Towards Partnerships in Industrialized Housing

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The purpose of this thesis is to describe and analyse purchasing strategies and their interdependence with the production process and supplier relationships in industrialized housing. The thesis is a multiple case study of four Swedish industrialized timber-housing manufacturers. The case studies included interviews with top managers concerning purchasing, production and supplier relationships. Production is considered the heart of the company. Therefore, to gain an in-depth knowledge of how production affects purchasing and thus supplier relationships and vice versa, observations were made to study the production process. Many different parts and competences need to be coordinated in the creation of a house. In the West, the construction industry has been heavily criticized for low efficiency and effectiveness. Conclusions from the case studies showed that co-development, customization and secure deliveries are regarded highly by industrial house builders and to obtain them, long-term relationships with suppliers are preferred. Industrialized house builders are argued to have more long-term relationships with their suppliers than traditional on-site builders. Industrial house builders choose their suppliers based on the purchased products’ value-in-production rather than price. Product and process innovations created in collaboration with suppliers seem to be a way to enhance the production process of houses. Through the site resource of the factory, industrial house builders have the potential to refine their processes in win-win partnerships with suppliers for a more efficient and effective production of houses, as onsite work is harder to standardize and control.
ACKNOWLEDGEMENTS

This thesis has been an exciting journey in my life. It has allowed me to discover the world of research and to meet people from many different places. I would like to thank my head supervisor Staffan Brege for giving me the opportunity to do this research. In particular, I would also like to thank my second supervisor Jakob Rehme, who has stood by me and supported me through the completion of this thesis and has reviewed everything I have written. I would like to give my deepest gratitude to Lars Stehn for taking me “under his wing” – without you this would not have been possible. Thank you also to Anders Björnfot for teaching me how to write papers and supporting me throughout my data collection, and Wayne Chan for correcting my English language. I would like to thank my pre-opponent Tomas Nord for reading the first draft and Roine Leiringer for being my final opponent at my licentiate seminar. I would like to thank all the companies for allowing me to interview them, in particular Lindbäcks Bygg. I also want to thank the Lean Wood Engineering programme for financing this project. Thanks to all my colleagues in Linköping and Luleå for a wonderful time at work and our many laughs. Finally, I would like to thank my friends and family for their support and cheerfulness.

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Louise Bildsten
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1. INTRODUCTION

This chapter gives background to the research, the purpose and research questions, the disposition of the thesis, and which papers are included.

1.1 Background

The construction industry has been heavily criticized by governmental reports in Sweden (SOU 2000:44; SOU 2002:115; SOU 2009:6) and in the UK (Latham, 1994; Egan, 1998; Strategic Forum, 2002) for having lower growth in productivity levels than other industries. Numerous authors claim that the supply of materials needs to be handled better to improve productivity levels (Egan, 1998; Dubois and Gadde, 2000; Vrijhoef & Koskela, 2000; Cox & Ireland, 2001; Love et al., 2004; and Briscoe & Dainty, 2005). The problems in the supply chain of the construction industry are argued to depend on the complexity of each project (Gidado, 1996; Winch 1998), unstable demand of construction projects (Segerstedt & Olofsson, 2010), uniqueness of each project (Eccles, 1981; Dubois & Gadde, 2000; Bertelsen, 2004), fragmentation of the industry (Dainty et al., 2001a, b) and short-sighted relationships with suppliers (Dubois & Gadde, 2000; 2002; Gadde & Dubois, 2010). To improve the supply chain in construction, closer and more long-term relationships with suppliers in the form of partnerships are suggested (Latham, 1994; Egan, 1998; Strategic Forum, 2002). For a long time, strategic purchasing involving close and long-term relationships with suppliers were argued to create better efficiency and effectiveness in the manufacturing industry (Frazier et al. 1988; Womack et al., 1990; Lamming, 1993; Morgan & Hunt, 1994; Hines, 1994; 1996; 2000; 2004; Van Weele,
2008). However, standardized processes in a factory characterize the manufacturing industry whereas the construction industry typically consists of one-off projects in different places, that complicate the supply chain. Each project places specific demands on supply chain and logistics (Eccles, 1981; Cox & Thompsson, 1997; Dubois & Gadde, 2000; Håkansson & Jahre, 2005; Bygballe & Jahre, 2009). The industrialized housing concept, i.e. the assembly of houses through factory-produced house components, is a way to simplify the supply chain through a more standardized production process (Gann, 1996; Gibb & Isack, 2003; Lessing et al. 2005; Vordijk and Mejboom, 2006). A standardized production process leads to more standardized and regular purchasing processes. However, industrialized house builders still buy much of their materials on a project-basis (Lessing et al., 2005). Moreover, house components are made of many different parts, some of which still needs to be installed separately on-site depending on the level of prefabrication. This leads to both complexity and waste within the production process, and in the seam between purchasing and production, which in the end also affects the assembly (Sandberg & Bildsten, 2011). Therefore, industrial house builders would have the potentials to benefit from more developed relationships with suppliers that offer innovative components (MacDuffie & Helper, 1997; Koskela & Vrijhoef, 2001; Van Weele, 2008). The innovative components would be in the form of sub-systems (Davies et al., 2001; Davies, 2004; Brady et al., 2005; Davies et al., 2007) to decrease the complexity in the production process (Håkansson, 1982; Womack et al., 1990; 1993; Lamming, 1993; Olivia & Kallenberg, 2003; Van Weele, 2008). Industrialized housing, as the process owner from design to finished product, would then act as a central coordinator, i.e. “system integrator” (Davies et al., 2001; Davies, 2004; Brady et al., 2005; Davies et al., 2007), not only for the partners, but also for the house components. This licentiate thesis discusses the interdependence between supplier relationships, purchasing and production in industrialized housing and the possibility to move towards partnerships with suppliers.
1.2 Purpose & research questions

The purpose of this thesis is to describe and analyse the purchasing strategies and their interdependence with the production process and supplier relationships in industrialized housing.

The first research question aims to map the research context. To create new paths in the area, know how things presently work is necessary. Therefore, to understand how industrial timber housing is concerned with purchasing and production, the first research question is as follows:

**RQ 1: What are the purchasing strategies and what is the production process in industrialized timber housing?**

The second research question aims to enable a deeper understanding of underlying relationships and causes in the purchasing behaviour of industrialized timber housing. Therefore, the next question aims to further understand the reasons behind the house builders’ purchasing strategies:

**RQ 2: Why do they purchase the way they do?**

The third question aims to clarify the interrelation between supplier relationships, purchasing and production. Moreover, it aims to create some new ground in the context by asking how they possibly can interrelate differently to be more successful in terms of efficiency and quality. The third research question is therefore:

**RQ 3: How do supplier relationships, purchasing and production interrelate and how can they interrelate differently?**
1.3 Disposition and reading instructions

Chapter 1: Introduces the reader to the research area, presents the research motives, aim and research questions, and guides the reader through the disposition of the thesis.

Chapter 2: Presents the research process and the researchers’ background together with a description and discussion of the chosen methods. The background to the chosen theory in the appended papers and theoretical framework are also here explained.

Chapter 3: To facilitate the reader’s comprehension of the industry context, chapter 3 outlines a synthesized picture of the industrialized timber housing construction industry.

Chapter 4: Contains the theoretical framework and to serve as a basis for analysis of empirical results from the appended papers.

Chapter 5: Summarizes the empirical results and conclusions of the five papers.

Chapter 6: Presents cross-paper findings.

Chapter 7: Presents the conclusions, scientific and practical contributions and proposals for further research.
1.4 Appended Papers

**Paper I: Coordination and waste in the industrialised building concept**

Erik Sandberg and Louise Bildsten wrote the paper published in the journal *Construction Innovation*. Both authors were planned, performed and evaluated the case study. Erik Sandberg outlined the first manuscript, and Louise Bildsten and Erik Sandberg finished it.

**Paper II: Value-driven Purchasing of Kitchen Cabinets in Industrialized Housing**

Louise Bildsten, Anders Björnfot and Erik Sandberg wrote the paper. It was first presented at the 18th Annual Conference on Lean Construction (IGLC-18), Haifa, Israel, 2010, under the name of “Value-driven vs Market-driven Purchasing of Kitchen Cabinets”. It was selected one of the best papers at the conference and later published in the *Journal of Financial Management of Property and Construction* under the name of “Value-driven Purchasing of Kitchen Cabinets in Industrialized Housing”. The editors were Christine Pasquire and Glenn Ballard. Louise Bildsten’s contribution to the paper was planning, performing and evaluating the case study. All authors contributed to the fundamental ideas and the Louise Bildsten and Anders Björnfot completed the paper.

**Paper III: Purchasing Strategies in Industrialized Housing- a Multiple Case Study**

Louise Bildsten, Jakob Rehme and Staffan Brege were the authors. An early version was presented at the Annual Research Construction Management Conference in Leeds, United Kingdom, 2010 under the name of “Applying the Kraljic-Model to the construction Sector – the Case of a Prefab Housing
Factory”. After, it was expanded on with more cases and theory and renamed to “Purchasing Strategies in Industrialized Housing – a Multiple Case Study. Louise Bildsten and Jakob Rehme planned, performed and evaluated the case study. All authors contributed to fundamental ideas for the paper. Louise Bildsten outlined the first manuscript, Jakob Rehme and Staffan Brege examined it, and Louise Bildsten finished it.

**Paper IV: The Study of a Kitchen Assembly Process in Industrial Housing**

Louise Bildsten and Wei Guan wrote the paper, which has been accepted for the 6th Nordic Conference of Construction Economics and Organization in Copenhagen, Denmark. Louise Bildsten’s contribution to the paper was planning, performing and evaluating the case study. Both authors contributed to fundamental ideas for the paper.

**Paper V: Innovative House Components to Decrease Complexity**

Louise Bildsten and Wei Guan were the authors, and it has been submitted to the Conference of the International Group for Lean Construction in Lima, Peru. Louise Bildsten’s contribution to the paper was planning, performing and evaluating the case study, and writing the first draft. Louise Bildsten and Wei Guan completed the final draft.
1.5 Additional papers (not appended)


2. **METHOD**

This chapter presents the researcher’s background. Moreover, it describes the research strategy and design, literature studies, data collection, analysis of the data and an evaluation of the research process.

2.1 **Researcher’s background**

If two people with different backgrounds were to do the same study independently, the character of the study would most definitely be quite different (Meredith, 1998). Therefore, my background will be presented briefly. My master’s degree was in Industrial Engineering and Management at Linköping Institute of Technology, with a specialization in Industrial Marketing. After my degree, I began working with lean production management at an automobile supplier plant, where experience in the automobile industry gave me a practical understanding of the lean concept. Through this experience, I learned how to measure operation times and map process flows in a factory, which were helpful when conducting the fieldwork of measuring operation times in an industrialized housing factory. I have no previous experience in the construction industry, which means I may look upon my research task differently than a construction engineer. The process of making this licentiate thesis has been a learning process for me as a researcher. My personal belief is that it is important to have a broad view before narrowing down to get an enhanced understanding and holistic analysis of the research in its context. Until now, I have studied various courses such as “timber engineering”, “parametric design”, “marketing and logistics”, “service marketing”, “value stream mapping”, “lean production”,

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“purchasing management” and “research methods”. Moreover, I have presented my research at two international conferences; the Conference of the Association of Researcher’s in Construction Management (ARCOM) at Leeds in the United Kingdom, 2010, and the Conference of the International Group for Lean Construction (IGLC) at Haifa in Israel, 2010.

