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Supply Chain Management in the Construction Industry

Olsson, Fredrik

2000

Link to publication

Citation for published version (APA):
Olsson, F. (2000). *Supply Chain Management in the Construction Industry*. [Licentiate Thesis, Engineering Logistics].

Total number of authors:
1

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Supply Chain Management in the Construction Industry

- Opportunity or utopia?

Fredrik Olsson

Thesis for the degree Licentiate in Engineering

Lund University
Department of Design Sciences, Logistics
2000

Supply Chain Management in the Construction Industry - Opportunity or Utopia?

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ISRN LUTMDN/TMTP-1035-SE
ISBN 91-630-9705-2

KFS AB
Lund 2000

Preface

A specialist is someone who knows more and more about less and less, until he or she knows everything about nothing. A generalist, on the other hand, is someone who knows less and less about more and more until he or she knows nothing about everything. And in between, I guess, we find ourselves, the logisticians …

As a logistician, the construction industry appears to me as a very interesting arena where the most amazing things happen. Unlikely and almost frightening, as well as the most wonderful persons perform their daily work in an environment where ideas, presumptions about the world and attitudes that hardly could be seen anywhere else in our society prosper and grow. I am truly fascinated by all the tremendously, impressing – and sometimes weird - competence I have experienced among the everyday construction site heroes. Men, because sadly enough it is almost only men, every other day accomplish impossible things on impossible places in spite of impossible time schedules. Isn't it fantastic?

However, it is my humble ambition to change the world. It is an interesting task, and it seems to me as there is a lot to be done out there. And this very special part of the world, the construction industry, is - in spite of all of its amazing phenomena - in really deep need of changes. One way of speeding up this change processes in the construction industry is the missionary work of preaching logistics knowledge in order to shape up the supply chains of most construction materials.

In my work, I often meet practitioners. That is one of the benefits from research in an applied field as logistics. From time to time, people I meet refer to a gap between the academic world and the world of practitioners. Avoiding the philosophical aspects of the implications of the existence of all these worlds, I reject such a dividing of the universities from the industry, and I hope I have contributed to bridge the gap.

- *Get real!* I've heard. - *Get a job! Stop trying to be a scientist or researcher! Get out in the reality and see how it works.* We have all heard that, and maybe by repeating these imperatives ourselves we constitute the dramatic gap between academia and practitioners. But I don't buy that. Because I have been there, in that so-called reality. And I have worked in it. I have spent more time at construction sites than many of the top managers in the Swedish construction companies. And it makes me wonder. Sometimes I think that it is a pseudo-reality out there in the construction industry.

Instead I think it would be very healthy for a lot of the practitioners out in the so-called reality to visit our reality for a while: The research world. Look at our models! Think about some of these theories for a while! Or in other terms: Get real! Come into this world and see a whole new set of astonishing

possibilities! And why not realizing once and for all that it is not fruitful trying to divide research from practice, and that there is most probably no reality anyway, just our biased and prejudiced interpretations, untiringly dividing and urgently requesting each other to get real…

I am critical. People who don't know me might think that I am negative, continuously directing critique towards my surrounding systems. If it provides comfort for the external representatives of the construction industry, I can reveal that I am also critical to my department; very critical to the Civil Engineering education where I teach; almost hyper critical towards Lund Institute of Technology not to mention Lund University.

The questioning attitude is, however, not a sign of aggression. I like the systems I criticize, and I always have a portfolio of ideas for improvements up my sleeve if someone is interested! Seriously, I think that the intellectual numbness is a major threat to any organization, big or small, as well as it is a threat to our society. I see it as our duty to demonstrate true commitment and enthusiasm in order to contribute to improvements. That's the way I would like to live my life, and that's also the way my life has been lived during the work with this thesis.

The result is my licentiate thesis written as an academic assignment for my degree of licentiate engineering. I chose to write it in English since I thought I could need the practice, and also because I think there is a need to spread research results in this subject internationally.

Read the thesis. Get in touch with me, and let me know what you think. Let's change the world! Or let's initially at least change the part of it that consists of the Swedish construction industry.

They say that time changes things, but you actually have to change them yourself.

Andy Warhol

Acknowledgements

It has been a true joy to work with this thesis, and I would like to thank all to whom I owe my gratitude for support.

Especially, I would like to thank my friends and faculty colleagues at the division of Logistics at Lund University of Technology; discussions and laughs have been as essential to me as the air I have been breathing. Thank you Daniel, Stefan and Robert for interesting discussions. I would also like to direct my gratitude towards Robert, for supporting me at the gym as well as supervising me in esthetical matters in this thesis.

Thanks Kenth and Ulf for valuable advise. And thanks Dag for all the wild discussions, common attacks on the world and for teaching me how important support is while you were writing your own thesis.

Kristin is worth tremendous gratitude since she has been struggling with my written English in the thesis. Thank you ever so much!

An inspiring group that hardly ever no one pay their tribute to is the students. I would like to warmly thank all the inspiring students that I have had the privilege to teach in logistics. Two students - and friends - have lately been a special source of energy and inspiration: Jerker and Johan. Thank you, be open to new ideas, but remember: Hold on to your values!

The companies involved in the case study in the thesis, especially Skanska, deserve thanks for providing me with information. The Swedish building costs committee has also supported my work and been a source of inspiration. Thanks to Nils Yngvesson, Juri Lutz and Eva Gabrielsson.

Thanks Everth, my supervisor, for letting me walk my own ways, while you still have been guiding me. Patiently you have read my drafts supporting me with new ideas.

Lena, my love. Thank you for all your support. Let's go out there and find out what it is all about!

Lund, May 2000

Fredrik Olsson

Summary

In this licentiate thesis the implications of a deliberate use of logistics knowledge have been investigated by describing and analyzing the use of a supply chain management approach in the construction industry.

A five-step approach is used in the thesis. First, theoretical models are developed from the supply chain management literature. Two models are elaborated; One model identifying supply chain criteria and the other comparing traditional to supply chain-based supply.

Secondly, the literature study of previous contributions in the field is analyzed in terms of the models. The supply of construction material is found to be mainly traditional, that is focused on issues inside the company instead of being supply chain-based. Explicit criteria for supply chain management are not found in the literature treating the supply of construction material or construction in general. The strong development of logistical tools and concepts seen in the stationary industry seem to have no such corresponding movement in the construction industry.

A methodological discussion is carried out covering the general need for methodology and the need for qualitative methods. The implications from the desire to change the studied environment are discussed. A qualitative case study is chosen for the thesis, and it is handled in a systems model. The primary data is achieved from interviews, observations and documents.

As a third step in the five-step thesis approach, a case study is presented. It is a housing project called Bo Klok, mainly driven by the Swedish contractor Skanska and IKEA.

With a strong customer focus, the project was developed by the project managers to meet the consumers' demands, including how much they were willing to spend on housing costs. The consumers were identified as people with normal income. A conventional construction approach was found to be too expensive, and hence the project management developed a new approach. By a series of systematical efforts to change the conventional business environment, the structure of the material flows has been altered and the prerequisites for construction have thereby been improved. Change actions in the case study are e.g. continuous ambitions for a holistic approach, incorporating site deliveries and challenging traditional purchasing patterns.

In order to secure a fast high quality production, an industrial approach was found to be necessary by the project management. To be able to evaluate how design decisions affect the conditions in the supply chains, a fruitful iterative communication between the architect and material suppliers was encouraged. This for example meant that some value adding activities were moved to earlier organizations in the supply chains. It also meant that the local

construction manager is not allowed to decide or influence methods, materials or planning in a Bo Klok project as in normal construction projects.

In order to reduce the total cost for the project to reach the pre-decided cost level, all possible parts of the project were investigated. In combination with the holistic approach in the project, this led to that the existing purchasing patterns for installation materials were challenged. In order to achieve cost transparency and be able to reduce costs for the installation materials' part of the total cost, Skanska tried to buy these types of products directly from manufacturers and wholesalers. But these new ideas concerning an altered material flow structure in the project have met strong resistance. Especially the participants in the traditional supply chains for installation materials protested loudly and tried to stop the challenge.

The active and pro active change of the conditions of the production that is seen in the case study is from a logistic perspective notable and unconventional for the Swedish construction industry. In general, active and deliberate efforts to change and improve the conditions for the on site production instead of accepting them are rare. The actions in the case have by the project management been considered to be forced in order to reach the project cost level decided by consumer preferences. As such initiatives are not seen in other types of projects on the Swedish housing market, a general unused cost saving potential exists. All types of changes that have been used in the Bo Klok project are not applicable for all types of construction projects, but still a general potential is undoubtedly present. The approach used in the Bo Klok project has enabled production of high quality housing to a cost level low enough for consumers with ordinary incomes to afford to demand.

In order to explain the unconventional purchasing patterns in the case study from a supply chain perspective in terms of action research, supply chain models have been introduced to the companies participating in the supply chains. The supply chain models have however not been recognized nor accepted. In order to bridge the gap that obstructs the understanding of structural changes in the material supply to meet consumer needs, a new model is presented in the thesis.

The model connects the phases in the construction value chain to the supply of construction materials by the common entity the construction phase on the site. The need for communication between early stages, e.g. between the designers and the construction material manufacturers, is essential in the model and this kind of information must be encouraged, managed and controlled.

In the fourth step of five, the actions and the pragmatical adoptions that have been done in the case are described and, finally, in the fifth step the case and the study in general is concluded. The approach used in the case study project Bo Klok is a step towards a supply chain-based supply, but it can not be

described as a supply chain management approach. Even if the actions in the case make sense in a supply chain management context, it has not been a question of a deliberate and systematical use of a supply chain management approach.

Supply chain management is a great opportunity for the construction industry primarily to reduce costs and time, and thus improve revenues and still make the products more worth their prices. New latent markets for low price housing could be developed. Also product development and marketing for construction material in the supply chains could be made more effective and efficient. Obstacles for supply chain management approaches are e.g. the poor level of logistical competence, the partly limited competition, the strong project focus as well as the attitudes and traditions in the construction industry.

Keywords: supply chain management, logistics, construction industry, effectiveness, efficiency, material flows, Sweden, case study, models

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1. Introduction

In order to show the relevance of the study the background described in this chapter contains an introduction to the Swedish construction industry, the changes on the market and the need for effectiveness and efficiency. From this a research question is stated followed by demarcations and objectives for the research.

