of knowledge in own organization	Good possibilty of evaluation of and retaining knowledge	Direct feedback, ocular distance to result
Opportunities for standardization of decision process	Establish coopoeration with subcontractor	Own labor force and a familiar management	All decsionson site, fragmentation of organization hinder standardization

Purchasing product from subcontractor is most favorable in projects between 1 to 6 houses, based on economical and risk aspects. This method creates a great opportunity to increase the production level without employing new craftsmen, creating an opportunity to bid on projects even if the work force is engaged elsewhere. On the other hand, experienced workforce might be lost in recession times since the method requires fewer personnel within the organization. If not the whole process is held within the organization, quality can be affected negatively since the transfer of knowledge will decrease.

In-door fabrication is most beneficial to use in projects when the distance is 20 km and the project size is 5 to 48 houses. Project size will decrease in correlation with the distance. When distance is 150 km will the project size be 7 to 18 houses. This size encapsulates most of todayĝs projects were residential areas are built. Control over the whole production process creates a possibility to monitor and respond to risk in totally different way compared purchasing from subcontractor. Since the organization gets more experience when using this method will the opportunity of transfer of knowledge be higher.

Industrial manner on site is favorable in projects with 49 or more houses when the distance is 20 km. This number decreases along with increase of distance. When the distance is 150 km, it will be most gainful to use this method down to 20 houses. Flexibility in the process is gained by decreasing coordination between factory and site. There is always a risk by erecting a factory on site due to different aspects such as weather and the assembly and demolition of temporary factory. The project process is easier to manage and most transportation is terminated.

6 Discussion

The result shows that an increased standardization in the decision-making process has a potential to benefit the contractors in the long term. Though, it is crucial that information is added continuously since it will be the foundation for selecting production method in upcoming projects.

The result shown when applying the tool developed as part of the research clearly indicates when it is most gainful to use a certain method. It also presents an opportunity for the contractors to use the factory in a wider range than it is used today. However, it is impossible to present exact results when it is most profitable to a specific type of production method. The limits are unclear so the need of consider other aspects is necessary.

When investigating the potential market the factory has, it indicates that there is a great potential for using it. The result shows that if the factory is used as today, a project in the size between 6 to 35 houses within a distance of 50 km will be the most gainful production method to use. This gives the factory a potential for a market where it lives approximately 135 000 inhabitants. If further rationalization of the factory is done, which should be possible since the factory is a method that is reborn for constructing self-contained houses. Looking at it in this perspective, there is an even larger potential market for the factory. If the production flow can be kept as low as in the last houses in the projects examined, it would be profitable to produce a greater span of projects, both in size and distance (Table 3). This means that the potential market for the factory within a distance of 100 km would embrace an area where it lives approximately 325 000 inhabitants. However, there is a high uncertainty in this prognosis. More projects needs to be executed with this tool to state this with better accuracy.

Table 3. *Prognosis of number of houses related to method and distance*

	Distance			
Production-method	20 km	50 km	100 km	150km
Purch. from sub-c.	-	-	-	-
In-door fabrication	1-51	1-38	1-27	1-21
Ind. manner on site	52-∞	39-∞	28-∞	22-∞

The study seeks the possibility to give a foundation to contractors in their selection of production method. The application presented in this paper indicates that there is an opportunity to improve the selection process by using a system to collect and analyze data. The process of making decision includes a never ending number of in data to consider. Focus in the tool was on how to make it possible to get an overview and compile all data that is needed to be considered in this phase. Risks of taking decision in the momentum will decrease since the tool will not provide an answer unless all data is registered in the tool. It is also shown that it is a possibility by using this tool to flatten the curves in the knowledge paradox (see Figure 1), giving an increased knowledge in this phase of a project. In the phase when this study was introduced into the project, the management still was uncertain if they had used the right production method. It can be seen as quite remarkable since the project was in the middle of its execution. This further strengthens the need of this investigation.

It is complicated to compare the result gained in this study to other studies, since it focuses on a specific case. Nevertheless, Grönhaug & Kollveit (2004), Bertelsen (2004), Cottrell (2006), Schaefer (1993) and Landaeta (2008) indicate similar needs of improve decisions making mainly by study the process and training of management. This study focuses on creating a base of knowledge that standardizes the procedure when selecting production method. Both are of course important and closely related to each other. Still, this paper promotes the importance of having a clear way of working in the management. Therefore is this tool is seen as an option. The project management paves the way for the outcome of a project by creating a climate where information can flow between and within the projects. Indeed, individual experience and performance of the site manager will have an important role to play. However, by not sharing the knowledge the opportunity to improve the process of selecting the right production method will decrease.

The possibility of creating a tool for decision making is proven by this study. Although only to rely on the result gained from a tool wouldnꞌt be enough when taking decisions since it is hard to state that one method is better than another. Many times the financial figure doesnꞌt pin point an exact indication, so other parameters will become conclusive. The money that can be saved in one method has to be compared with the increased risk and the allocation of manpower when selecting a specific method. The tool used here can only indicate a point of direction but it will never be able to replace the experience and the instinctive feeling that good project management posses. Further limitation is the short time to develop and validate a tool of this type.

7 Conclusion

In this paper it is argued that the application of an experience-based tool would be useful to improve process of selecting production method when constructing self-contained timber houses. Standardized ways of working is helpful for the project management to get an overview of the parameters in the process of decisions. Indications of this study state that a tool based on the aspects in the paper would improve the selection production methods. However, this tool needs to be further developed to increase the reliability. It is clear that different productions methods are profitable in different project sizes. In the studied case presented in the result, small project in the range between 1 to 4 houses it is most beneficial to use sub-contractor, depending on the location of the site (in this case within 20 km from the factory). The factory is most favorable to use in the range of 5 to 48 houses. Industrial manner on site should only be used when project is in size of 49 or more houses. The tool also shows that in certain occasions there is a fuzzy limit between which production methods that is most economical favorable to use. When this occurs, other aspects need to be considered and a long-term commitment on a certain method might be the best solution.

According to Grönhaug & Kollveit (2004) in comparison to the level of accumulated knowledge within fields of work processes, little concerns has been shown on the importance of improving the processes made when making a decision. Expanded understanding of this process is one key in illuminating why some projects fail in the execution phase and thereby decrease the project value. The model in this paper shows the opportunity to improve the process when selecting production method, going from decision made in momentum to more rationalized decisions.

The conclusion in this paper need to be reinforced by future empirical and theoretical works addressing other aspects than dealt with here. Though this study provides a premise for reasoning and results, it is suggested that further research is clearly necessary to examine the practical implications of the arguments in different work settings. It would be interesting to generate more developed and precise tools to support the decision-making process.

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