2.2 Research strategy and design

A research strategy with case studies was chosen to maximise the closeness to empirics and to analyse the companies holistically. A case study is a type of research methodology that is based on an in-depth investigation of a single individual, group, or event (Yin, 2007). Here, the units of analysis were industrialized house construction companies. The case companies were chosen because they are the largest and most advanced industrialized multi-storey timber housing manufacturers in Sweden. Merriam (1994) recommends the case study approach, when solving a problem that requires a profound knowledge of its context and practice. To get a deep understanding of purchasing strategies in industrialized timber housing and their impact on the production process, case studies seemed to be the ultimate choice. Yin (2007) argues that a case study is a suitable research strategy for “how” and “why” questions of explaining character.

Multiple-case study

The whole thesis including all the papers can be classified as a multiple case study. A multiple-case study is advantageous, since it can high-light complementary aspects that otherwise could have been overlooked (Eisenhardt, 1989; Yin, 2007). Hence, the cases in each of the papers contribute with different input as pieces of a puzzle-solving analysis (Yin, 2007).
Explorative, descriptive and explanatory studies

According to Yin (2007), three different types of case studies exist: explorative, descriptive and explanatory. Explorative is typically the first phase of the research process to create an understanding. Descriptive studies describe the phenomenon as it is; explanatory case studies search for causation to find underlying principles. The first two papers had an explorative approach, and the next three were more descriptive and explanatory. The thesis as a whole, including the cover paper and all appended papers, can be viewed as descriptive and explanatory. It is descriptive to answer RQ1: “What are the purchasing strategies and what is the production process in industrialized housing?” and explanatory to answer to RQ2: “Why do they purchase the way they do?” and RQ3: “How does supplier relations, purchasing and production interrelate and how could they interrelate differently?” The “what?” question is largely based on Paper III, a multiple case study of three companies, but can also be seen as a survey study of different ways to purchase materials within the three studied case companies.

Qualitative and quantitative studies

A study can be either qualitative or quantitative (Lekwall & Wahlbin, 2001). Qualitative methods are suitable when studying a phenomenon in its natural context, aiming for rich (detailed and thorough) descriptions of the phenomenon and a deeper understanding of underlying or ambiguous elements (Miles & Huberman, 1994). Quantitative methods are data collections of numeric formats that are analysed with mathematic-statistic formulas. Usually, case studies are based on qualitative research, but in some cases quantitative data is also collected (Lekwall & Wahlbin, 2001). In this study, both qualitative and quantitative data were collected.

Iterative research

Miles & Huberman (2003) argue that iterative processes are expected in qualitative studies, which proved to be true in the collection of data for these
The “Why?” questions always made me dig deeper to gain a further understanding. Ohno (1988) talks about this in the concept of lean as a method to find the root cause of a phenomenon.

**Inductive, deductive or abductive?**

A study can be inductive, deductive or abductive (Alvesson & Sköldberg, 1994). Inductive research means to develop theory from empirics; and deductive research means to prove a theory in an empirical study. Abductive is a combination of inductive and deductive research and means to go back and forth between theory and empirics (Alvesson & Sköldberg, 1994). This study can be categorized as abductive research, since the need for theory developed during the empirical data collection and vice versa (Dubois & Gadde, 2002). In the next two sections, Chapters 2.3 and 2.4, the studies of theory (literature) and empirics (data collection) are further explained.

**2.3 Literature studies**

In the search for appropriate theories to refer, relate and reflect to the empirical findings and research context, literature was studied throughout the entire research process. To find the appropriate literature, discussions were made with supervisors, colleagues and teachers at Ph.D. courses, colleagues in the Lean Wood Engineering (LWE) research team and researchers at the ARCOM and IGLC conferences. Much literature was also found through Internet searches using various keywords that relate to purchasing strategies. When an interesting paper was found, the references of that paper led to other papers in the form of the so-called snowballing effect. The scope of the thesis then emerged to be the interdependence between supplier relationships, purchasing and production (See Figure 1).

![Image of a diagram showing the theoretical field of supplier relationships, purchasing, and production.](image-url)
2.4 Data collection

There are many ways to collect data. Yin (2007) states six commonly used methods of data collection: personal notes, archival data, interviews, direct observations, participating observations and physical artefacts. However, Yin (2007) argues that this is not a complete list and numerous of other ways of collecting data exist. In this study, all six of Yin’s (2007) data collection methods were used as well as a seventh, i.e. workshops. The data collection conducted in each specific paper is found in Table 1.

Table 1: Data collection methods for the Papers

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<td>Personal notes</td>
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<tr>
<td>Archival data</td>
<td>-</td>
<td>Drawings and production planning lists</td>
<td>Company’s accounts</td>
<td>Drawings and production planning lists</td>
<td>Drawings and production planning lists</td>
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<tr>
<td>Interviews</td>
<td>Fifteen semi-structured</td>
<td>Ten semi-structured</td>
<td>Three semi-structured</td>
<td>Ten semi-structured</td>
<td>Five semi-structured</td>
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<td>Workshops</td>
<td>-</td>
<td>Yes, two at the housing manufacturer</td>
<td>-</td>
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<td>Direct observations</td>
<td>The kitchen assembly line</td>
<td>The kitchen assembly line</td>
<td>-</td>
<td>The kitchen assembly line</td>
<td>The kitchen &amp; bathroom assembly line</td>
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<tr>
<td>Participant observations</td>
<td>-</td>
<td>Purchasing &amp; lean manager</td>
<td>-</td>
<td>Purchasing &amp; lean manager</td>
<td>Purchasing &amp; lean manager</td>
</tr>
<tr>
<td>Physical artefacts</td>
<td>Volume elements</td>
<td>Kitchen cabinets</td>
<td>Building materials</td>
<td>Kitchens cabinets</td>
<td>Kitchen &amp; Bathrooms</td>
</tr>
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The following sub-sections detail the different data collections methods in Table 1, used in the different papers.
**Personal notes**

Written sources in the form of documents, such as letters, meeting minutes, previous studies relating to the subject of investigation and newspaper articles, are always relevant in case studies (Yin, 2007). However, these kinds of sources are considered less predictive, as they are typically secondary sources (Ibid.). Therefore, these sources should be regarded more as “clues” rather than final conclusions (Ibid.). Previously written reports and investigations on the case companies were therefore read and verified through personal observations, interviews, or both. Personal notes were constantly taken during the visits at the case companies. Not taking of all impressions, meetings and conversations was an important part of the research to remember all information and pin-point what was important. These notes can be regarded as rather predictive because they were made by me as a researcher. Previous studies of the same companies and industry was also read.

**Archival data**

Archival data can sometimes be relevant in case studies (Yin, 2007). Yin (2007) points out that it is important to consider how the data was created. Examples of archival data are maps, registers and organisation charts (Ibid.). The archival data that was studied involved the case companies’ documents including drawings, sales offers and account information.

**Interviews**

Yin (2007) argues that interviews are the most important source of information in case studies. Interviews were conducted for the collection of empirics for all four papers. Different methods concerning how interviews should be conducted exist. In case studies, interviews are typically not as strictly structured as in survey studies and are often more of a flexible and less rigid character. All interviews were semi-structured interviews (Rubin & Rubin, 1995; Yin, 2007).
Workshops

Lekvall & Wahlbin (2001) argue that focus group interviews, e.g. workshops, are fruitful in achieving a deep understanding of a narrow area. A focus group interview is a more or less free group discussion led by an interview leader (Lekvall & Wahlbin, 2001). For the second and fourth papers, two workshops were conducted with the purchasing manager, lean coordinator, two representatives from the local cabinet supplier and two university colleagues. The first focus group interview was a discussion about setting the targets for the investigation. The second focus interview was an open discussion about the cycle times and detailed descriptions of the steps involved in kitchen installation with a discussion of the results.

Direct observations

Direct observations are carried out through visits for example, to a factory and observing their work (Lekvall & Wahlbin, 2001). In this study, direct observations were an important part of the data collection because they constituted a significant amount of the entire data collection for the study and formed the empirical basis for the first, second, fourth and fifth papers. During the direct observations, the activities in the factory on the shop floor of both industrialized housing factories were observed. For the second, fourth and fifth papers, the kitchen installations operation were studied in detail concerning each step of the procedure and the cycle time for each step. This observation was a structured observation because schedules were drawn in advance on how to register the phenomena (Lekvall & Wahlbin 2001). The schedules were in fact value stream mapping diagrams, designed according to the methodology described in Rother & Shook (2001). These diagrams were to be completed with the measured cycle time for each of the installation steps as well as the intermediate waiting time periods. Lekwall & Wahlbin (2001) also describes observations as open (people know they are being observed) or hidden (people do not know they are being observed). In this study all observations were open.
Participant observation (Action research)

Participant observation is to actually participate in the studied environment, such as an employee in a company (Lekvall & Wahlbin, 2001). Participant observation is also sometimes called action research and is often done to study a current situation to improve it. The approach can also be used to reproduce something that has been proven to work elsewhere. A typical characteristic of action research is the self-involvement of the researcher in the studied environment (Mckay & Marshall, 2001). Action research implies both contributing to common knowledge, while acting as a problem-solver for the case company (Kock et al., 1997). In the studies for the second, fourth and fifth papers, the visits to the factory lasted four months on an almost daily basis, with me as a researcher participating in meetings with the management staff at the company, i.e. it was like being employed within the company and it can therefore be regarded as a participant observation. It made me as a researcher part of the research context by collaborating with the management team in the data collection process.

2.5 Analysis of the cases

The cases were analysed through pattern matching (Yin, 2007). Pattern matching is a type of analysis that matches empirical findings with theoretical propositions. There is a special type of pattern matching referred to as explanation building, which is a way to find an explanation to the case itself rather than follow already set explanations. This study can be seen as both a matching to existing theories and a modification of these theories to explain the phenomenon found in the studied cases. The purchasing strategies and production of the four different companies were investigated to describe and relate them to existing theories.

2.6 Evaluation of the research process

To ensure “accuracy” and “goodness” of the research, one must carefully evaluate the research regarding the data collection method and analysis of
data (Kirk & Miller 1986). The researcher should continuously critically evaluate the quality of research (Ibid.). Generally, there are two aspects to consider when evaluating a research process: reliability and validity (Denzin & Lincoln, 1994; Yin, 2007). Reliability evaluates the resistance of influences of various interfering aspects during the measurement (Lekvall & Wahlbin, 2001). Validity evaluates if the method really measures what it is intended to measure (Ibid.). There are three main kinds of validity: construct validity, internal validity, and external validity (Denzin & Lincoln, 1994; Yin, 2007).

**Reliability**

As previously mentioned reliability is the ability of the methods to be repeated and give the same results, while resisting influences from interfering aspects (Lekvall & Wahlbin, 2001; Yin, 2007). The test-retest method can be used to ensure reliability, repeating the same test over and over on the same person. The method must therefore be resistant to interfering coincidences, e.g. researcher’s or interviewee’s physical health (Lekvall & Wahlbin, 2001). By recording and transcribing the interview in the first paper, the interview gained a high reliability. The notes were then unaffected by surrounding circumstances and the recording prevented errors in interpreting the interviewee. By measuring the same carpenter repeat the same exact procedure over and over again, reliability was also ensured in the second, fourth and fifth papers. Test-retest was also made by interviewing the same person on several occasions with the same questions concerning the third paper.