A thesis structure that will be used in the text in order to be able to present answers to the research question is also presented.

1.1 Background

1.1.1 The Swedish Construction Industry[1]

The construction industry is considered to be an engine in the national economy. It is a large, mature business and it has many important links to the rest of the economy, e.g. private costs for housing and business investments. There are more than 600 million square meters of residential housing or other types of houses of various types in Sweden, and the total annual turnover in the construction industry is estimated to nearly 200 billion SEK.[2] Totally, more than 450 000 people are employed directly or indirectly by the construction industry.[3]

The construction industry in Sweden was heavily subsidized in various forms since the second world war; the political policies and the ambitions for the national standard of living influenced and determined the conditions for the construction industry to a large extent.[4] During this period that continued until the early 1990s the Swedish construction industry operated in, adapted to and was comfortably familiar with - this existing climate.[5] The production of dwellings culminated during the time from 1965 to 1975 when the political goal for the period to produce 1 000 000 new homes was accomplished.[6]

In the early 1990s, the Swedish construction industry experienced a crisis, and production volumes decreased dramatically.[7] The number of multidwelling blocks that have been completed yearly since that time reached the lowest

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[1] When the Swedish construction industry is mentioned in this thesis, focus is on the part of the industry that produces residential housing.

[2] http://www.bfr.se

[3] http://www.byggentreprenorerna.se

[4] Sandberg, N-E (1997), "*Byggkraschen*", Ekerlids förlag

[5] Fernström, G (1990), "*Byggbranschen på 90-talet – kris eller tillväxt*", Byggförlaget

[6] Turner, B & Vedung, E (1997), "*Bostadspolitik för tjugohundratalet*", Meyers information & förlag

[7] Ibid

levels ever in modern Swedish history, about 10 000 units a year.[8] Subsidies were dramatically reduced in several steps, and the VAT for residential housing suddenly rose to the same levels as other industrial products. Regulations that earlier were extensive were now partly reduced.[9] These were hard strokes against the existing industry, and suddenly the environment that the parties on the market had been used to seemed very far away. And even though productivity improved, the market was still unable to afford the products that the construction industry offered.[10] The only exception was the market for extremely expensive flats in the city centers of the big cities, at least in Stockholm. A general recovery of the economy has to some extent recently changed the conditions for investing in building projects, but for dwelling houses the number of new projects still is very small.[11]

The cost development for housing in relation to other industries is worrying *(*Figure 1*),* and the industry could today, regardless recent improvements, be described as high cost industry with low productivity.[12]

[8] Byggentreprenörerna (1997), "*Fastigheter och boende i siffror 97/98*"

[9] Fernström, G (1990), "*Byggbranschen på 90-talet – kris eller tillväxt*", Byggförlaget

[10] McKinsey Global Institute (1995), *"Sweden's Economic Performance"*

[11] http://www.byggentreprenorerna.se

[12] McKinsey Global Institute (1995), *"Sweden's Economic Performance"*

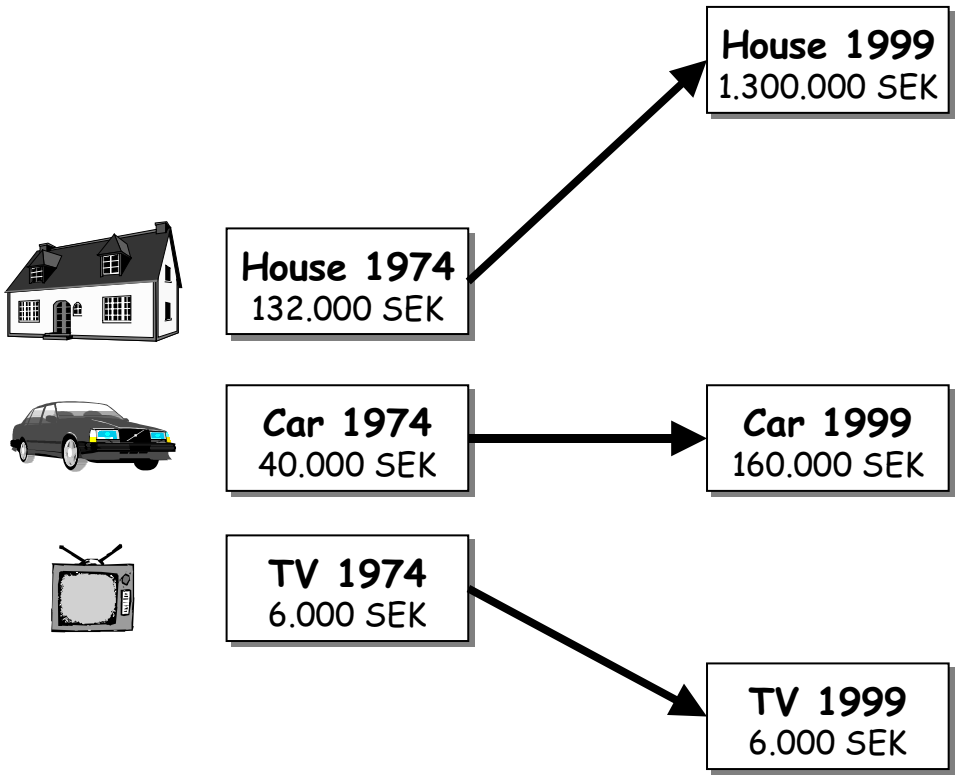


Figure 1: Approximate cost development for three product groups 1974-99. (Consumer price index about 300 %.)

There is a strong connection between the state of the market and the productivity in the construction industry; when there is an upward economic trend, the productivity becomes worse. The contrary development is seen when there is a downward economic trend.[13]

The last ten years have been a harsh time, but absolutely not wasted, for the construction industry. Companies have been forced to ask themselves what they are doing, and spoken as well as unspoken questions about efficiency and effectiveness in the business have been raised.[14] Before the subsidies disappeared, the ambition for the construction companies was maybe not always to improve efficiency but rather to adapt to regulations and the large number of rules. There were even extremely detailed rules, e.g. stating the minimum length of the hat shelf in a Swedish home, that the construction companies had to follow in order to get subsidies for the project. So the hunt for costs in the business has been neither continuous nor dominating the development of production techniques and processes in the cyclical business environment, experienced as extremely difficult by the companies. The industry's awareness of the importance of systematically reducing costs seems to have been repeatedly disturbed or even almost completely forgotten in consequence of the extreme fluctuations on the construction market. From

[13] Sveriges Byggindustrier (2000), "*BYGGkonjunkturen 2/2000*", Ekonomiska sekreteriatet

[14] Fernström, G (1996), "*Ett epokskifte. Samverkan för framgång i bygg- och fastighetsbranschen*", Byggförlaget

time to time, or from market to market, the business is today overheated. Busy making fast profits on the golden, temporary markets where costs does not matter, no one seems to have the time or patience for reducing project costs. And on the difficult markets, where reducing costs ought to be essential, there is unfortunately hardly any time nor money for new kinds of thinking in the sparse projects that are started.

The domestic market consists of a few very large and a lot of small construction companies. Firms with just one or a few employees are representing nearly half of the total employment.[15] The medium sized companies have been knocked out during the difficult times. The big companies are now dominating the scene of the Swedish market in media and in the political debate with a handful powerful actors. But in spite of their size, the revenues from the construction activities have been alarming, about two percent and the revenues are still poor.[16] Repeated mergers as well as internal reorganizations have been done in the larger construction companies, and new strategies are now tried out. Even though concepts for improving quality and productivity have been introduced and stayed in focus during the 1990s, and the purchasing patterns highlighted and generally improved, the market for housing is still difficult. The prices are too high for the customers to afford. This has probably many reasons. The total tax pressure is one worth discussion, but one reason of more strategic importance is that the companies have settled in a performance where the cost levels are too high. And today they almost only operate on markets were the high costs are accepted since the prices that the rare financially insensitive customers are willing to pay are even higher. Today the construction companies are thus not forced to intensively put all their efforts into reducing their costs on the market they act on.[17] But this market is small.

1.1.2 Activities in the Logistics-Construction Field

The environmental conditions for the flows in the construction industry are often more difficult to control than the conditions for the stationary industry. Instead of more or less continuos flow to be managed in a specially designed environment as in most of the stationary industry, many different flows are often fairly successfully managed in a project-unique environment. So far this has however not meant that the construction companies have put more efforts into developing logistical skills. On the contrary, the activities to control and manage these flows have been limited and sparse.

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[15] Byggentreprenörerna (1999), "*Fakta om byggandet 98"*

[16] "*Byggföretagens ekonomi 1997*" (1997), Byggentreprenörerna

[17] Olsson, F & Larsson, E (2000), "*Flödesorienterat byggande – lägre boendekostnader med hjälp av helhetssyn på byggindutrins materialflöden*", Byggkostnadsdelegationen

The construction sites are in one way a very intense logistical spot; there is a lot of material that is managed in a complicated way in order to build the products and fulfill the customers' requirements. But from a logistical point of view, very little is actually done in order to affect and change the conditions of the material flow. Generally conditions on the site seem culturally accepted and mostly unquestioned instead of being an area of deliberate and active change in order to meet the often not articulated customer needs on the site.[18] A logistical problem in a project is thus not a real problem; it is just a part of the everyday situation on the site.

A lot of logistical activities are of course being done in most parts of the construction industry. But there seems to be very little of the deliberate, pro active actions that are the most efficient and effective way of controlling and managing material flows.

Logistics knowledge is seldom represented in the organizations in the industry, and trained logisticians are in principle not seen, at least not in the construction companies. This makes difficulties related to logistics hard to solve, since there is a lack of terminology as well as ideas of possible solutions. And in the Swedish as well as international research related to the construction industry, logistics is an almost non-existing field. A number of studies have come to the conclusion that there is an enormous potential concerning logistics in the construction field.[19]

1.1.3 Supply Chain Performance

The efficiency and the effectiveness in the supply chains of the construction industry are poor.[20] Customer power seems not to influence the supply chains to reduce costs and improve performance, and the customers hence experience their situation as powerless. But also the large construction companies are - in spite of their scale - acting surprisingly weak and as if they were powerless, regarding the control of the supply chains.[21] And the end customers, e.g. the consumers or their representatives, often relate to the industry in general and the contractors in particular as unwilling to improve performance or reluctant to reduce prices. The purchasing patterns have however slowly been changed during the last years, and one may now see a movement in the big Swedish construction companies towards a more professional behavior controlled by

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[18] Jarnbring (1994) "*Byggarbetsplatsens materialflödeskostnader*" Institutionen för teknisk logistik, LTH

[19] Eg. Statens byggeforskningsinstitut (1995), "*Logistik i byggeriet*", SBI-rapport 256, Fransson, H (1996), "*Byggmaterialflödets övergripande struktur och styrning*", Institutionen för teknisk logistik, LTH

[20] McKinsey Global Institute (1995), *"Sweden's Economic Performance"*

[21] Olsson, F & Larsson, E (2000), "*Flödesorienterat byggande – lägre boendekostnader med hjälp av helhetssyn på byggindutrins materialflöden*", Byggkostnadsdelegationen

the headquarters' strategy.[22] And partnering with suppliers includes thinking that highlights upstream phenomena and supply chain aspects. But today, still, the actions related to the flow seldom seem to be coordinated with the initiatives of others involved in the supply chains.[23] Sub-optimization in various forms seems often to be the result. There is a clear gap in supply chain practice between the manufacturing and the construction industries.[24]

Different parts of the performance in the supply chains of the construction industry have been examined in different contexts. This repeatedly and undoubtedly reveals a substantial potential for improving the overall performance.

1.2 The Research Question

How could a more deliberate use of logistics knowledge change the conditions for the actors in the construction industry?

1.3 Purpose and Objectives of the Thesis

The general purpose of this research project is to improve the effectiveness and efficiency in the construction industry.

To describe and analyze the effects of using a supply chain management approach in the construction industry is the specific objective in the thesis.

Sub-objectives are:

- Highlighting potentials for improving effectiveness and efficiency for the actors in the construction industry - including companies as well as the end consumers - by studying material flows.
- Designing models for explaining and connecting new knowledge to existing, related ideas in order to show opportunities and potential of supply chain management and logistics in the field of construction.
- Putting logistics as phenomena on the agenda in the Swedish construction industry, in the researchers' world as well as among the practitioners.
- Contributing to widening the focus in the construction industry of today from the production site to include supply of materials.

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[22] Dubois, A & Gadde, L-E (2000), "*Supply Strategy and Network Effects – Purchasing behaviour in the construction industry*", IMPSERA Workshop, Jönköping 2000-03-31

[23] Olsson, F & Larsson, E (1999), "*Godsflöden och transporter inom byggindustrin – Studie av förutsättningar för effektivisering och reducerad miljöbelastning*", Rapport 4954, Naturvårdsverkets förlag

[24] Naim, M M (1997), "*Lessons for construction from manufacturing systems engineering*" Logistics Technology International 1997

- Discussing methodological aspects in order to contribute to logistics and construction management research.

1.4 Focus and Demarcations

The empirical data in this thesis comes from studies on the Swedish market. Even though many of the observations are of a general nature, the focus is on residential housing.

The material flows discussed are flows during the production phase. This implies that it is not rebuilding, redesigning or maintenance phases that have been studied.

Notable is that technology and operational aspects of flow control are not in focus, although frequently mentioned. It is rather the prerequisites for implementing the technology and the relevant complexity and structures of the flow that have been examined.

When it comes to aspects of how the housing market is operating today - or how it could operate tomorrow – political implications might emerge. A lot of the work in this thesis may have political implications, but the ambition of my work is in itself not political.

In accordance with the very idea of supply chain management, a holistic approach is used in the study. The total efficiency and effectiveness in the material supply is the scope of the study, and the discussions could to a large extent be seen from the clients' perspective.

1.5 A Guide to the Thesis

1.5.1 Thesis Approach

In order to answer the research question, a five-step approach *(Figure 2 & Figure 3)* will be used in the thesis*:*

First, theoretical models for identifying and classifying supply chain activities will be developed from the literature. This is presented in *Chapter 3, Supply Chain Management.*

Secondly, the literature review of the field of logistics in construction will be analyzed in terms of the theoretical models in *Chapter 3, Review Summary and Analysis*.

The terminology of the models will subsequently be used to structure the data presented in the case study, *Chapter 4, An Unusual Construction Project - Case Description and Initial Analysis.*

In the fourth step, the analysis, the case findings will be understood in the light of the supply chain models.

To complete the picture, the case findings and the findings from the literature review in the conclusions will finally be summarized and condensed in a structure based on the theoretical models.

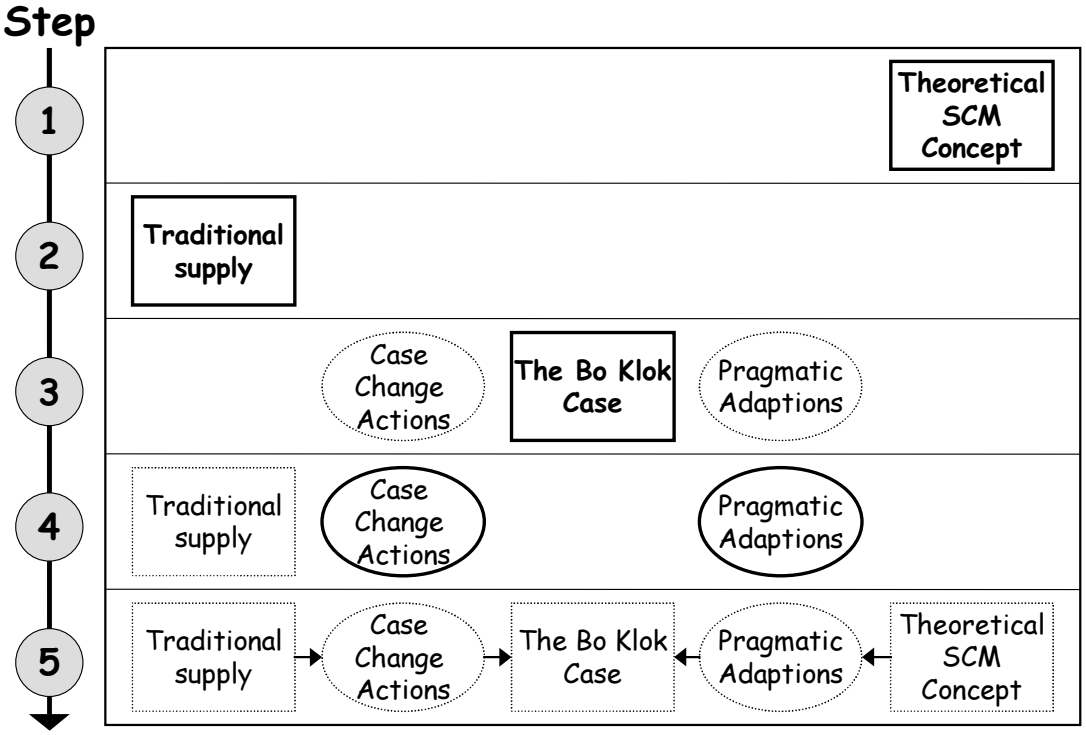


Figure 2: The five-step model used for the approach in the thesis.

This five-step thesis approach will be used to guide the reader in the text, and the steps will be explained with a figure.

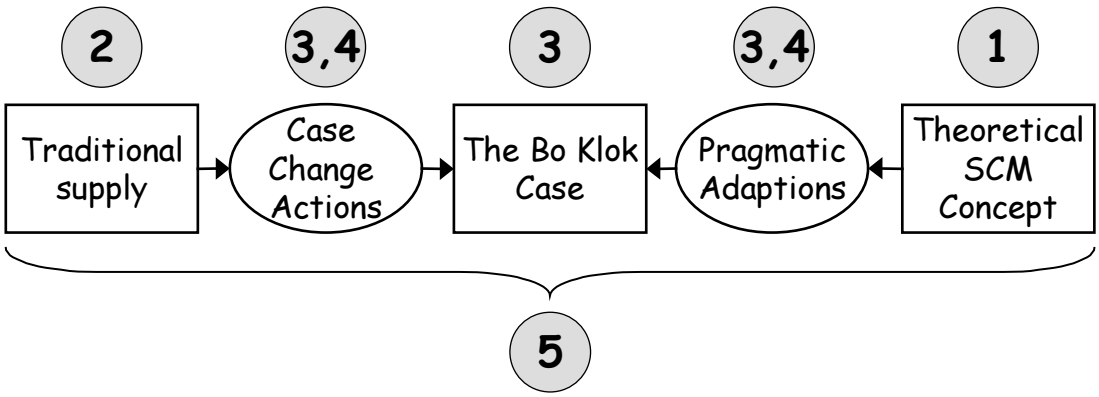


Figure 3: The five steps arranged in a non-sequential structure, used as a framework in the thesis.

Together the five parts in the thesis approach constitute a scale, from traditional supply on to the left, moving towards ideal theoretical supply chain management on the right *(Figure 4)*. The scale is used for discussing the case study.

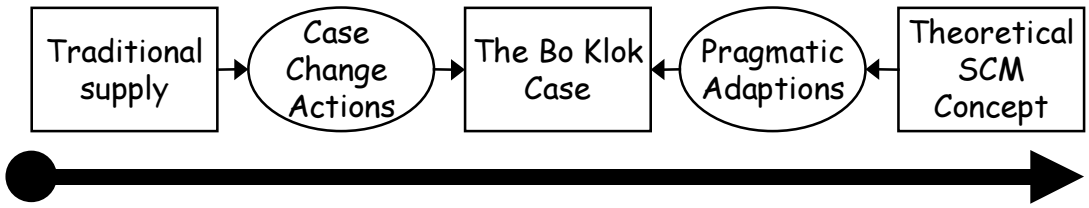


Figure 4: The five steps arranged to constitute a scale for describing to what extent supply chain management is used.

1.5.2 Thesis Outline

In Chapter 2 the methodology used is described. A general discussion about methodology in the field of logistics research is included. Reflections on contemporary research in the Swedish construction industry and systems thinking are also included in this chapter.