**Construct validity**

Construct validity is defined as having the correct measures for a studied concept (Yin, 2007). To ensure construct validity, the tool of measurement, e.g. a questionnaire, can be pre-tested before the actual study. This way, the questionnaire can be altered to measure what is intended. This was done to ensure the quality of the structured interviews for the third paper. Another way of testing the method, i.e. measuring the construct validity, is data
triangulation (Denzin, 1994). Data triangulation implies using different kinds of data collection methods, sources, researchers, theories or a combination thereof to ensure that the data coincides towards the same result (Denzin, 2006). By collecting data through different methods and sources, as described in Table 1, data triangulation regarding the use of different methods and sources was practised to improve construct validity. Through discussions with researchers in the field and the snowballing effect, while conducting literature searches, to the author’s knowledge, relevant theories were considered for construct validity through theory triangulation. Construct validity can also be increased by letting key informants review the collected material. The interviews for all five papers were reviewed by letting the respondents read the result of the interviews.

**Internal validity**
Internal validity is an estimate of the degree to which conclusions about causal relationships can be made based on the research design (Eisenhardt, 1989; Yin, 2007). This is typically only important when trying to answer “why” questions (Eisenhardt, 1989), which is not a research question of this study. However, to understand what the source of the problems is and how to solve it, the relationship between cause and effect is relevant. Hence, for my own understanding of the research context and theories, the “why” question was frequently asked during the process and answered by multiple reliable written sources as well as researchers and industry professionals.

**External validity**
External validity is the degree of certainty concerning the extent of which the findings of the study can be generalized to a wider group of situations (Yin, 2007). Moreover, external validity indicates how well the theory coincides with empirical data (Grönfors, 1982). A criticism of case studies is that it is hard to generalize one case to another, as every process is unique in its context (Yin, 2007). Similarly, Kock et al. (1997) argue that action research is often questioned on the basis of its external validity because it is difficult
to generalise the findings. However, Svensson & Starrin (1996) argue that the theories presented from qualitative work can be applied to other situations of similar context. Svensson & Starrin (1996) also argue that parallel conclusions can be made with similar studies to strengthen the arguments. In the case studies of this thesis, theories previously tested in the manufacturing industry are applied to the context of industrialized housing, perhaps resulting in new practices in the industrialized housing industry. Generalization can then be made to other house construction companies with similar prerequisites. Further studies concerning the possibility of test-installation of a kitchen cabinet sub-system (Paper II) are necessary to strongly conclude whether or not such a solution would be successful. However, through studies of purchasing literature and lean production literature, it seems like a promising solution. The study of purchasing strategies of different products in Paper III is generalizable, since it is made through comparative studies of three house builders considered the main actors on the Swedish market for industrialized timber housing. Paper I, Paper IV and Paper V concerning process improvements can be generalized to the industrialized housing industry because the outcome was expected through comparison with studies in other companies and industries.
3. INDUSTRY CONTEXT: INDUSTRIALIZED TIMBER HOUSING

This chapter includes a brief history of industrialized timber housing, theoretical definitions of the concept, a description of the market in Sweden, advantages and disadvantages with timber, and different prefabrication methods.

3.1 Industrialized timber housing

Industrialised housing can be traced far back in history. The advantages of planning and control through prefabricated timber frame construction were discovered as early as the medieval times in the UK (Hairstans, 2010). Carpenters were then fabricating frames and joints in their backyards before transporting them to the construction site to ensure quality. The prefabricated timber construction system has been refined over the centuries, but was truly exploited in the 1830s by John Manning. A carpenter and builder from London, Manning developed a concept of timber housing sections that were fabricated in the UK and shipped to Australia (Ibid.).
Industrialized timber housing is a somewhat ambiguous concept with different interpretations of how it can be viewed. Two different perspectives are the product and the process view. This pattern of categorization can also be found in the theory of process and product perspective of technological innovations (Leiringer, 2003). The industrialized timber-housing concept is not a new innovation (Hairstans, 2010), but can be seen as a continuous innovation in development from both a process and product view. Hairstans (2010) and Höök & Stehn (2005) define industrialized housing from a product perspective in viewing how the building is made. However, there is no clear line of how large factory-made parts of the house should be to be called industrialized housing. Höök & Stehn (2005) describes industrialized housing as constituting the parts of the construction process in both how the product is made and in what environment it is made, See Figure 2.

![Figure 2: Different levels of prefabrication (Höök & Stehn, 2005, p. 319)](image)

In the model in Figure 2, Höök & Stehn (2005) distinguishes between three types of construction organisation: (1) On-site, (2) Panel and (3) Volume. In
these three types of organization, the point of where factory production ends and on-site production starts is different. Höök & Stehn (2005) view industrial housing as the product produced in a factory environment before transport to the construction site. Thus, industrial housing in an on-site organisation includes the fabrication of doors, windows, nails and sawn timber. In panel prefabrication, the houses are made by wall and floor elements, whereas in volume prefabrication, the floors and walls are assembled into three-dimensional volumes before leaving the factory. The point when the parts leave the factory to the final location of the house is referred to as the decoupling point. Höök & Stehn (2005) argue that this point is the most complex part of the process due to coordination issues. This point is clear in element prefabrication, whereas in on-site and volume element construction the point is unclear. Hairstans (2010) defines industrialized housing from a product view as the manufacturing and pre-assembly of components into elements or modules in a factory before erection at the construction site, which constitute the second and third steps in Höök & Stehn’s model (Figure 2).

Lessing et al. (2005) view industrialized housing from a process perspective, i.e. the entire process from design to finished building. The more industrialized the process, the higher level is the level of fulfilment of the eight characteristics that Lessing et al. (2005) identify as the concept of industrialized housing. These eight characteristics are: (1) The planning and control of processes, (2) Developed technical systems, (3) Off-site manufacturing of building parts, (4) Long-term relations with participants, (5) Supply chain management integrated with the construction process, (6) Customer focus, (7) Use of information and communication technology and (8) Systematic performance measure and reuse of experience; see Table 2.
Table 2: The industrialized housing concept (summarized from Lessing et al., 2005)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning and control of the processes</td>
<td>The design, production and assembly and other related processes are centrally coordinated by management to eliminate waste.</td>
</tr>
<tr>
<td>Developed technical systems</td>
<td>To facilitate production, there are standardized solutions that can be modified into unique houses. Examples of such solutions are frame solutions, electrical and sanitary installations and façade systems with varying levels of flexibility.</td>
</tr>
<tr>
<td>Off-site manufacturing of building parts</td>
<td>As large parts of the building as possible are fabricated in an environment suited for production with advanced equipment and good working conditions.</td>
</tr>
<tr>
<td>Long-term relations between participants</td>
<td>The designers and suppliers are engaged on a long-term basis with common goals and an established procedure to work together to minimize waste.</td>
</tr>
<tr>
<td>Supply chain management integrated in the construction process</td>
<td>There is one supply chain to the pre-assembly and one to the construction site. The pre-assembly requires supplier routines of material deliveries and the final assembly needs close relations for JIT delivery.</td>
</tr>
<tr>
<td>Customer focus</td>
<td>Focus on satisfying the customers’ needs in terms of right products at the right quality to the right cost.</td>
</tr>
<tr>
<td>Use of information and communication technology</td>
<td>Production process and information exchange should be supported by Information and Communication Tools (ICT-tools) to keep documents updated in order to avoid problems in production.</td>
</tr>
<tr>
<td>Systematic performance measure and re-use of experience</td>
<td>Improvement of methods and solutions in construction should be carried out through continuous measurements of soft and hard parameters.</td>
</tr>
</tbody>
</table>

Table 2 constitutes a summary of the eight characteristics by Lessing et al. (2005). The characteristics are only found partly in the industrialized housing in Sweden today (Ibid.). However, total fulfilment of the eight characteristics can be seen as a utopia of the future.
The definition of industrialized timber housing in this thesis is the fabrication of panels or volumes for erection at the construction site. In my view from a product perspective, the industrialized housing company is primarily responsible for the framing system, i.e. the house shell. All other parts, such as cabinets and sanitary goods, do not necessarily need to be included. The thesis is also limited to studying the factory process of the panels and volumes from input to output.

3.2 Industrialized timber housing market in Sweden

Timber housing has a long history in Sweden. For centuries, timber was the dominant housing material in many Swedish cities (Levander, 2010). However, this changed in the late 19th century due to large fires that swept over entire cities. As a consequence, the Swedish government prohibited the construction of multi-storey houses (more than 2 storeys) that were made of timber. The building regulations changed in 1994, and timber was allowed again (Sardén, 2005; Nord, 2008; Levander, 2010). This meant that almost all multi-storey houses of the past century were made of concrete. However, the industrialized timber housing industry of villas and vacation houses is well-developed, comprising 90% of the total Swedish market for single-family houses (Levander, 2010). Timber has been attributed many advantages compared to concrete (Stehn et al., 2008; Levander, 2010) because of its high strength combined with light-weight and ease in cutting and handling (Ibid.). Moreover, timber as a construction material has a lower environmental impact than the fabrication of concrete houses from a carbon dioxide emissions point of view (Gustavsson et al., 2006; Gustavsson & Sathre, 2006). The use of timber in multi-storey houses has increased and in 2008, according to Brege et al. (2004) and Stehn et al. (2008), had approximately 15% of the total multi-storey market. The development of industrialized timber housing has typically been driven by small companies (Levander, 2010).
3.3 Advantages with timber constructions

There are several advantages with the production process of timber houses compared to concrete houses. Stehn et al. (2008) describes these as the following:

**Lower shipping costs**
Timber frame constructions have low weight compared to concrete constructions, meaning much lower shipping costs and thus the possibility to reach a large market. For example, the maximum load on Swedish roads is 30 tons. This is equivalent to 65 square meters of concrete and 270 square meters of timber panels (massive wood) (Stehn et al., 2008).

**Lower costs for erection and assembly**
Prefabricated timber constructions can be erected with a normal crane for construction. A normal crane costs eight times less than a mobile crane for concrete constructions (Stehn et al., 2008). Further, Haller & Stehn (2010) argue that long erection times are costly and that prefabricated timber constructions can be erected quicker than most other kinds of constructions.

**Lower costs for changes and add-ons**
House plans are often distributed at an early stage to craftsmen, making changes inevitable. Moreover, an important competitive advantage is the ability to modify the house after completion, according to the wishes of different tenants. It costs ten times more to make a hole or saw in a concrete wall than in a wall made of wood. Furthermore, no special equipment or sub-contractors is needed to make holes in wood, which eliminates waiting times and disruptions.
Simplified service installations
Because of preinstalled pipes and electrical wires in the factory, the on-site service installation procedure is simplified. Only minor completions of connections are carried out on-site.

Elimination of drying costs
The cost of drying concrete constructions is usually referred to as an on-site cost, not included in the calculation of the house cost. When comparing a timber house project with a concrete house project, the erection time was 33% faster with timber due to the drying time of concrete. This equalled 4 weeks (160 hours) of additional on-site work for concrete. There are also extra costs of machinery and electricity for the drying procedure. The first two years also have an extra cost for heating due to moisture.

Possibility for construction at low temperatures
Timber construction is a convenient method during the winter because it does not require heating during construction. Concrete cannot support temperatures below -10 degrees Celsius. This implies pre-heating the concrete, and heating cables must be moulded inside the concrete to avoid temperature tensions. Newly moulded concrete blocks must be protected from the cold with insulation, which implies an additional cost.