Chapter 3 contains the frame of reference for the study including the development of the theoretical model and a literature review.

In Chapter 4, the main case study, Bo Klok, is presented.

Chapter 5 is the synthesis where the findings in the case study are used to point out what could be done in order to improve the situation.

Chapter 6 is the analyzing part. Another model is also presented, trying to bridge the supply chain theories to other existing knowledge in the industry, with the purpose to create and increase understanding.

In Chapter 7 the conclusions from the work are finally presented.

1.5.3 Target Audience

This thesis is written as an academic assignment, the degree licentiate of engineering. However since logistics is an applied science and the objective is to show the potential for - and to initiate – changes, the thesis is written for the university graduates as well as for practicians and politicians. The explanative nature of the research, and the desire to show the potential of logistics, means that the language used is trying to connect to the existing knowledge among the practitioners. In order to get a holistic understanding of the study – and that is indeed desired when studying complex problem situations – the most reasonable reading recommendation is to read the whole thesis.

Readers that have an interest in methodology and management science might take special interest in the discussions in chapter 2 and 3. For researchers, logisticians and non-logisticians engaged in research related to the construction industry, the literature review of primarily Swedish contributions relating to the construction-logistics could be of special interest.

Any reader confused by the author's desire to show the need for logistics and supply chain management and the rejection of a pseudo-neutral research stance, is advised to read the background of logistics in construction in chapter 2 and 3.

Practicians interested in how to benefit from the ideas in the thesis are advised to initially direct their main focus on the case study, and then pay attention to the analysis and the final conclusions.

For politicians trying to support an industry development that leads to reduced housing costs besides the ones mentioned in the conclusions, the case description, case synthesis and analysis are advised as main focus.

In the suggestions for future research, any actor can find what we together can dig into tomorrow.

1.5.4 Ambition

My ambition is to initiate and support changes in the construction industry. Thus the work behind this thesis could be described as embraced by action research. Action research means that the researcher rejects a neutral relation to the studied environment and deliberately tries to initiate changes. And in order to influence and be a part of the environment where the desired changes are wished to take place, without reducing the quality of the research work, an interest for methodology is seen as an essential part.

By acknowledging the complexity of the studied problem in harmony with qualitative research traditions, I also think that methodological aspects of research are emerging in such complex studies. It is extremely important to understand the problems before they are solved!

An emancipatory interest is the desire to change unsatisfactory state of things in order to free someone from mental models, social, political or legal restrictions. By my interest in methodology I try to consciously manage the effects of my emancipatory interest, and, in order to benefit from this driving force, to improve validity and reliability in my research work.

1.5.5 Relation to Earlier Work

Before this thesis was finished, a number of research projects intimately relating to this area have been completed. Especially two major projects are worth mentioning since they will frequently be referred to, and they have both been important for the author's present level of understanding.

During 1998 work was done in a study for the Swedish Environmental Protection Agency, in which flow of goods and transportation were studied in

the Swedish construction industry[25]. And in 1999 a report for the Swedish Building Costs Committee, Ministry of the Interior, was written[26]. The latter report was to a large extent built upon the same empirical data as this thesis.

[25] Olsson, F & Larsson, E (1999), "*Godsflöden och transporter inom byggindustrin – Studie av förutsättningar och reducerad miljöbelastning",* Naturvårdsverkets förlag, Rapport 4954

[26] Olsson, F & Larsson, E (2000), "*Flödesorienterat byggande – lägre boendekostnader med hjälp av helhetssyn på byggindustrins materialflöden",* Byggkostnadsdelegatioen & Avd. för teknisk logistik, LTH

2. Research Approach

After reflecting upon methodology in general, the methodological considerations for this research are described. A discussion whether the attraction to qualitative methods leads to complications for engineers is followed by some ideas about how systems thinking comes about.

A systems approach for the thesis is elaborated in order to structure, present and analyze data in the case study. In order to show consciousness, the implications from the desire to change the studied environment is also discussed.

2.1 Why Bother About Methodology?

In the logistics field not much has been published on methodological issues[27]. And in an often very pragmatic discipline as logistics, it might sometimes be considered as an unnecessary task to deal with methodological questions. This could be explained by the relatively new part of the scientific world that logistics represents. But if methodological issues are neglected, it may threaten to damage the discipline in the long run.[28] In order to meet demands of quality regarding the research work, such as validity and reliability, an aware and deliberate use of appropriate methods is required.[29] Another reason for rigor concerning methods in an applied science as logistics where researchers are working close to consultants – and sometimes even as consultants – is the risk that the logistics researchers might sometimes not even be aiming for creating new knowledge. And that kind of work could hardly be considered as research.[30]

> *It is not surprisingly that engineering as a professional activity attracts action-oriented people who value practical achievement above all else. A result of this is that engineers and technologists are impatient with theorizing; after a good design has been successfully realized in practice they are little inclined to analyze the way they went about achieving it. As a result the literature of engineering methodology is not extensive, in spite of the fact that public speculation on the role of engineers usually embodies rather grand vision.*[31]

I would like to contribute to, and build upon, the methodological evolution that has taken place on my department. Many of my associates have done,

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[27] Stentoft Arlbjörn, J & Halldorsson, Arni (1999), "*Logistics Knowledge Creation: Reflections on content, processes and context*", Proceedings from NOFOMA 1999

[28] Ibid

[29] Wallén, G (1993), "*Vetenskapsteori och forskningsmetodik*", Studentlitteratur

[30] Gummesson, E (1985), "*Forskare och konsult – om aktionsforskning och fallstudier i företagsekonomin*", Studentlitteratur

[31] Checkland, P (1993), "*Systems thinking, systems practice*", Wiley

from my point of view, admirable efforts to discuss and develop methodological issues applied in the field of logistics.[32] Because in my opinion, there is in the academic world and in the research world of logistics in general, a notable lack of patience in attitude towards the methodological issues, and e.g. philosophy is often considered as something that has nothing to do with it. If you just conduct your research correct, then there really is nothing to discuss. But what is then the correct method? The choice of method depends on what problem you are studying. But the problems that are studied - and in the world of logistics it is often indeed complex problems that are examined – are experienced in different ways depending on the researcher's opinions about the world. Such - more or less aware - assumptions about how the researcher sees his/her relation to the studied problem can be described and is called ontological assumptions. And the researcher's very basic assumptions about the world and its possible reality is his paradigm[33]. The paradigm affects the way the problem is seen, the way the possible methods are regarded and how knowledge might be gained. So included in a paradigm is also the epistemology, that is the ideas about how knowledge about the world is created and what relation the knowledge has to the observed world. Epistemology is knowledge and theory about theory.[34] And this is indeed philosophy!

So an important part of the research work is the reflections from time to time concerning methods and the philosophical implications on the research. These reflections must aim for awareness about the paradigms that the research is founded upon. Alvesson and Sköldberg[35] write:

> *Reflection means that you interpret your own interpretations, you perspectivize your own perspectives and you put your own authority as interpreter and author in a self-critical highlight.*

And reflecting seems essential if knowledge:

> *… takes place in a real sense (and in an ethically correct manner) for both the creator of knowledge and for his or her environment only when the work is based on a conscious assumption about reality: When the creator of knowledge understands what knowledge is and how it comes about.*[36]

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[32] Lately e.g. Näslund, D (1999) and Knudsen, D (1999)

[33] Abnor, I & Bjerke, B (1994), "*Företagsekonomisk metodlära*", Studentlitteratur

[34] Wallén, G (1993), "*Vetenskapsteori och forskningsmetodik*", Studentlitteratur

[35] Alvesson, M & Sköldberg, K (1994), "*Tolkning och reflektion*", Studentlitteratur

[36] Arbnor, I & Bjerke, B (1997), "*Methodology for Creating Business Knowledge*", Sage Publications

2.2 Methodological Frame of Reference

Burrell and Morgan[37] offer a four dimensional scale for social science *(Figure 5)*. Since I think that my work is not independent from social dimensions, I will briefly state my own research stance in the light of these four dimensions that are based on an objective-subjective scale. The dimensions are odontology, epistemology, human nature and methodology.

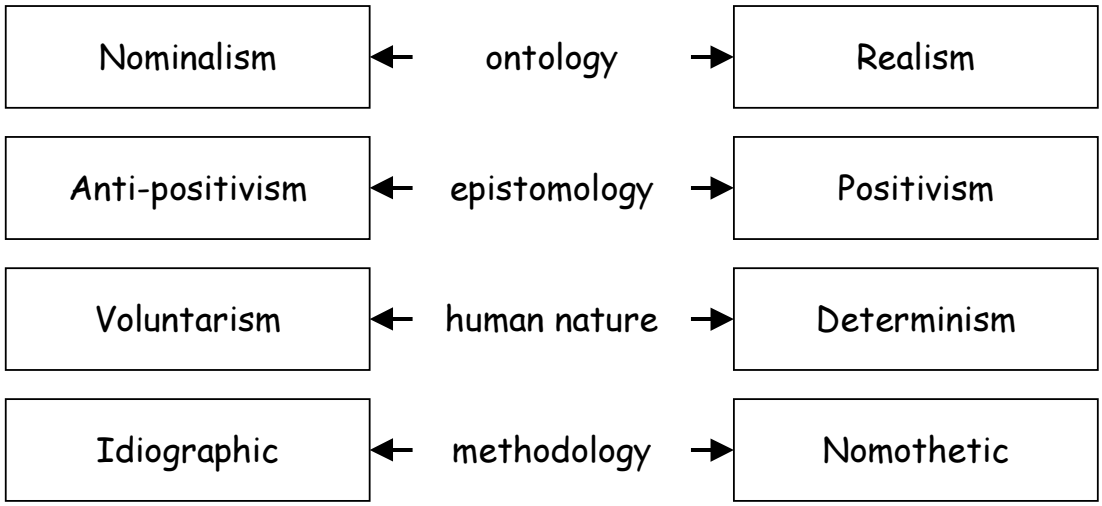


Figure 5: Assumptions about the nature of social science.[38]

The discussion of the Burrel and Morgan model is here quite brief, but it will be more elaborated, explained and discussed later in relevant context. By mainly rejecting an objectively existing reality, I put myself in a position closer to nominalism. And in terms of epistemology I see myself clearly attracted by anti-positivistic thoughts - or I am rather rejecting the positivistic standpoint. In my view it is also natural to accept a more voluntaristic view on the human nature scale. Fatalism and deterministic views do not attract me, but I do see the dimension, also discussed by Wigblad[39]. As a relevant methodological dimension it is complex and heavily relying on the other three dimensions.

The position on the four scales will lead to a certain research approach. This is probably also true in my own research work, where I end up in conducting a qualitative case study with a systems approach.

The objective-subjective scale that Burrell and Morgan's model is based upon is by Arbnor and Bjerke[40] roughly seen as three different parts, a view supported by for example Wallén[41] and also Holme and Solvang.[42] They state

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[37] Burell, G & Morgan, G (1994), *"Sociological Paradigms and Organizational Analysis: Elements of the Sociology in Corporate Life*", Ashgate & Aldershot

[38] Burell, G & Morgan, G (1994), *"Sociological Paradigms and Organizational Analysis: Elements of the Sociology in Corporate Life*", Ashgate & Aldershot

[39] Wigblad, R (1997), "*Karta över vetenskapliga samband*", Studentlitteratur

[40] Arbnor, I & Bjerke, B (1994), "*Företagsekonomisk metodlära*", Studentlitteratur

[41] Wallén, G (1993), "*Vetenskapsteori och forskningsmetodik*", Studentlitteratur

that we can look upon research work with an analytical view, a systems view or an actor's view *(Figure 6)*. The first and the last views are not difficult to compare to Burrell and Morgan's model but the systems view is somewhat a hybrid in the middle. Arbnor and Bjerke see an important difference between explaining and understanding. One question is whether it is necessary to reduce complexity or if it is better to problematize in order to increase complexity when (social) phenomena are examined. Wigblad recommends increasing complexity when studying (open) systems, e.g. the causes of production disturbances.[43]

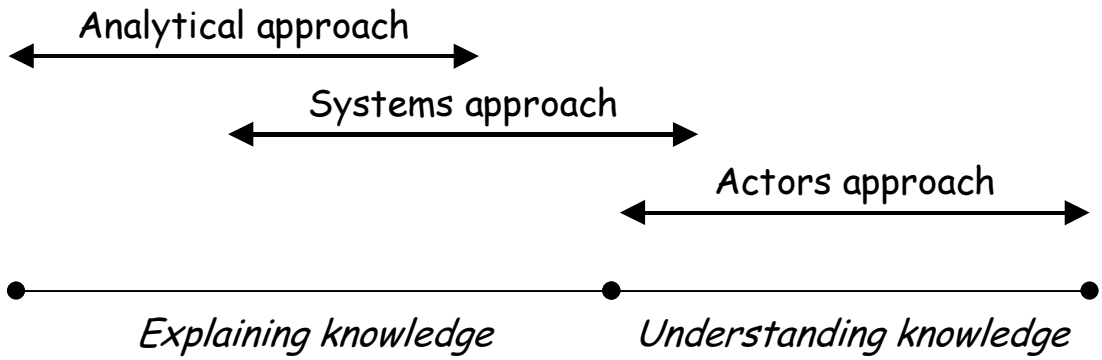


Figure 6: Different objectives of the methodological approaches.[44]

The analytic view requires an existing theory and is aiming at falsifying or verifying hypothesis. Causes and effects are sought in a logical context, where the results are possible to generalize. An underlying assumption is that there is a reality, and that it is independent from us.

Working with the actor's view, theories about theories often lead to philosophical discussions about our consciousness and the social constructs in our environment. Knowledge is not considered a cumulative process and hence the research front is not considered a meaningful term.

The systems approach will be further discussed later in the thesis.

I have chosen to further discuss methodology in terms of quantitative and qualitative methods, a level of complexity chosen in the light of the importance of epistemology, emphasized for example by Denzin and Lincoln[45]. I would not describe it as a fight between the two methods; it is today not a question of qualitative versus quantitative methods. There is no conflict! Most authors would now certainly agree that it is an anachronistic fight. But for the researcher who has his roots in a quite positivistic field, as

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[42] Holme, I M & Solvang, B K (1986), "*Forskningsmetodik. Om kvalitativa och kvantitativa metdoder*", Studentlitteratur

[43] Wigblad, R (1997), "*Karta över vetenskapliga samband*", Studentlitteratur

[44] Arbnor, I & Bjerke, B (1994), "*Företagsekonomisk metodlära*", Studentlitteratur

[45] Denzin, N, K & Lincoln, Y, S (1994), "*The Handbook of Qualitative Research*", Sage Publications

myself, I think it is worthwhile to stop for a moment and consider the pros and cons related to the quantitative and qualitative methods. How will the choice of methods affect the results of the research within a certain context?

2.3 Overall Methodological Reflections

2.3.1 Quantitative and Qualitative Stances

As an engineer I'm trained to think in an analytical way. This means for example reductionism, the belief in causality and an overall belief in that knowledge itself is independent of individuals. During most of my higher education the methods used were not often a discussed matter. It was more like an unspoken assumption, which for me now seems as mostly an analytical and quantitative relation to knowledge, that was commonly used and almost entirely unquestioned in the engineering environment at the Institute of Technology.

But as I started my Ph.D. studies, I soon paid interest in methodological issues. Basic studies of the business methods literature led to more studies. Studying the methodological literature widened my previous quite myopic view of methodology. Suddenly there was a wide range of different methods offered for the researcher, and this was an important insight. Different methods applied on the same question often lead to different answers. Also different methods are more or less appropriate for different problems.

> *If you only have a hammer to solve your problems, it is likely that you treat all problems as nails.*[46]

To me, there seems to be a tendency among engineers and scientists like logisticians with engineering roots to forget the implications of humans in the systems. It might be all right when studying "hard facts" in a "hard system", but it is dangerous if "soft" conclusions are drawn in the analysis. I fear that this often is caused by a lack of methodological knowledge.

This is to me an epistemological insight that highlights that in general terms we have objectivity on one hand and the idea of duality of mind and reality on the other (as the Burrell and Morgan scale). This latter idea, originally introduced by Immanuel Kant, was at first in conflict with classical analytical philosophy and general western thinking[47]. The conflict sometimes still seems to be hidden under the surface. To me, researchers unwilling to accept qualitative methods in research are still suffering from these days of conflict. From the idea of so to speak inside-the-head knowledge, different branches and methods have evolved.

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[46] Unknown

[47] Denzin, N, K & Lincoln, Y, S (1994), "*The Handbook of Qualitative Research*", Sage Publications

2.3.2 Considerations Regarding Quantitative Research

Working with quantitative methods provides the researcher with a powerful tool. Answers are likely to be precise, measurable and easy to understand. It was this eager ambition to produce "real research" and "real results" that was the driving force for August Comte when he introduced the term *positivism.* He wanted to guide society with the help of social science to a "better" stage, from the religious via the metaphysical to the scientific stage, the "true" stage (*positive* in French).[48]

Quantitative research often means that historical data is examined. This could be seen as a disadvantage as well as a possibility. But it is sometimes hazardous to look back in order to predict the future. Another aspect is that you in quantitative studies probably only find what you are looking for. Results that do not fit with your assumptions are hard to find, since the survey, the quantitative model or the algorithm are not designed to measure it. Generally a few variables are examined by studying a lot of samples.[49]

Mature subjects or research areas are more appropriate for quantitative methods, since quantitative research is more or less depending on quantitative data. But what happens if the field does not provide the necessary data? Olsson and Larsson relates to authors who highlight the lack of previous research within the logistics-construction field and the difficulties to understand or interpret the results from the few quantitative studies that have been conducted.[50] Silverman[51] writes that purely quantitative researchers may neglect the social and cultural construction of the "variables" which they seek to correlate.

So the tricky question is: What do your answers really mean? It is a question that has to be faced when working with quantitative methods. Van Maanen[52] illustrates with this dialogue:

> Qualitative researcher: *"Many people these days are bored with their work …"*
>
> Quantitative researcher: *"What people, how many, when do they feel this way, where do they work, what do they do, why are they bored, how long have they felt this way, what are their needs, when do they feel exited, where did they come from, what parts of their work bother them most, which…"*

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[48] Arbnor, I & Bjerke, B (1994), "*Företagsekonomisk metodlära*", Studentlitteratur

[49] Wallén, G (1993), "*Vetenskapsteori och forskningsmetodik*", Studentlitteratur

[50] Olsson, F & Larsson, E (1999), "*Godsflöden och transporter inom byggindustrin – Studie av förutsättningar för effektivisering och reducerad miljöbelastning*", Rapport 4954, Naturvårdsverkets förlag

[51] Silverman, D (1993), "*Interpreting Qualitative Data*", Sage

[52] van Manen in Stentoft Arlbjörn, J & Halldorsson, Arni (1999), "*Logistics Knowledge Creation: Reflections on content, processes and context*", NOFOMA Conference in Lund 1999

Qualitative researcher: *"Never mind."*

Surveys can be difficult to carry out in a field where definitions are unclear.[53] Logistical phenomena in the supply chains in the construction industry are not easy to define, such as late deliveries, total costs, disturbances and so forth. The researcher and often the studied environment as well, has to understand the problems well enough in order to raise the proper questions and answer in a meaningful way. There is a substantial risk for the more impatient and quantitative oriented researchers that we - as the poor humans in "the Hitchhiker's Guide to the Galaxy"[54] - are eager to find the answer even before we fully understand the question…

Wigren[55], who has been working with many quantitative research projects in the construction industry in Sweden, mentions the difficulties concerning definitions. In his research about construction materials, he describes parts of the terminology as a "black box"[56]. Even though the quantitative data describing for instance the Swedish building materials' cost development over time is extensive, still it is very hard to analyze the data in a meaningful way; what does it say?