Load bearing capacity
The load bearing capacity of timber is high, making it comparable to concrete constructions. The ability to adjust the timber dimensions to specific purposes makes the timber frame system flexible.

Light-weight construction
Due to the light-weight of a timber frame construction the ground-load is 30-50% less than concrete constructions. The foundation therefore costs less, which is critical when it comes to multi-storey houses.
Demolition
The costs for demolition may seem unimaginable at the moment. However, to keep high standards and adapt to the modern high-pace of living, the life of a house may be short. The life of a timber frame house in Sweden is estimated to 50-70 years. In other countries such as Japan, the average life is 26 years. The demolition of concrete is very costly compared to timber.

From a marketing perspective, the nine factors mentioned are important when convincing customers to buy a timber framed house instead of concrete. It is also important to consider the wishes of the house buyer from a supply chain perspective.

3.4 Some issues with timber framed housing

Sound
Sound is argued to be a problem in timber housing (Stehn et al., 2008). The sound of footsteps causes vibrations where the floors are connected to the walls. This is currently being investigated at Lunds University (Thelandersson, 2009). Further, drilling and remodelling are much more disturbing in a concrete house.

Moisture and mould
Moisture is frequently a discussed topic within timber housing. Wood is a material that attracts mould when wet. However, if the house is constructed wisely, mould and moisture should not be a problem (Thelandersson, 2009).

3.5 Methods of construction
There are two main construction systems of industrialized timber construction; the volume elements system and the panel elements system
The volume elements and panel elements are produced in a factory and later transported to be assembled onsite. (see Figure 3).

Volume elements require less work at the final location than panel elements because volume elements have almost all the interiors, e.g. kitchen cabinets, bathrooms, floors and stairs included, upon leaving the factory. According to Stehn et al. (2008), 80% of the work is carried out inside the factory when using the volume elements system. When using the panel element system, panel elements in the form of the floor system and walls (see Figure 3) leave the factory separate from all the interiors, left to be later assembled at the final location of the house. The volume element manufacturer usually owns the process from sales to completion (Höök, 2005, see Figure 4). Owning the whole process is called being a design-build contractor (Levander, 2010). A design-build contractor is the most lucrative, eliminating other players from sharing in the profit (Höök, 2005). Otherwise, the most occurring situation in on-site house construction is when house builders compete for projects of already designed houses, referred to as design-bid-contractors (Nord, 2009). If the house factory only produces the volumes and elements for a main contractor, the house factory is just a sub-contractor. Panel element manufacturers usually act as sub-contractors, only delivering the house shell. In this thesis, purchasing strategies are explored concerning companies that use both element and volume construction systems.
Volume elements

The production process of volume elements inside the factory starts with the making of panel elements, such as roof, floors and wall elements. The work is carried out with hand-held tools as well as larger pre-programmed nailing machines. The pipes for plumbing are placed inside the floor elements as the floors are being made. Because the windows and doors are assembled to the wall elements early in the process, they must be ordered early on due to their long delivery time. The roof, floor and wall elements are then assembled into volume elements, the walls are attached to the floor elements, and the roof is placed on top of this. The interiors of the volume elements are then painted and equipped with inner floors, bathrooms, wardrobes and cabinets. The volumes are then stored until assembly at the construction site. A subcontractor usually makes the foundation, to be ready when the volume elements arrive to the construction site. The volumes are then assembled into a complete house on the already fabricated foundation (Meiling, 2008). Figure 5 shows assembly of volume elements to the left, and panel elements (that will be explained in the next section) to the right.
The design of the house can vary with the timber volume elements system as long as the design is set at an early stage and fits with regards to the volume elements (Levander 2010). Even though the houses can be designed differently, the same volume system solution is used regardless of house design. Each project is unique and adapted after the customers’ demands. However, some houses contain almost identical apartments and the repetition effects are therefore gained, since the layout is standardised within the house project. The degree of customisation influences production efficiency where the information flow is important. Material that is not bought through annual agreements increases the complexity in purchasing (Höök, 2005).

**Panel elements**

With a construction system based on the panel element method, panel elements in the form of walls and floors are assembled onto the finished foundation and the house is equipped with its interiors at the final location. The panel elements include electrical installations and pipes. The design is freer with the panel element system because the apartments do not have to be divided into volume elements. A more open layout in house design is possible than with volume elements (Levander 2010).
4. THEORETICAL FRAMEWORK

This chapter includes an introduction to purchasing and a presentation of theories associated with purchasing, the position of purchasing in the value chain, the purchasing process, the Kraljic (1983) model, make-or-buy theories, cost analysis, the story of lean production, and purchasing relationships in the form of partnerships with suppliers.

4.1 Introduction

Purchasing has recently gained increased attention from industry professionals and academics as an important function in a company (Carr & Smeltzer, 1997; Cousins & Spekman, 2003; Van Weele, 2008). Only in recent decades, purchasing was mostly regarded as a clerical function that serves production according to the “five rights” of purchasing. These “five rights” are the right price, at the right time, with the right quantity and right quality from the right supplier (Lenders and Fearon, 1997; Cousins & Spekman, 2003; Van Weele, 2008; Monzka & Handfield, 2008). For a long time, the five rights were claimed to be the basic rules of purchasing. With purchasing as a clerical function the tasks of the purchasing function are considered mainly operational and administrative, focusing on the business transaction (Van Weele, 2008). This old way of supplier management is characterized as reactive and opportunity-driven with arms-length relationships with many suppliers, taking the lowest bid that meets the functional requirements of the product. Because the purchasing function
was seen as a clerical task in the past, it was typically a decentralized sub-
department. This sub-department often reports to the production or logistic
manager concerning purchasing decisions, which means little corporate
decision making (Van Weele, 2008).

Cox & Ireland (Lowe & Leiringer, 2006) argue that Forrester (1958) was the
first to highlight the importance of purchasing with his seminal work,
concluding that the way purchasing is handled has a large impact on profit
margins. Carr & Smeltzer (1997) argue, however, that it was Porter (1979)
who recognised the buyer’s role as a higher, top management function in his
model of five forces. Further, Van Weele (2008) states that Porter’s value
chain (1985) plays a central role in describing the importance of purchasing
in an industrial company. The value chain consists of all the activities within
a company that contribute to the flow within a production unit from the
input of raw materials to the output of finished products. The Porter value
chain (1985) is very much related to lean management (Van Weele, 2008) in
how the lean philosophy covers all aspects of the value chain, including
design, manufacturing and supply management (Womack et al., 2008).

Originating from Japan, the purpose of lean is to combine a low-cost
strategy with a differentiation strategy through a minimum of resources and
long-term collaboration with key suppliers (Womack et al., 1990; Van Weele,
2008). Japanese companies commonly outsource 50% of their engineer
hours to their closest suppliers (Van Weele, 2008). Because the lean
business system relies on collaboration with suppliers it is interesting to
relate it to theories of make-or-buy, such as Williamsson’s (1975 & 1985)
transaction costs analysis and Ellram’s (1993) total cost of ownership model.
These latter models intimately relate production with purchasing and are
philosophies in finding costs related to a product. However, it is not explicitly
stated how they should be applied in practice to actually and accurately pin-
point these costs. There are tools in lean that can be applied to find causes
of waste in a process, such as value stream mapping (VSM). VSM is carried
out by tracking a product (like a parcel at the post) through the value chain
of Porter (1980), i.e. from incoming to the outgoing truck in a factory. Since causes of waste are in fact costs, this is an alternative way to analyse a product’s costs. However, following all the products in a factory is too much work, and only products whose flows need improving are therefore analysed (Rother & Shook, 2003). Kraljic (1983) made a classification of products based on purchasing volume, where only those that comprise a significant part of the purchasing volume are considered worth elaboration. However, according to Van Weele (2008), the bottom-line with the Kraljic (1983) model is that core competences should be produced in-house, while the non-core competences should be outsourced to specialist suppliers. The actual relationship with the supplier becomes very close in collaborative relationships, which can have good and bad sides. This will also be discussed later in this chapter.

4.2 The position of purchasing in the value chain

Value chain management is central in the business strategies of many industrial companies (Van Weele, 2008). The value chain is composed of a company’s value activities and its margin; see Figure 6.

![Figure 6: Porter's (1985) value chain](image)

According to Porter (1985), the task of all participants in the value chain is to improve the buying company’s offer to its customers. The activities in the value chain are divided into two groups, called primary activities and
support activities. Primary activities physically transform and handle the products and deliver them to the customers. These activities are inbound logistics, operations, outbound logistics, marketing and sales and services. Support activities comprise the firm infrastructure, human resource management, technology management and purchasing management. The support activities are required to support the primary activities. The value activities of Porter’s (1985) value chain will now be explained, starting with the five primary activities.

*Inbound logistics* is a function within the company that is responsible for handling all incoming materials to the production unit. This includes reception of goods, warehousing, inventory control and dissemination of materials into the production process.

*Operations* are involved in transforming the incoming materials into the final product. This normally includes machining, assembly, packaging, testing and maintenance of equipment.

*Outbound logistics* have the responsibility to handle the final product regarding finished goods warehousing and outbound transportation.

*Marketing and sales* relate to activities such as advertising, promotion, sales, customer relations and pricing.

*Services* are related to enhancing and maintaining the value of the product to the customers. These activities may include installation, repair maintenance, training, supply of spare parts and product adjustments.

The four support activities of the value chain will now be explained.
Procurement relates to the function of purchasing the inputs used in the company’s value chain. These inputs may be raw materials and other consumable items as well as machinery, laboratory and office equipment and buildings.

Technology development is, according to Porter (1985), a broad view of the term technology including “know-how” and procedures and technology embodied in the process or product design.

Human resources management is the handling of all personnel in the value chain. Such activities consist of recruiting, hiring, training, compensating and developing personnel.

Firm infrastructure includes general management, planning, finance, accounting, legal, government affairs, quality management and facilities management. These activities may be divided among several business units in large organisations.

Porter’s (1985) view of the value chain is that it produces more value than it costs. This means that the total value of the company is determined by the value in sales. According to Porter (1985), the activities of the value chain create value to the company’s customers and the margin is the reward for the company’s undertaking of its activities.

It can be argued that purchasing plays a central role in Porter’s (1985) value chain where it is connected to the entire product flow throughout the company. Purchasing management is responsible for buying for both primary and support activities. However, buying for primary activities is often of greater interest to management, since it concerns buying for
production. Because the focus on this thesis is on purchasing and its relationship to production and suppliers, this chapter will treat only purchasing for primary activities, what Van Weele (2008) refers to as production purchasing.