Bertrand Russel stated that it is better to be "clearly and evidently wrong, than to be unprecisely right"[57]. Companies as well as authorities are today desperately trying to find quantitative measurements for among other things the environmental impact of transports in the Swedish construction industry.[58] Even though these measurements – with our contemporary level of understanding - would be very invalid, some of the actors seem to be willing to go on in Russel's spirit…

> *A scientific view that is in power provides security for the ones that do not suspect that there are cracks in the wall. Mathematical formulas standardized scientific methods and strict demands on evidence are supporting a weakening self-esteem.*[59]

2.3.3 Considerations Regarding Qualitative Research

From a post-positivistic standpoint I think the most important aspect of methodology is the awareness that there are qualitative methods! The insight is

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[53] Wärneryd, B (1990), "*Att fråga – om frågekonstruktion vid intervjuundersökningar och postenkäter*" SCB

[54] Adams, D (1983), "*The Hitchhiker's Guide to the Galaxy*", William Heineman

[55] E.g. Wigren, R (1995), "*Byggkostnader och bostäder",* Meyers

[56] Seminar at the Swedish Building Costs' Committee 1999-05-05

[57] From Arbnor, I & Bjerke, B (1994), "*Företagsekonomisk metodlära*", Studentlitteratur

[58] Evertsson, D & Welbert, D (1999), "*Byggindustrins transporter ur ett miljöperspektiv*", Teknisk logistik, LTH

[59] Halldén, S (1980), "*Nyfikenhetens redskap*" in Arbnor, I & Bjerke, B (1994), "*Företagsekonomisk metodlära*", Studentlitteratur

important. This methodology part in the thesis is an attempt to reflect such an insight of the author. The purpose is to clarify to the reader the methodological standpoint and its implications for the research that has been done.

What are then qualitative methods?

Qualitative research is multimethod in focus, involving an interpretive, naturalistic approach to its subject matter. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meaning people bring to them. Qualitative research involves the studied use and collection of a variety of empirical materials – case study, personal experience, introspective, life story, interview, observational, historical, interactional, and visual texts – that describe routine and problematic moments and meanings in individuals' lives. Accordingly, qualitative researchers deploy a wide range of interconnected methods, hoping always to get a better fix on the subject matter at hand.[60]

The discussion about what qualitative methods are is in itself an essential part of the method.[61] I agree on this, and I think that researchers who use qualitative methods should be confident and not try to meet the expectations from positivists or more quantitative oriented peers. Instead it is maybe necessary to remind that qualitative methods call for rigor. The researcher coming from a quantitative field who turns towards more qualitative tools should pay attention to the "new" methods so they are not only seen as a convenient escape way from the problems that would have to be faced in quantitative research.

Qualitative methods are appropriate for many topics in logistics, and the logistic research field is in need for qualitative research.[62] All problems cannot be solved with the same methods, and Näslund shows that surveys and other types of quantitative research so far have dominated the logistics research field.

In qualitative research, a few entities are examined more carefully, and it is often not considered possible to know all the variables in advance. So by studying a lot of variables, the relations between different phenomena and contradicting findings are possible to investigate. Often the present is studied, and focus is more on the research process rather then the final results.[63]

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[60] Denzin, N, K & Lincoln, Y, S (1994), "*The Handbook of Qualitative Research*", Sage Publications

[61] Ibid

[62] Näslund, D (1999), "*Logistics Needs Qualitative Resarch - Especially Action Research, Towards Bridging the Gap Between Strategy and Operations – A Process Based Framework",* Department of Design Sciences, Logistics, Lund University

[63] Merriam, S B (1994), "*Fallstudien som forksningsmetod*", Studentlitteratur

2.4 Case Studies

2.4.1 General Reflections

A way to collect data, that often is qualitative, is by studying a case. A case study is according to Yin[64] an empirical enquiry that investigates a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly evident.

Yin argues for the benefits of case studies, since they have possibilities to cope with the situation when you have many more variables than data points. He also points out the fact that there is a possibility to rely on multiple sources of information by using triangulation. And there is the opportunity to notice various contradictions in the findings that probably would have remained unnoticed in a survey.

Yin sees the case study primarily as a research strategy, intimately connected to the research question. Research questions like *what* and *how many* are often best answered by doing a survey, while questions like *in what way* and *why* fit better into a qualitative case study. All methods are possible to use in a case, but qualitative methods are aiming at interpretation in a context, and the philosophical fundament comes rather from qualitative paradigms than from quantitative. And qualitative methods are inductive, stressing understanding and interpretation in contradiction to deductive research focusing on experiments.[65] But Yin, on the other hand, emphasizes that case studies are not limited to qualitative data, on the contrary.[66]

Merriam[67] stresses that the researcher's view of the world affects the work in the (qualitative) case study, a fact I have tried to consider. An often discussed matter is whether the results from a case can be general, the issue of generalization of the results. Eisenhardt[68] spent a lot of energy on how to generate theories from case studies, and her efforts are aiming at creating a roadmap for building theories. Yin argues for separating analytical generalization from statistical generalization, a rather unnecessary discussion to me. He explains, what he refers to as a common flaw in case studies, the risk for claiming statistical generalization from samples in a case, which I think must be seen from a quite positivistic background. Why should we be aiming for statistical correctness in a case study? With terminology such as "collecting data" instead of "creating data", one might suspect a smell of positivism. And

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[64] Yin, R K (1994), "*Case study Research*", Sage Publications

[65] Merriam, S B (1994), "*Fallstudien som forskningsmetod*", Studentlitteratur

[66] Yin, R K (1994), "*Case study Research*", Sage Publications

[67] Merriam, S B (1994), "*Fallstudien som forskningsmetod*", Studentlitteratur

[68] Eisenhardt, K M (1989), "*Building Theories from Case Study Research*", Academy Research Review 1989, Vol. 14, No. 4

the extensive discussion of validity and reliability by Americans such as Eisenhardt and Yin indicates to me - from a European point of view - a lack of confidence in the qualitative methods. Why spend so much time to defend and justify a method that by positivists is often considered as weak? Instead of trying to create a case study methodology aiming for survey validity and survey reliability, I think it is more interesting to actually reflect on how to actually benefit from the opportunities of the qualitative case study. Only by spending time in the case, by watching, listening and feeling and being present in the case, the data can be meaningful.[69] If time is not spent in the case environment, some authors do not consider it a real case study. In the words of Denzin and Lincoln: Get out there, see what is going on![70]

As case studies rarely end up as planned (!), adaptiveness and flexibility are necessary skills for the researcher[71]. This does not mean that the purpose of the study changes, but procedures and technique might be modified during the investigation. It is also important to determine the unit of analysis[72]. If not, it might be tempting to collect and analyze "everything", which is simply impossible to do.

The logistics field is in many ways a "new" field where we find few publications and so far we suffer from an uncertainty about definitions. Surveys are difficult, since sending questionnaires is hazardous when the topic is not familiar to the respondents.[73] In the beginning of this project, the research work was to a large extent seen as explorative, and thus appropriate for a case study.[74] Ellram, arguing for the use of case studies in logistics research, focuses however more on a discussion about misconceptions related to case studies.[75] Such discussions can be hard to see the use of from a European research perspective, where case studies are more recognized as a (qualitative) method.

Considering it all, we from the department thought that it would be a fruitful way to do a case study, and in the beginning of this research project we started to investigate the prerequisites for such a case.

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[69] Dingwall, R (1997), "*Methodological Issues in Qualitative Research, Account, Interviews and Observations in Context and Method in Qualitative Research",* Miller & Dingwall, Sage publications

[70] Denzin, N, K & Lincoln, Y, S (1994), "*The Handbook of Qualitative Research*", Sage Publications

[71] Yin, R K (1994), "*Case study Research*", Sage Publications

[72] Ibid

[73] Wärneryd, B (1990), "*Att fråga – om frågekonstruktion vid intervjuundersökningar och postenkäter*", SCB

[74] Rosengren, K E & Arvidsson, P (1992), "*Sociologisk metodik*", Almquist & Wiksell

[75] Ellram, L (1996), "*The use of the case study method in logistics research*", Journal of Business Logistics, Vol 17, No. 2, 1996

2.4.2 Interesting Failures

Before the main case study described in this thesis started, a few attempts to study cases of supply chains in the construction industry failed. The holistic ambition to study whole supply chains from a logistics view turned out to be harder than expected. Literature studies, examples from other industries and our own pilot studies all convinced us that studies in the field of intra- and inter-organizational logistics in the construction industry would bring new and useful knowledge into the day. And it did not seem so controversial to state that results in this area would enable the companies to improve efficiency and effectiveness.

For quite some time we had discussions with representatives for different parts of typical supply chains in the Swedish construction industry. But in the big construction companies we often met the opinion that they already knew all about on-site logistics. We were once even told that innumerous studies had been done in that field and that there was nothing of interest left to be done! This was a rather frustrating period since we had actually found very few studies covering just the on-site logistics. So these studies were – if they ever had been done – not scientifically or otherwise published. Some studies were conducted within the companies, and the results were kept as internal results that the companies were unwilling to share with us. However, we believe that most of this work had poor quality from a research perspective, and a lot of the secrecy that surrounded the alleged work in the area within the companies in fact only proved that very little had been done in a systematical and continuous way. One sign was that we found no logisticians in the companies to talk to about our ideas. The lack of an appropriate discussion partner often caused confusion about what we wanted to study and why.

One representative from Skanska, however, liked the idea of studying a whole supply chain. We discussed possible and likely partners in such a study, representing the different parts of the chain, where Skanska was one link. We then contacted the suggested partners, who were chosen from the background that Skanska described them as partners or allied. We informed them about our project, and we offered them to join the study and let their company represent one link in the supply chain case. But now it was time for our next surprise; a majority of these organizations turned out to be unwilling to participate in such a study. There were probably a large number of reasons for this, but we surely got the impression that they did not understand what they could possibly get from such a study. Some of them were obviously suspicious of Skanska's purpose with the study. This is the comment from one of the companies, a supplier of roof covering materials, suggested by Skanska:

> *-No, we will not participate in such a study. Yes, I know your ideas about supply chains and logistics; I've read your papers and all that. But now we have discussed it with the managing director. We are fed up with logistics; we have just invested in a new production planning*

system. And by the way: What could we possible benefit from such a study?

This comment shows the gap between how two different actors can look upon a partnership. The roof material company was described in terms of being a strategic partner to Skanska.