4.3 Types of manufacturing processes
The organisation of the manufacturing process affects the purchasing for production (Van Weele, 2008). Basically, there are three types of manufacturing processes: (1) make-to-stock, (2) make-to-order and (3) engineer-to-order. The make-to-stock process produces products on forecast in large batches, which are then stored to be directly accessible to customers. The make-to-order process occurs when already designed products are manufactured from raw materials after a customer order has been received. An engineered-to-order process is all the activities from design to final assembly and even the purchasing of specific materials, though Porter (1985) regards purchasing management per se as a support activity. Naturally, the purchasing process becomes more complex with engineer-to-order products than make-to-stock depending on the higher variability of engineer-to-order products. In house construction, the architect usually starts the product specification process, making traditional house construction a classic engineer-to-order industry (Winch, 2003). However, industrialized housing is a solution to restructure the production process of houses to increase productivity (Lessing, 2006; Johnsson et al., 2006). With industrial housing the production process aims for a make-to-order strategy and thus purchasing management less complex. Jensen (2010) has made a classification of different types of house construction systems with different customer decoupling point (see Figure 7).
Jensen (2010) states that apart from engineer-to-order, houses can also be produced through *modify-to-order, configure-to-order* or by *select variant*. In modify-to-order, houses are produced through technical platforms. This method has recently been introduced by some of Sweden’s largest construction companies, e.g. Skanska’s Xchange, NCC’s Bostadsplattform, PEAB’s PGS system (Andersson et al. 2010). Configure-to-order houses are made of components and modules. The companies studied in this thesis, i.e. industrialized timber multi-storey buildings, can be placed into this category. Another example from the same category is NCC Komplett, a highly configurable system that was launched in 2006 but had to be shut down due to the slow payoff of the investment (Andersson et al. 2010). The last category in Jensen’s (2010) model is select variant. This category can be classified as Van Weele’s (2010) make-to-order, as these houses are standard products. Most factory-produced villas fall into this category, such as Älvsbyhus in Sweden.
4.4 The purchasing process

The purchasing process will now be described, since it constitutes the work of the purchasing management function. Van Weele (2008) views purchasing as the process of buying and has made a definition to reflect this:

“The management of the company’s external resources in such way that the supply of all goods, services, capabilities and knowledge which are necessary for running, maintaining and managing the company’s primary and support activities is secured at the most favourable conditions.” (Van Weele, 2008, p. 8)

Many terms and concepts are used interchangeably in practice as well as in literature to mean purchasing, such as procurement, contracting, sourcing and supply management. In the definition of Van Weele (2008), the whole purchasing process is considered including determining the need, selecting the supplier, arriving at a proper price, specifying terms and conditions, issuing the contract or order and following up to secure delivery. The purchasing process can be long, especially with new buys that can last several months (Emiliani, 2000). However, this process only applies for first-time buys of a product or service. In practice most buys are straight rebuys. Robinson et al. (1967) distinguish between three types of purchasing situations: (1) new-task situation (2) modified rebuy or (3) straight rebuy. A new-task situation occurs when a company decides to purchase a totally new product from an unknown supplier. A modified rebuy is when the company wants to buy a new product from a known supplier. The straight rebuy, also known as routine buy, is the most common situation when a known product is bought from a known supplier.

Each of the six steps in Van Weele’s (2008) definition of the purchasing process will now be explained.
Determining the need is the initial stage of the purchasing process. Here, the company must decide what to produce and what to buy, i.e. make-or-buy decisions. When the company decides to buy something the capacity and requirements must be defined. In general there are two types of specifications, functional and technical. Functional specifications describe what functionalities the product should possess. Technical specifications include detailed descriptions, such as technical drawings and activity schedules. The functional and technical specifications are parts of a set of documents referred to as the purchase order specification. This document includes technical norms and standards that the product should meet, logistics specifications including quantity, time and place of delivery, maintenance service, legal and environmental requirements, and a target budget.

Selecting the supplier is the next step after the purchasing requirements have been defined. Van Weele (2008) proposes a four-step procedure when choosing a supplier. The first step is to determine which is the two types of sub-contracting should be chosen, turn-key or partial sub-contracting. In turn-key sub-contracting one supplier takes care of everything, often including design. Partial sub-contracting, however, implies that the supplier is only responsible for part of an assignment shared with other sub-contractors. In the case of partial sub-contracting, Van Weele (2008) argues that the entire project stands and falls with the buyer’s ability to coordinate the different sub-contractors. If the buyer fails, substantial costs will arise, but if the buyer successfully handles the coordination, savings can be made. The second step in choosing supplier is to select one of essentially two contract types of contract, fixed price and cost-reimbursable. With a fixed-price contract the sub-contractor has to finish the assignment at a determined date at a determined price. This type of contract implies that the supplier takes all the risk and the buying firm has certainty about the completion date. The disadvantage for the buyer is that it is difficult to evaluate such a proposition if the buyer lacks expertise about the supplier’s
costs. A cost-reimbursable contract is vaguer and the nature and scope of the assignment is not predetermined. The supplier is paid according to worked hours and materials consumed. The advantage with this type of contract is that the costs are known, though because there is no predetermined price, the financial consequences and completion date are uncertain. The third step is to make a bidder’s long list, consisting of suppliers that meet the requirements determined in the first two steps. The suppliers of the bidders’ long list are requested to send a proposal and references of previous engagements. The best proposals then qualify for the bidders’ short list and the suppliers are asked for a detailed quotation. When the buyer has received the quotations, a commercial and technical evaluation is made, considering all aspects of the suppliers’ offerings. Finally, one supplier is chosen, or in some cases two or more if multiple-sourcing is preferred.

Arriving at a proper price is closely related to choosing a supplier. The price can be agreed on through competitive bidding or negotiation. Van Weele (2008) states that a fixed price contract is preferred from a cost control and budget perspective and, ideally, the supplier should take all the risks.

Specifying terms and conditions are important and the buyers should strive to prescribe the company’s terms of purchase, which can often be difficult. Van Weele (2008) points out that suppliers often only accept an order on their own sales conditions. Still, if the supplier does not reject the terms and conditions in their order confirmation, the terms of purchase are legally valid. It is common that payment takes place on several occasions, since the supplier commonly makes large investments to produce the desired product. The payment is generally based on the supplier’s performance, for example 20% of the total funds when 25% of the work is completed. Penalty and warranty are commonly written in contracts concerning quality and performance of the purchased product.
**Issuing the contract or order** is made after a contract has been agreed upon. The contract can in some cases be the purchase order. In cases of routine buying, call-off agreements are negotiated to cover the supply for one or more years. In the latter case, contracting and ordering are separate activities.

**Following up to secure delivery** is the last activity of the purchasing process. Van Weele (2008) indicates the importance of documenting experiences with individual suppliers. The documented experiences are useful for to rate suppliers and to choose only the best suppliers in future buys. According to Van Weele (2008), the documentation should include the suppliers quality and delivery record, competitiveness and innovativeness.

### 4.5 Organization of Purchasing within a company

Van Weele (2008) mentions different kinds of purchasing organizations, such as decentralized and centralized. Traditional purchasing is dominated by decentralized purchasing functions (Van Weele, 2008). The advantage with decentralized purchasing is that the purchasing function is close to production and can therefore satisfy their needs (Leenders et al., 2002; Van Weele, 2008). A disadvantage with decentralized purchasing is that expertise about purchasing and materials may be limited (Leenders et al., 2002; Van Weele, 2008). Leenders et al. (2002) argue that centralized purchasing is more advantageous than decentralized. The main arguments for centralized purchasing are that the company gains purchasing power, the increase in specialisation and decreased administrative costs (Leenders et al., 2008). However, Kraljic (1983) stresses the lack of flexibility in centralized purchasing, as the purchasing becomes more standardized.

Construction companies that do not produce prefabricated parts in factories conduct most of their activities onsite (at the final location of the house), i.e. they move around from place to place and work in temporary organisations.
In these companies, construction materials have typically been ordered by the local project leader from temporary suppliers and sub-contractors (Dubois & Gadde, 2002), which can be seen as decentralized purchasing. According to several authors, e.g. Dubois & Gadde (2000), Vrijhoef & Koskela (2000), Cox & Ireland (2002), Cooper et al (2003), Love et al. (2004), and Briscoe & Dainty (2004), the supply of materials in construction companies is inefficient, mostly due to coordination issues, which may have its roots in the non-standardized character of a decentralized organization.

4.6 The Kraljic model

In 1983, a McKinsey consultant named Peter Kraljic wrote a groundbreaking seminal paper for the Harvard Business Review, titled “Purchasing Must Become Supply Management.” Kraljic’s paper, perhaps viewed as the most important paper in purchasing literature, describes the principles of modern strategic sourcing and argues that the purchasing function should go from being clerical to a strategic role of optimal supply. Kraljic (1983) made a classification of purchasing strategies for different kinds of products, divided into four types: non-critical items, leverage items, bottleneck items and strategic items. Figure 8 shows the Kraljic model (1983), which illustrates the different items concerning risk and value.

![Figure 8: The Kraljic model](image)
Non-critical items
Non-critical items have a low value and several possible alternative suppliers (Kraljic 1983). A common problem with this product category is that the handling of the products often costs more than the product itself (Van Weele, 2008). Van Weele (2008) says that the non-critical item strategy should not be used for production materials.

Leverage items
Leverage items are raw materials or primary products that can be obtained from various suppliers at standard quality grades. Because these products are bought in large quantities, price is important as a small change in price can greatly impact the cost of the end-product (Kraljic, 1983; Van Weele, 2008). Cartels and price agreements can develop in these markets even though they are forbidden by law (Van Weele, 2008). Suppliers lacking sufficient trust at all levels of the supplier’s organisation for a true partnership are argued to fall into this category (Gelderman & Van Weele, 2002).

Bottleneck items
Bottleneck items have low value related to the total profit, but can be hard to find because of a scarce supply, making the company vulnerable (Kraljic, 1983). The supplier dominates in this market, often resulting in high prices (Van Weele, 2005). Overall, a company should avoid suppliers in this category (Kraljic, 1983; Gelderman & Van Weele, 2002).

Strategic items
Strategic items are complex products with few suppliers on the market. These items are purchased most successfully through long-term relationships, i.e. a sole supplier partnership. Strategic technological development is facilitated by a close technological relationship, since
strategic products are typically developed together with the supplier (Håkansson, 1982; 1993; Rehme, 2001). The share of information in these kinds of relationships usually spares extra time and resources to solve problems (Sanchez & Pérez, 2001). One of the drawbacks of a sole supplier relationship is the fact that competition among suppliers is lacking, which means that there is no market to which a buyer can turn to in case of unexpected volume or price changes. The absence of alternative supply sources makes contract specifications important (Walker & Weber 1987). Strategic partnership implies a high mutual dependence where trust is central (Gelderman & Van Weele, 2002). A typical example of long-term partnerships can be found in the car industry, where car manufacturers have moved from traditional arms-length buyer-supplier dealings into much closer relations (Helper & Sako, 1995).

According to Cox & Ireland (2001), construction components range from raw or primary products to complex systems that require skilled craftsmen to install. Dubois & Gadde (2000) also share this view, arguing that building materials are primarily characterised by an exchange of standardised products, i.e. components of more complex systems. Hence, construction materials must be categorized into the squares of leverage and strategic items, depending on the company’s production process.

4.7 Make-or-buy decisions
The make-or-buy decision in a company is important because it sets the boundaries of the firm. This decision can indeed be regarded as a top management issue and decides where in the supply chain the company should be positioned (Cousins et al., 2008). To manufacture the entire product in-house, vertical integration requires an extensive amount of skills and resources that few companies possess (Ibid.). Various scenarios of a company’s position in the supply chain, defining the firm’s boundaries, are therefore possible. Cousins et al. (2008) give three examples of a firm’s
boundaries in a simplified supply chain of four stages (raw materials, manufacturing, assembly and retail), illustrated in Figure 9. In the first example (A) the company only conducts the manufacturing part of the supply chain. The second example (B) illustrates a firm that makes raw materials and conducts manufacturing in the supply chain. In example (C) the firm does the manufacturing and assembly part of the supply chain.

Neoclassical theory, one of the earliest and still taught economic theories, explains the interactions in the marketplace. In neoclassical theory, full rationality and full information exist to maximize profits of a production set that transforms inputs to outputs (Hart, 1989; Chandler, 1992). According to neoclassical theory, a firm’s *raison d’être* is to maximize profits existing in perfect competition where profits are only temporary and determined by the price mechanism. However, neoclassical theory says nothing about what happens inside a company, which is important for managers. Two theoretical perspectives that further explain the existence of companies therefore emerged, the resource perspective and the transaction costs perspective. These two theories are the most classic theories for make-or-buy decisions, and will now be elaborated upon.
The transaction cost perspective

The transaction cost approach emerged to explain the existence and scope of a firm. Coase (1937) believed that firms exist due to marketing costs, now known as transaction costs (Williamsson, 1975). Transaction cost economics is based on two behavioural assumptions, bounded rationality and opportunism, and two transaction assumptions, asset specificity and uncertainty (Williamsson, 1985). The relation between these terms can be clarified by Figure 10.

The middle of Figure 10 shows the level of transaction cost, which is in fact the cost of the entire purchasing process from Van Weele (2008). This is explained in Chapter 4.4, namely determining the need, selecting the supplier, arriving at a proper price, specifying terms and conditions, issuing the contract or order and following up to secure delivery. According to Williamsson (1985), this purchasing process is dictated by transaction and behavioural characteristics. The level of transaction cost then determines the decision to make or buy. The transaction characteristics consist of asset

Figure 10: Transaction cost of Williamsson (1985), adapted from Cousins et al. 2008

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specificity and uncertainty. *Asset specificity* considers the level of specialisation of a physical object, person, site or dedication. *Uncertainty* costs consist of ex ante, environmental costs, and ex post, the behaviour of the partner firm. Behavioural characteristics consist of bounded rationality and opportunism. *Bounded rationality* means that people act rationally based on what they know. This might not be the optimal decision if all information is at hand. *Opportunism* implies that people are driven by self-interest to achieve their goals, even if it means lying, stealing, cheating or providing false information to mislead the other party.

**The resource-based perspective**

The resource-based perspective is different from the transaction cost perspective in that the *raison d’être* of a firm is independent of opportunism (Cousins et al., 2008). It implies that all companies act of good reasons because the most competent are the winners and buying is generally a preferable choice over making. The resource-based view originates from the seminal work of Penrose (1959), where the firm is seen as a bundle of resources. This differs from the neoclassical view of the firm, where the firm is seen as a production unit that transforms inputs into outputs. Resources, according to Penrose (1959), are tangible things like the plant, equipment, land, raw materials and human resources, e.g. skilled and unskilled staff of all divisions within the entire firm. The combination of resources yields services that give the unique character of the firm. According to Barney (1991), resources are sometimes also referred to as capabilities, which basically mean the same thing. Resources within the firm and between firms have different levels of efficiency (Peteraf, 1993), where the efficient resources enable producing at lower costs or better satisfying the customers so that larger profits can be gained (Rumelt, 1987). The conditions of how competitive advantage can be sustained are therefore important and are said to depend on three variables: inimitability, non-substitutability and immobility (Barney, 1991). Inimitability depends on the unique historical conditions, causal ambiguity, social complexity or combination thereof.
Unique historical conditions can be temporal opportunities that firms develop at certain circumstances. Causal ambiguity is the link between the firm’s resources and the firm’s competitive advantage, which can sometimes be hard to understand and therefore hard for rival firms to copy (Reed & De Fillippi, 1990). Social complexity is concerned with reputation and culture, which can be hard to replicate (Cousins et al., 2008). Moreover, resources should be resistant to substitution; otherwise they cannot sustain competitive advantage over the long-term (Ibid.). The resources between firms should also be immobile and non-tradable or have less value to others (Ibid.).

The resource-based approach starts by looking inside a firm before searching elsewhere (Cousins et al., 2008). This approach in make-or-buy decisions begins with the question “Do we have the capabilities to produce in-house?” If the answer is “no”, the next question is “Can we develop the required capabilities to make this product?” If the answer is still “no”, then “Can we acquire the required capabilities to make this product?” Finally, if the answer is still “no”, the last option is to buy. The choice between the different levels depends on the costs of developing and acquiring the capabilities. According to Barney (1999), the cost of developing resources internally is dependent on the historical context, i.e. developing the capabilities at the right time, the cost of learning, social complexity and causal ambiguity. If the cost of developing the capabilities inside the firm is too high, the firm has to look outside its boundaries. This means through mergers or acquisitions or buying from an external supplier. Again, these options mean costs, such as legal constraints, the value of the firm may rise and fall due to a merger or acquisition, the technology within the desired firm may be unsustainable because technologies and fashion change, or the desired firm may have unwanted “baggage” (Cousins et al., 2008).
4.8 Cost analysis in purchasing

Price is not the whole truth in determining the value of a product. High priced products can be proven to be less expensive in the long run (Ellram, 1995; Van Weele, 2008). Ellram (1995) believes that to select a supplier or improve the integration and relationship with a supplier, a proper identification of all the costs in the supply chain must be identified. Total cost of ownership (TCO) is a philosophy that is utilized to get an overall picture of the total cost of buying a particular good or service from a particular supplier. These costs concern all the costs, from acquisition and possession to use and subsequent disposition of a purchased product. Examples of these costs are costs of order placement, research and qualification of suppliers, transportation, receiving, inspection, rejection, storage and disposal. TCO has its roots in transaction cost analysis (see Chapter 4.7).

The TCO model has similarities with value stream mapping (VSM), which originated from the lean concept (Rother & Shook, 2003). VSM usually maps the process from incoming to outgoing truck in a factory; see the appended Paper IV for further reading about VSM. Because TCO is all the processes from acquisition, use and disposal of a product, both process models therefore illustrate the flow from input to output in a factory. TCO can serve to analyze hidden costs, and is argued to be a relevant tool when a more strategic focus on purchasing and supply management is needed (Van Weele, 2005; Wouters et al., 2005).

Compared to traditional approaches used to select and evaluate suppliers, which are based solely or primarily on price, the TCO approach has the advantage of examining the cost associated with the buyer’s internal costs (Ellram, 1995b). The concept of activity based costing (ABC) is a relevant technique applied in TCO to monitor the buying organization’s internal cost (Ellram, 1995a). In ABC calculations, the costs are related to cost drivers, i.e. products fabricated inside the factory. To follow a cost driver throughout
the supply chain from acquisition to disposal, both TCO and ABC together are a good combination of tools in purchasing decisions (Ellram, 1995a). In the US in the 1970s, the accounting method ABC began to also gain popularity among line managers (Armstrong, 2002). Lean (see chapter 4.8) created a need for accounting to support decision-making in the creation of a lean supply chain focusing on activities that cause costs. ABC promotes decisions consistent with lean production, e.g. reducing inventories, increasing common components, increasing quality by minimizing total quality costs, minimizing costs of ownership through supplier management, assessing customer profitability, and linking product design decisions to manufacturing cost (Cooper & Kaplan, 1991).

Yet, TCO can be difficult to apply in practice. Ellram & Siferd (1998) argue that there are four barriers: (1) Data availability, (2) Complexity, (3) Corporate culture and (4) Proper use and relevance of models. Mena et al. (2002) state that tracking costs can be a very complex task and many organisations are unfamiliar with their own costs.

4.9 The story of lean production

The story of lean production began in the U.S. with Henry Ford and continued in Japan through Toyota. However, this concept was only recently (in 1990) known worldwide as lean from the book “The Machine that Changed the World”, by Womack et al. In this chapter, the basic ideas of lean are described and how it emerged over time.

Henry Ford

Lean production has its roots in the manufacturing of cars. In the old days, cars were expensive and scarce and few people owned them. The demand for less expensive cars for the common person was huge at the beginning of the 19th century (Lamming, 1993). To make more cars at a lower price, Henry Ford started a business with a new strategy. He began to mass-produce
cars, where the most famous model is known as the black T-ford. The Ford factory became well-known due to its great productivity and people from all over the world came to visit. The success resided in making the car from a standardized system of components that were interchangeable so a specialised mechanic to refurbish the car was no longer needed. The production line was also fed with material so that the line workers could work uninterruptedly. Because all the processes in the factory were standardized, an experienced work force in the factory was not necessary. The quality increased by standardizing the procedures and reducing the things that can go wrong. Leadership was strong in central policy making to incorporate all standardization in the company. The suppliers were vertically integrated into the firm, i.e. Ford bought all his suppliers to control every step of the supply chain (Lamming, 1993).

Changing market demands and scarce resources after the war
During the 1950s, demand for a variety of products by customers increased. The European market was more segmented to different tastes and money for large-scale production after the Second World War in Europe was lacking. Europeans then began to make small series of luxurious cars and export them to rich and affluent customers in the U.S. The same situation as in Europe occurred in Japan (Lamming, 1993). However, in reaching the common customer, Ford was still unbeatable.

Taiichi Ohno’s discoveries of production process improvements
A scareness of resources called for an innovative production system that required less capital to compete with Ford. Taiichi Ohno, a Japanese businessman, bought some machinery from the Americans and started experimenting (Womack et al., 1990). Ohno discovered that frequent machine changeovers decrease stock levels through the making of smaller batches. Moreover, when visiting the Ford plant (which was the seed to his thoughts) he discovered that there were many defect cars. The cars were defect because it was very expensive to stop the assembly line to correct the
defects. Ohno decided that in his new system any of the workers could stop the assembly line at any time when there was a defect. Ohno’s system became less costly, since there was no extra work of unfinished cars when the assembly line was stopped. Further, all the workers learned by finding the root cause of defects when stopping the line. Learning what caused the problems eliminated future defects. This became waste-reduction by eliminating the extra work of semi-finished cars and only producing cars with zero-defects from the assembly line (Womack et al., 1990). Ohno tried to pinpoint all sorts of waste, a strategy that became the core of lean production. Ohno discovered that because the Ford factory was so reluctant to stop the expensive machinery of the assembly line, more cars were produced than necessary. He viewed this as a waste in terms of overproduction. The Japanese way, therefore, was to only produce what the customer wanted, which he called pull production, as opposed to push by Ford. The lean philosophy and marketing coincide in their views that customer value is to satisfy customer needs (Piercy & Morgan, 1997). Lean production strives after perfection and to eliminate waste. To do so, process improvement is the key. Therefore, to implement lean in a company, it is essential to visualize the work flow and thus include everyone in it. Then, everyone is informed about the plant’s overall situation and can respond to problems (Womack et al., 1990). To enhance the workflow, the process is visualized through value stream mapping, which is a large-scale drawing of company processes from the input of raw material to finished products (Rother & Shook, 2003). More simple information display systems are also used to fulfil set targets in production (Womack et al., 1990).

**Japanese supplier strategy**

Ohno had neither the capital to vertically integrate upstream (as Ford had organized his supply) nor did he wish to pursue such a strategy (Lamming, 1993). Instead, he organized his supply chain as a network of companies with first tier suppliers working closest to him. A few system suppliers have their own suppliers, in the form of a pyramid, minimizing the number of
components and suppliers to each company. The large number of suppliers in a traditional supply chain (see Figure 11) leads to an extensive workload for the purchasing department (Gadde & Håkansson, 1994; Van Weele, 2008) and the relationships are characterised as arms-length and transaction-based (Van Weele, 2008).