One likely reason that contributed to our failure was the fact that very few of these companies had logisticians to discuss such matters with. The questions were treated on a general top management level, and we believe that they may have missed the point, so to speak. They lacked the inter-organizational perspective of the flow. This was an interesting period when we learned a lot about the attitude towards logistics and the environment in the construction business.

2.4.3 The Bo Klok[76] Project

With our new understanding of the environment for the case to be, we changed our strategy. Our relation with Skanska had developed through discussions and our successful cooperation in the field of logistics education in the Civil engineering education at the Lund Institute of Technology. The company had been persuaded to be more and more involved in one specific course[77], we could now discuss the case problem with Skanska. Maybe it would be a fruitful way to study a project and try to map the activities and the flow without any dramatic commitment from the suppliers? A particular project was brought up in these discussions:

- Regarding all that logistics you keep talking about, you might be interested in a project that we run. It is called Bo Klok. I don't know so much about it, but I think there is some new thinking there, and it just might be of interest from your logistical point of view. The construction material is for example delivered to the site in flat packages. You know, like IKEA handles their products.

So we used our contacts within Skanska, and soon we found out more about the project. But some of our contacts in the organization could not see the connection to logistics:

- No, it's not a logistical project. These new ideas? Well aren't they just common sense?

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[76] "Bo klok" in Swedish means *live wise* (or something similar)

[77] MTT 202, "*Logistik i byggprocessen*", http://www.tlog.lth.se/courses/lb/

But as all logisticians know – common sense is not so common[78]. So in the following initial discussions with the Bo Klok project manager at the time, the project was found to be very interesting. With our pre-understanding described in *Chapter 3, Logistics in Construction – A Frame of References*, we got the impression that new ideas were tried out in this project. New ideas that were unconventional in this environment and therefore they were interesting enough from a logistical point of view.

The word "flow" was used a lot by Skanska's Bo Klok project manager as she described the initial phase of the project. Why did she use *flow*?

> *- Do I? I have not thought about that …But it is quite natural, isn't it? Trying to smooth the flow; get rid of bottlenecks; get the right things to the right place at the right time. Right?*

Purchasing patterns seemed interesting, the customer focus was remarkably clear and articulated, the cost level was decided and originated from thorough customer investigations and the project was aiming for industrial and repeated production. An unquestionable goal to reach a certain cost level had called for new thinking and new solutions that were remarkably fresh and clearly interesting in our eyes. Some of these ideas might seem obvious enough for the skilled logistician, but we had become quite chastened regarding the logistics in the construction industry by that time. So these were the immediate impressions from the first contacts with the project manager.

Would it be possible to gain useful knowledge about how thinking, classified as elements of logistics, affected the performance and costs in a supply chain in the construction industry by studying Bo Klok? This would mean that we by describing and analyzing the case could show that new thinking – and some of that likely related to logistics and supply chain management - did affect the performance as well as the total costs and each company's costs. We thought so and thus decided to choose the Bo Klok project as the main case in this research. The ambition was to investigate what logistical elements that could be recognized in the project and how supply chain management contributed to the result of substantially lower cost level for the end customer, that is the person living in the product as his/her home! Because this was just what Skanska had achieved, successfully recognized by satisfied customers, according to the press. So the case fit with the research question. The unit of analysis in the case was determined essentially as the flow of material and information.

The idea to study Bo Klok was described and formulated in a research project plan. The Swedish Building Costs Committee[79] in cooperation with The

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[78] Originally expressed by Voltaire as "*Common sense isn't.*"

[79] Regeringskansliet (1996), *"Åtgärder mot byggkostnadsökningen – tillsättandet av en särskild byggkostnadsdelegation",* Kommittédirektiv1996:38, Regeringens Offsetcentral

Swedish Council for Building Research decided to finance the project. Worth mentioning might be the unfortunately - but not surprising - fear from Skanska, that they were expected to finance the research project. When it was clarified that the research project was already financed, Skanska relaxed. Another obstacle that had to be discussed was whether the research publications – likely to show potential for improvement – would make Skanska seem incompetent in their present performance status. In these discussions it was a bit unclear to Skanskas' representatives what the Building Costs Committee and its purpose was. The discussion ended however fruitfully and Skanska's top management was informed and - if not committed – positive.

The holistic ambition in the research, and the aim to analyze whole supply chains led to the insight that systems thinking might offer the right methodological tools for the case. In terms of self-reflection, a probably quite post-positivistic view of the world suits pretty well with systems theory when it comes to performance evaluation of for instance efficiency[80]. So it turned out to be a methodological challenge to find and use the appropriate knowledge about systems thinking.

2.5 Systems Approaches

2.5.1 Historical Background

Even Aristotle argued that a *whole* was more than the sum of its parts. But this view was later considered outdated as the Scientific Revolution came to dominate during the 17th century in Europe.[81] As Newton's ideas provided a more mechanical description, the former ideas of Aristotle about teleology and purpose were set aside. But many years later, modern biology reestablished similar ideas about purpose, and soon a debate between reductionistic ideas met more holistic ideas about the world in the new methodology direction.[82] Abnor and Bjerke as well as Checkland refer to a debate between *mechanists* and *vitalists*. Vitalists were hesitant towards the use of analytical methods on organisms (and organizations). Mechanists on the other hand argued that analytical methods could be applied on all phenomena.

So biologists, e.g. Bertalanffy, were the pioneers in establishing these "new" ways of thinking in terms of wholes. Generalizations were presented to allow this thinking to any kind of whole, not only biological systems, and in the 1950s groups of researchers were aiming to present the *General Systems Theory*. Electrical engineering was also a field where ideas, concepts and theories at the

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[80] Denzin & Lincoln p532

[81] Checkland, P (1993), "*Systems thinking, systems practice*", Wiley

[82] Ibid

same time were developed as contributions to systems thinking. Also in social science problems less technique-oriented and more problem-oriented problems emerged. This called for a new language and a new way to describe, analyze and construct new solutions.

So the combination of doubts in the possibilities of the analytical systems, a need for interdisciplinary ways to attack a problem and research in problem oriented fields led after the Second World War to the development of a new methodological approach. The systems approach consisted of systems analysis, systems theory and systems construction *(Figure 7)*[83]

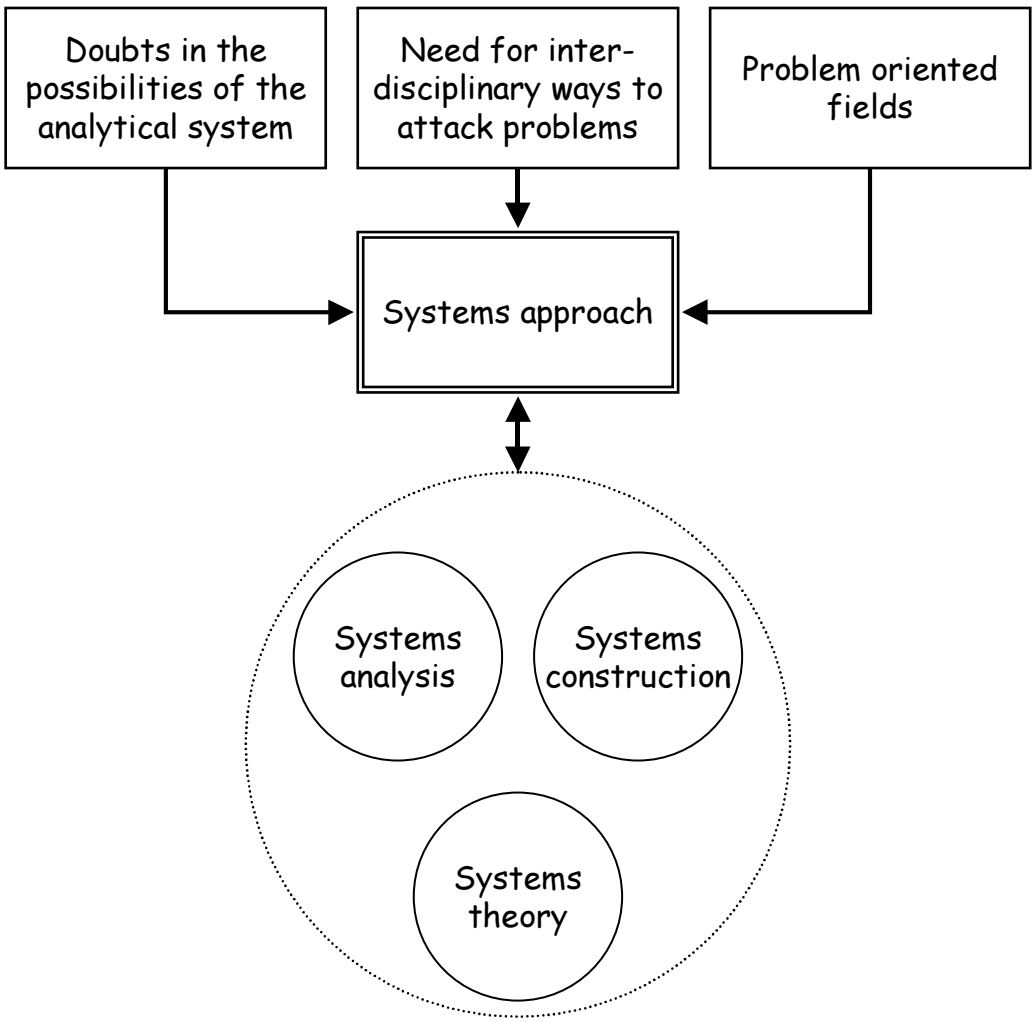


Figure 7: The development and use of systems approach. (Free from Arbnor and Bjerke [84])

> *It might have happened that the exploration of holistic thinking developed in various disciplines using the language appropriate to each different subject. What in fact has happened is that wholes in many different areas of study, from geography to sociology, have been studied*

[83] Arbnor, I & Bjerke, B (1994), "*Företagsekonomisk metodlära*", Studentlitteratur

[84] Ibid

using the ideas and the language appropriate to systems of any kind. That the systems movement is, even on a jaundiced view, at least a loose federation of similar concerns – linked by the concept "system" – is the main achievement of Ludwig von Bertalanffy.[85]

2.5.2 Systems Theory and Systems Thinking

The systems view accepts the existence of an objective – or at least objectively available – reality.[86] But there is a quite clear difference in the construction of reality compared with the opinions from a more analytical point of view. The reality is arranged in such a way that the whole differs from the sum of the parts.[87] And reality consists of components mutually depending of one another, and they cannot be summarized or measured without complications. This construction means that we have to consider synergy effects. It also means that systems thinking rejects a reductionistic standpoint, since parts could not be removed from a system without completely changing the system and its characteristics.