![Figure 11: Lean supply structure (to the right) and traditional supply structure (to the left)](image)

In the layered triangle supply structure, the suppliers closest to the top are 1\textsuperscript{st} tier suppliers. These suppliers have in turn specialist component suppliers, which are 2\textsuperscript{nd} tier suppliers to the top, and the 2\textsuperscript{nd} tier have their own component suppliers as 3\textsuperscript{rd} tier (Womack et al., 1990; Van Weele, 2008). In lean, cross-functional teams are typical, consisting of professionals within product development, R & D, production, marketing, distribution and finance, together with professional purchasers to effectively consider all aspects of supplier offerings (Van Weele, 2008). The 1\textsuperscript{st} tier suppliers are often involved early in product development; Japanese OEMs typically delegate half of their engineer hours to their 1\textsuperscript{st} tier suppliers (Van Weele, 2008). In Japan, it is not uncommon that one manufacturer represents more than 50\% of a suppliers total sales (Gadde & Håkansson, 1992; Van Weele, 2008). This way, every company can focus on their core competence to strive for perfection. The relationships in the lean concept are close, in the form of partnerships based on a contract of profit sharing and transparency (Womack et al., 1990). Through a transparent and collaborative environment, the goal is to reduce problems that cause costs (Lamming, 1993). Moreover, the suppliers deliver the materials exactly when production needs it, for stockless production, called just-in-time (JIT) (Womack et al., 1990). The layered supply chain structure is also supported by market
channel theories, which argue that intermediaries can add value to the product, to the benefit of the buyer (Bucklin, 1966; Coughlan et al., 2006; Kotler & Armstrong, 2010).

Cousins et al. (2008) has classified different supplier structures in the different quadrants of the Kraljic model (See Figure 12), where the “Japanese” supplier structure is also present.

![Figure 12: Different supplier structures in the Kraljic model according to Cousins et al. (2008)](image)

Figure 12 shows that for leverage and strategic items, the supplier structures are pyramids with a reduced supply base. The non-critical item square has flatter supply structure with many different suppliers. The bottleneck item square is based on a close relationship with a single supplier to secure supply of scarce bottleneck products. The non-critical item’s square seems to correspond with the supply structure, described by Van Weele (2008) as traditional. Strategic items are obviously the collaborations of product development of sub-systems, as mentioned earlier. But what is the idea behind the pyramid structure of the leverage square? Some people might think this is the square of competitive bidding with many short-term relationships, like the traditional flat supply structure. However, Kraljic (1983) argues that bidding with many suppliers is a very unstable strategy;
he was one of the early proposers of long perspective planning with close supplier relationships. Even before Womack et al. (1990), Kraljic (1983) argued that cross-functional teams between purchasing and production planning can enhance the work of purchasing and the profitability of the company. Through long-term planning, purchasers can concentrate on enhancing the purchasing process. Short-sightedness in production planning affects the purchasing department and leads to solving problems where quick solutions to save the situation can be very costly. Therefore, long-term planning with few suppliers, which serve the production of the buying company by keeping stock, customized deliveries and a broad product line of leverage items, can be cheaper in the long run than chasing for “good-deals” and problem-solving.

The Japanese way of product development
In the Western world, a common problem in project management is that critical design trade-offs usually are resolved very late in a project (Womack et al., 1990). Womack et al. (1990) argues that this depends on the cultural reluctance to confront conflicts directly and on vague commitments to a set of design decisions at the beginning of a project. By contrast, Japanese project members sign formal pledges to do exactly as agreed in the group at the beginning of a project. This way, problems are solved much earlier, reducing waste in terms of time and money (Womack et al., 1990).

4.10 Win-win partnership relations with suppliers
The interest of partnerships arose in the 1980s through the inspiration of Japanese manufacturers that are in very close relationships with their suppliers (Leenders et al. (2002). Partnership has been widely discussed in the construction and manufacturing industries. Many authors claim that improved relationships and integration of key stakeholders are crucial to improve the construction industry. The multiple case study of Paper III revealed that industrial house builders have long-term relationships and strive after close collaborative relationships with suppliers.
What is a partnership?
There are different levels of close relationships between suppliers and buyers. This causes some ambiguity in the definition of partnership. Leenders et al. (2002) state that people also use the term “preferred supplier” or “strategic alliance” instead of partnership. Kraljic (1983) discussed long-term relationships as a strategy for certain products. Gelderman & Van Weele (2005) elaborated on Kraljic’s (1983) model and found through a study that partnerships can be of various forms. Both authors saw the nature of a partnership ranging from partnership-of-convenience to strategic partnerships, with the latter one being much closer. The partnerships-of-convenience was defined as a long-term supplier relationship whose focus is on quality, logistics and efficiency, but there are no co-designed solutions. A strategic partnership also involves the co-creation of products.


“…a firm with whom your company has an on-going buyer-seller relationship, involving a commitment over an extended time-period, a mutual sharing of information and a sharing of risks and rewards resulting from the relationship…”

The definition by Ellram & Henricks (1993) also mirrors how Lamming (1993) and Womack et al. (1990) describe the buyer-supplier relationship in the Japanese car industry.

The development of a partnership
Van Weele (2008) points out that sole-sourcing is not the same as partnership and that development of a partnership takes time. According to Gelderman & Van Weele (2002), a partnership-of-convenience can be with a beginning. When sufficient trust (Gelderma...
attractiveness (Ellegaard & Ritter (2006) between the two parties exist the relationship can become a strategic partnership, see Figure 13.

According to Ellegard & Ritter (2006), the business attractiveness between buyer and supplier can create added value, which is the purpose of the partnership. Ellegaard et al., (2003) state that the buyer should create attractiveness towards the supplier by developing the supplier so that the supplier is more interested in a collaborative relationship.

**Sharing of information and organization**

Many authors emphasise, in particular, the importance of mutually sharing information as a characteristic of a partnership (Leenders et al., 2002; Van Weele, 2008). Lamming (1993) and Van Weele (2008) claim that to get the most out of close supplier relationships, it is important to share information about costs. Knowledge of each other's processes and costs can enable collaboration in process improvement, which can reduce costs. Slack (1991) argues that production efficiency alone is not enough for competitive advantage; organisational processes must create a seamless fit between customer value, the design process, production and the supply chain. Early involvement by suppliers in the buyer's design process can prevent unnecessary costs and reduce the time-to-market.

Van Weele & Rosemeijer (1996) argue that strong leadership, motivation and performance are key elements in long-term relationships where cultural change is a prerequisite. Another key are clear directives from top management, with a clear and set agenda of company goals on how to interact with the supplier’s organization (Womack et al., 1990; Van Weele,
2005; Frödell, 2009). Otherwise, the supplier and buyer must “invent the wheel” together on every single project. Moreover, cross-functional teams from both sides should be implemented to share information on all levels of the organization (Van Weele, 2005). It is a challenge for these teams to interact and takes a lot of time and effort (Van Weele, 2008). The interaction between companies is facilitated by a similar company culture (Galbraight, 2002). Further, Cox & Thompson (1997), Cox & Ireland (2002) and Van Weele (2005) argue that buyer-dominance in the buyer-supplier relationship is necessary to succeed in a partnership. Cox & Thompson (1997) and Walker & Weber (1987) stress the importance of contractual agreements of risk and responsibilities in buyer-supplier relations to obtain business success. Womack et al. (1990) claim that supplier relationships in the Japanese car industry are built on detailed contracts rather than trust.

**Critical voices concerning partnerships**

There are, however, some criticisms concerning partnerships. A study within the British automobile industry (DTI, 1994) showed that mutual trust between supplier and buyer was still very far away and that it had been many years of “broken promises, abuse of trust and conflicts.” Cox & Thompson (1997) are sceptical that engineers and architects will make construction projects more profitable through product development via partnerships and stress that Japanese firms pay 50% higher prices with their partnerships than Western firms operating through arms-length contracts. Nevertheless, Van Weele (2008) emphasises that price and value are not the same and that low-price purchases can be more costly than high-price purchases.
5. RESULTS OF PAPERS

In this chapter the main results of the five appended papers are summarized.

5.1 Summary and findings from paper I: Coordination and Waste in Industrialized Housing

This paper is a single-case study of an industrialized timber housing factory. The case company is one of Sweden’s largest producers of multi-storey buildings with a turnover of 15 million Euros. The construction technique is timber volume elements that are produced in the factory and later transported for assemblage at the construction site (See Chapter 3.5). The purpose of this paper was to explore the coordination of activities in industrialized housing and the occurrence of different types of waste.

The findings revealed that the root causes to waste are often created during the early stages of the production process, which is in line with previous research by Vrijhoef & Koskela (2000). Decision-making that is not dealt with at the beginning of the process, such as customer specifications, leads to waste in production. Vague instructions and understanding of how the assembly work is executed causes errors in production, which leads to rework on the assembly site. Production is still largely carried out onsite due to coordination issues and the company would benefit from finishing as much as possible in the factory because it would be less costly. According to the interviewees in the case study, the coordination of personnel executed during the on-site assembly becomes more difficult and expensive in an
industrialized housing setting as a consequence of the distance to the factory where suitable tools, spare parts, etc. are greatly available.

5.2 Summary and findings from paper II: Value-driven Purchasing of Kitchen Cabinets in Industrialized Housing

This paper is a single-case study of another industrialized timber housing factory. The case company has a turnover of 50 million Euros. The construction technique is also volume elements, as in Paper I, though different in wall structure. The paper compares the characteristics of market-driven with value-driven purchasing. The hypothesis is that value-driven purchasing of customized kitchen cabinets is more profitable than market-driven purchasing in industrialized house construction. According to the case study, from a value perspective, a long-term relationship with a dedicated and local smaller supplier is a preferable choice over a short-term bulk supplier, even if the short-term supplier has (much) lower prices. The start of value-driven purchasing will initially imply high transaction costs, since the new kitchen sub-system must adapt to the volume element production. Once established, the lean system has the potential to double the output of the housing manufacturer (Hines, 1996). Experiences from the UK construction industry (Khalfan and McDermott, 2006) show that close collaboration with suppliers leads to higher profitability, fewer delays, and better quality of the finished buildings. Through value-driven purchasing, the house manufacturer can accelerate production, since the production line becomes less complex when kitchens no longer need to be assembled. In market-driven purchasing, long lead-times enforce preliminary orders and drawings that often require adjustments, which are often discovered late in the process requiring a “quick fix” at the construction site, thus leading to extra costs. In this case study, only half of the kitchens were completed in the factory due to unfinished design. Extra costs and an extended time for finishing can be eliminated with value-driven purchasing of complete kitchens. Also, geographical proximity, close technical collaboration and JIT
will proactively eliminate errors. The kitchen cabinet manufacturer can grow with an increasing and steady sales volume due to their extreme customer adaptation and the house manufacturer’s dependence on this adaptation. In the efforts for the lean enterprise, a system supplier seems ideal, creating a win-win relationship between both companies.

5.3 Summary and findings from paper III: Purchasing strategies in industrialized housing – a multiple case study

This paper is a multiple-case study of a three industrialized timber housing factories. The purpose of this paper was to describe and analyse the purchasing strategies of industrialized housing. The top management of the three companies were interviewed concerning their view on purchasing in industrialized housing. The interviews revealed that the companies strive after long-term collaborative relationships with their suppliers. The most important is the terms of delivery to feed the production line. The only reason to change supplier is quality issues. Suppliers that provide “turn-key” solutions are preferred. However, their view regarding the purchasing of timber differed slightly, with one of the companies preferring to cut their own lengths, whereas the others preferred to buy customized lengths. It can be concluded that value is not measured in price but “value-in-production”. A product with a higher price might prove to be more profitable in the long-term. The interviewed managers all agreed that buying for production is easier than buying for onsite production because factory production is easier to control.

5.4 Summary and findings from paper IV: The study of a kitchen assembly process in industrial housing

This is a single-case study at the same industrialized housing factory as in Paper II. It is a detailed study of how kitchen installation is carried out inside the timber volume elements, from arrival to exiting the shop floor. The
purpose was to investigate how value stream mapping (VSM) can be used to target waste. It is easier to discuss within the company what the processes really are when visualised on paper. Otherwise, processes can be interpreted differently between different people within the organization. The systematic observation of a process can be lengthy, especially in construction, though a deeper knowledge is obtained than with second-hand descriptions. Many kinds of waste were detected during the VSM process, which shows the importance of top management’s mapping of production to improve the processes. Targeting waste can be more fruitful in understanding the true source of costs. An accurate value of the costs in numbers are, otherwise, hard to gather and it is unclear what is behind the figures.

5.5 Summary and findings from paper V: Innovative House Components to decrease Complexity

This is a case study of the same industrialized housing manufacturer as in Papers II and IV. It is a study of kitchen and bathroom installations and discusses the complexity of such installations in house construction. Moreover, it discusses the possibility of supplier’s making sub-systems of kitchens and bathrooms and thus render the construction process for the entire house leaner. A literature review revealed that complexity depends on (1) the number of parts and interaction between parts in the process, (2) the degree of difficulty in understanding and carrying out the tasks, (3) the familiarity and uncertainty of the environment and (4) the number and variety of tasks in the process. According to these four factors of complexity and the variability caused by late customer choices, bathroom and kitchen installations seem like tasks of high complexity and high variability in house construction and could therefore be possible areas for sub-system suppliers to add value to the construction process.
6. CROSS-PAPER FINDINGS

In this chapter the cross-paper findings of the five appended papers are presented.

6.1 Purchasing at a strategic level in the organisation

In all the studied companies in Paper III, the purchasing decisions are made at a high level in the organization. This is in line with Porter’s (1979) view of purchasing as an important management function within the company. According to Porter (1985), purchasing has a high impact on the company’s primary activities in the value chain and should be superior to those processes. The purchasing in industrialized housing can be regarded as superior to the process flow. The primary activities of the process flow in Porter’s (1985) value chain are, however, inconsistent with the primary activities in industrialized housing. Porter’s value chain (1985) is based on repetitive manufacturing, where sales are at the end when everything is already produced. This is not the case in industrialized housing. The selling of the house in industrialized housing is at the very beginning. Another difference in industrialized housing is that there are usually no services after delivery, as in Porter’s (1985) model. In Söderholm’s (2010) process model of the industrialized housing process, design is one of the most time-consuming parts of industrialized housing. This process is not present in Porter’s (1985) model. Moreover, the industrialized housing factory is in most
cases also responsible for the assemblage and finishing at the construction site. Therefore, the primary processes of industrialized housing also span beyond the factory walls, which do not apply in Porter’s (1985) model. This discussion calls for a new version of Porter’s (1985) value chain that fits industrialized housing, see Figure 14.

Figure 14: Porter’s value chain (1985) adapted to industrialized housing

In industrialized housing purchasing interacts with all the primary activities in Figure 14. Purchasing interacts with marketing and sales to know the customer’s choices and thus make orders (see Paper II). The design activity interacts with purchasing so that the right amount and sizes of building materials and coordinate subcontractors of installations can be ordered. Inbound logistics are intimately connected to purchasing to handle all incoming trucks with materials and to check their quality. Production and purchasing collaborate in determining what materials are better to work with in production (see Paper III). For instance, some inner floors are easier to install than others. Purchasing interacts with outbound logistics regarding rest orders of missing or broken materials (see Paper IV). The final step is assembly and finishing where purchasing coordinates different subcontractors and materials. According to the house builders, purchasing for production is described as rather easy to coordinate compared to the coordination of activities and materials onsite. The house builders who do not finish everything in the factory before assemblage at the construction site have problems onsite with their coordination (see Paper I).
6.2 Information about process is necessary to evolve

The study of the kitchen assembly process in Paper IV revealed the importance of making in-depth studies of company processes to improve. To coordinate the activities and thereby make the building process and supply chain more efficient, the process must be identified and documented. By mapping materials and information flows, a standardized process can be formed, creating more value and eliminating waste. The use of value stream mapping to target waste can help make the right purchasing decisions. Value stream mapping can be used together with total cost of ownership and activity-based costing to put a monetary value on the process. However, it can be difficult to estimate a monetary value and the most important is to know the process. A lack of information between the different parts of the process is a source of problems, especially for the assembly and finishing.

6.3 Long-term supplier relations

Purchasing strategies in industrialized housing seem to be long-term, according to the conducted case studies. All the companies in the multiple-case study in Paper III have had long-term agreements with their suppliers for several years. The deliveries arrive through call-offs for each project. The long-term contracts are motivated by the need to secure supply for production. This means that the price is generally slightly higher, but the companies all agree that this is better than the risk of standing without materials or low quality materials. The long-term agreement also benefits the supplier, who gets a steady sales volume. These agreements can be seen as a form of partnership where commitment and attractiveness (Ellegaard et al., 2003; Ellegard & Ritter, 2006) play a central role in helping each other out through good and bad times of order fluctuations. Loyalty is important when cheap materials are available on the market, but purchases are still made from a slightly more expensive supplier to give them support and get the advantage of buying cheap from the same supplier when material prices on the market go up. The interviewed companies agree that chasing “good deals” is more costly than staying with the same supplier. Closely connected
to long-term relationships are terms of delivery, which can be pinpointed as the main reason to have long-term relationships. For all the studied companies, one of the primary reasons for choosing suppliers is terms of delivery. A small firm studied in Paper III even view it as cheaper to have a long-term relationship with a builder’s merchant, because they can provide materials in smaller batches and thereby keep warehouse for the house manufacturer even though the price per product was much higher.

6.4 Striving to diminish variants of components
A house is of great complexity with its many different parts (Gidado, 1996; Winch, 1998). The studied companies in Paper III strive to diminish the numerous variations of components, since it makes the purchasing process complex (Van Weele, 2008). For example, if it is agreed within the company to use the same type of screws for a particular joint, purchasing can concentrate on buying those kinds of screws. Otherwise, too many different types lead to confusion and unnecessary stock. The same applies for all other parts of the house not requiring variation. Apparently, this is something that already has been done in manufacturing companies (Van Weele, 2008). However, it is better to purchase certain products customized so that they do not need to be adjusted before being disseminated into the production line. The companies have different views concerning the level of customer adaption of these kinds of purchased goods. In Paper III, one of the studied companies strives to buy as much “ready-to-use” components as possible, whereas the other company buys standardized commodity components that have to be adapted before use in production, e.g. the sawing of timber.

6.5 Buying to create value-for-production
Purchasing has a key role in its powers of creating value in the construction process (Lamming, 1993). The studied house builders in Paper III desire supplier relationships that are long-term and collaborative to facilitate the
construction process. Therefore, the concept value-for-production is introduced and considered as important in supplier selection (see Paper III). The price of material is not that important in choosing a supplier and a new model is created to reflect this, see Figure 15.

![Figure 15: Effectiveness of purchasing strategies on production related to risk](image)

The model was developed and inspired by Kraljics (1983)-model in the appended Paper III. The axis of “purchasing value” in Kraljic’s (1983) model has been replaced by “purchasing’s contribution to value in production”. All four squares mean other things than in Kraljic’s (1983) model due to the change of axis.

The lower left square is items that are bought at low risk and with purchasing adding little value to production. The studied company B (in appended Paper III) owns their own sawmills and thus has to cut their own timber, meaning a lot of work in-house. Therefore, this item exemplifies this square and the purchasing strategy is then argued to be vertical integration.
The lower right square contains items that are missing when doing finishing at the construction site. Here, purchasing adds little value to production and the risk of not completing on time is high. These items are typically rush-ordered or bought at local builder's merchants near the construction site. In all the appended papers there was the problem of incomplete modules.

The upper left square has low cost items and should always be at the factory. A typical example is screws. These can preferably be bought in large quantities.

The upper right square is high risk and high value for production. These items are house components and other customized solutions like pre-sawn timber. This purchasing strategy is typically characterized by a close relationship with the supplier in partnerships. Typically, a partnership starts as a partnership-of-convenience. The more collaborative the relationship the more it can evolve towards a strategic partnership.

All firms regard systems that can be directly integrated into the framing system positively, as it is a form of "turn-key" solution that has little interaction with other parts, except for a straight angle in the corner. The interviewed companies seem positive towards buying solutions, as a supported theory for efficiency improvement (Saxon, 2002; Green, et al., 2004; Brady et al., 2005; Bertelsen, 2005). The systems could be functional modules from suppliers in the form of house components that can be developed to more easily manage the construction process. However, full information and control of the construction process is needed to achieve this. By standardizing and controlling the process, co-created house components together with suppliers in partnerships can be integrated into the process and industrialized housing can evolve to new levels.
7. CONCLUSIONS AND FURTHER RESEARCH

In this chapter the conclusions of the thesis are presented as well as directions for further research.

7.1 Conclusions

Co-development, customization and secure deliveries seem to be the main reasons for industrialized house builders to have more long-term relationships than traditional onsite construction. The special competences of suppliers in the co-development of product and process innovations add value to house builders. Make-or-buy decisions are therefore central for house builders, where companies must carefully consider what capabilities are available inside and outside the company. Non-existent competences or those that can be enhanced by suppliers may be subject of co-development with partners. For specific components or services, the boundaries between buyers and sellers may become blurred through the close collaboration, which of course does not happen by itself. Integration requires a mutual understanding between people from different organizations. Here, leadership is important because it sets the rules of working, which contributes to knowledge and confidence in how to carry out tasks and decreases the risks for conflicts. This is a challenge for managers, since the construction process must be well-known, step-by-step to set the rules of working. Hence, one of the main challenges in making construction efficient and effective is that it is project-based and every project is unique. However, industrialized housing
has the pre-conditions of developing repetitiveness and standardization due to their placement in a factory environment. Through a site resource, a factory, industrial house builders have the prerequisites to gradually develop and refine their processes, e.g. according to the lean philosophy.

The more components and competences to coordinate the more complex becomes the organization. Complexity places great pressure on the purchasing department to coordinate purchased materials and services, which can be very costly if they fail or do it poorly. From a purchasing point of view, it is important that everything is complete when leaving the factory, as it is easier to coordinate deliveries to the factory than to the construction site. Industrial house builders should therefore go to the main reasons why the volume elements often are incomplete when leaving the factory, as noted in the case studies.

“Turn-key” solutions of smaller house components (e.g. the bathroom floor solution in Paper III) or larger house components (e.g. the bathroom pod in Paper V and the prefabricated kitchen in Papers II & V) decrease the risk of production failures in the form of delays, errors, unexpected costs and poor quality. It may initially be rather costly to develop and integrate “turn-key” solutions in collaboration with suppliers. However, once established, it may be less risky and less costly than coordinating everything in-house. The risk decreases because the responsibility is shared between supplier and buyer. The long-term relationship creates long-term business opportunities for the supplier in exchange for a secure production flow and cost control in a win-win collaboration of partnerships.

7.2 Further research

Further research of industrial house builders outside of Sweden would be interesting. Also, onsite construction and more studies of the assembly and finishing parts of industrialized housing would contribute further knowledge
concerning the coordination of suppliers and materials. Further, it would be interesting to study the hindrances to partnerships and how to overcome these hindrances.
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