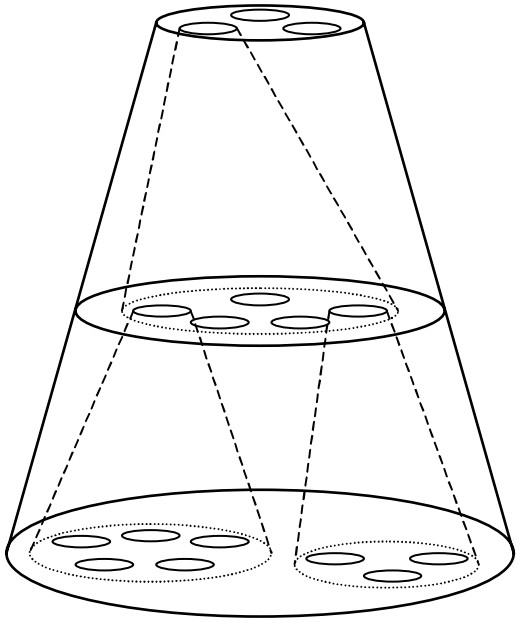


Figure 8: Systems levels for analysis. (Norrbom [88])

Systems could be analyzed on various systems levels *(Figure 8)*.[89] Every part of a system can be developed and analyzed as a subsystem.[90] In order to describe a systems structure, a certain system is defined. The holistic ambition is

[85] Checkland, P (1993), "*Systems thinking, systems practice*", Wiley

[86] Arbnor, I & Bjerke, B (1994), "*Företagsekonomisk metodlära*", Studentlitteratur

[87] Ibid

[88] Free from Norrbom, (1973), "*Systemteori*", M&B fackboksförlaget AB

[89] Norrbom, (1973), "*Systemteori*", M&B fackboksförlaget AB

[90] Arbnor, I & Bjerke, B (1994), "*Företagsekonomisk metodlära*", Studentlitteratur

restricted to the systems studied, but it is of course difficult to define an appropriate system. To make it even more complicated one actor can have relations to many different actors in various systems in so called multi-lateral structures *(Figure 9).*

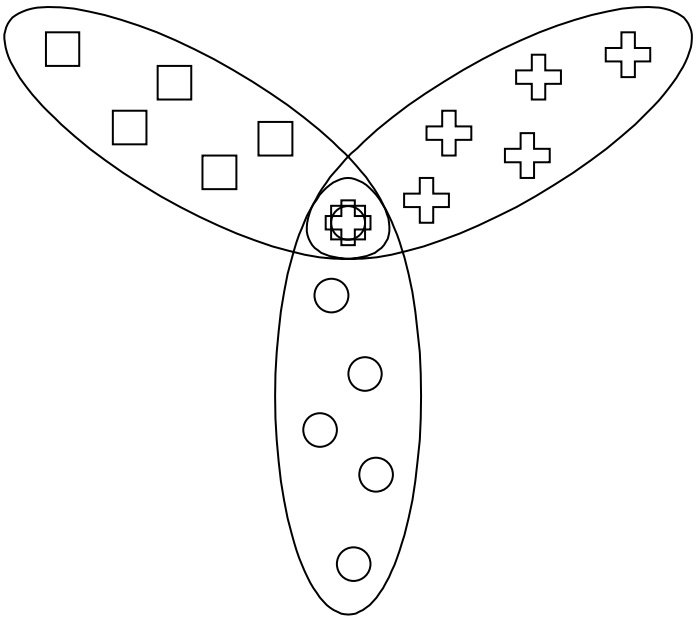


Figure 9: Multilateral structure. (Free from Norrbom [91])

According to Churchman there are many problems in the world that could be solved, but they will not be eliminated since we are not organized to deal with the situation.[92] From a systems perspective it was only possible to put a man on the moon because we (humanity) created an organization to do it. In accordance with this, Churchman means that we should not be surprised that e.g. starving remains an unsolved problem in the world; we have not created an organization to deal with it. The creation of such an organization calls for a systems language.

So it is to a vast extent a question of seeing interrelationships rather than linear cause-effect chains, and seeing processes of change rather than snapshots.[93] In systems thinking it is an axiom that every influence is both a cause and effect.[94] Nothing is ever influenced in just one direction.

The systems thinking is to me more of an attitude towards reality and the creation of knowledge. The quite utopical *General Systems Theory* is maybe not

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[91] Free from Norrbom, (1973), "*Systemteori*", M&B fackboksförlaget AB

[92] Churchman, C W (1968), "*Systemanalys*", Rabén & Sjögren

[93] Senge, P (1990), "*The Fifth Discipline – The Art & Practice of The Learning Organization*", Random House Business Books

[94] Ibid

desirable to strive for. The problem with the attempts to state a *General Systems Theory* is that it pays for its generality with lack of content.[95]

2.5.3 Systems Practice in Logistics

Systems thinking was the result of the need for a new methodology, a new set of tools, and a new language to describe and analyze complex problems. Different branches has evolved in various scientific context, and it is not clear how logistics came into the systems scenery – or rather systems thinking came into the field of logistics. However it seems quite natural to many logisticians to consider more or less sophisticated systems thinking. As an almost evolutionary process, the logistics concept has come to embrace more and more of the activities in companies. This is maybe both a cause and effect of the affection for holism.

It is characteristic that of the engineering world that principles should be learnt from experience and grasped intuitively long before they are codified and expounded.[96]

The key words *actors* and *relations* probably attracts the logistican, who all the time tries to cope with the holistic ambition of seeing and working with wholes, in accordance with the very definition of logistics.

One systems pioneer in the field of logistics seems to have been Forrester, as he modeled supply chains as dynamic systems in the 1960s.[97] This was part of a pattern from the 1940s and 1950s, when a number of fields, such as operations analysis and simulation, tried to use systems thinking.[98] This quite mathematically oriented studies, including Forrester's work, seems to me quite positivistic.

According to Checkland, systems thinking offers a language for describing complex systems, and logistics sure often provide complex systems enough.[99] Arbnor and Bjerke highlights that systems thinking is beneficial when it comes to interdisciplinary research and there is need for interdisciplinary communication and interdisciplinary problem solving. Also the possibility to describe a relation as a flow, mentioned by e.g. Arbnor and Bjerke, seems appropriate for logistics.[100]

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[95] Checkland, P (1993), "*Systems thinking, systems practice*", Wiley

[96] Checkland, P (1993), "*Systems thinking, systems practice*", Wiley

[97] Forrester, J (1991), "*System Dynamic and the Lesson of 35 Years*", in De Greene, K B (1991), "*The Systemic Basis of Policy Making in the 1990s"*

[98] Arbnor, I & Bjerke, B (1994), "*Företagsekonomisk metodlära*", Studentlitteratur

[99] Checkland, P (1993), "*Systems thinking, systems practice*", Wiley

[100] Arbnor, I & Bjerke, B (1994), "*Företagsekonomisk metodlära*", Studentlitteratur

Mattsson sees companies as open systems with the systems borders similar to the limits of the company, because the components of the systems not only have relation to one another, they also have relations to suppliers, customers and competitors. Supply chains can consequently be seen as open systems with subsystems consisting of more or less independent companies.[101] Naim says that it is a systems engineering approach to logistics that extends the business process view of individual companies to encompass whole supply chains.[102]

But Churchman criticizes users of systems approach, unreflectingly aiming for improving efficiency.[103] He claims that they (too fast) try to find out where there are for example unnecessary high costs, and then they start trying to get rid of this ineffectiveness. An understanding of the system, its structure and its purpose is essential. Maybe this could be worth thinking about for the systems researcher in logistics? Churchman relates to the early scientific management, where the hunt for efficiency often showed a lack of systems understanding.[104] Was this maybe an early contribution to the later debate of the pros and cons of business process engineering (BPR)[105]?

However it does not seem to have been developed an deliberate, adjusted and specific scientific language, in terms of systems thinking, for the field of logistics, as e.g. in biology. This might be – in systems terms! – both a cause and effect of the quite weak methodology and theory work in the field of logistics.

This could partly be explained by the difference Checkland sees between science and technology/engineering:

> *Where science is interested in new knowledge, and whether it is true or false, technology and engineering are interested in action directed to a defined end, and whether it is successful or unsuccessful.*[106]

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[101] Mattsson, S-A (1999), "*Improving supply chain efficiency and effectiveness*", Växjö Universitet

[102] Naim, M M (1997), "*Lessons for construction from manufacturing systems engineering*" Logistics Technology International 1997

[103] Churchman, C W (1968), "*Systemanalys*", Rabén & Sjögren

[104] Ibid

[105] E.g. Jones, Hines & Rich (1997), "*Lean logistics*", International Journal of Physical Distribution & Logistics Management, Vol 27 No. ¾ 1997

[106] Checkland, P (1993), "*Systems thinking, systems practice*", Wiley

2.6 Methodological Choices in this Thesis

2.6.1 Paradigm

The understanding of a researcher's paradigm is necessary in order to understand his research. But it is also of significant importance for the researcher himself/herself to be aware of his/her own paradigm in a reflective manner.

The paradigm is the connection between the researcher's basic understandings of the subject and the view on methods.[107] Regarding my own paradigm, there seems to be an important difference between myself and most of the contemporary research when it comes to the construction industry. My starting point is that it is not only possible but even desirable and necessary to change the conditions of the actual construction work in general and on the construction site in particular. And this could, according to my view, be done by deliberately and pro-actively changing the structure of the material flow before the material is handled on the site. So the importance of the flows cannot be stressed enough. To logisticians, this seems obvious, but in the context of studies in the construction industry it must be stressed as an almost unique starting position. From a logistical point of view, this difference is important and has paradigmatical dimensions.

Senge emphasizes the importance of mental models, a discussion similar to paradigms. The effects of such models might be worth considering when studying the construction industry:

> *We tend to blame outside circumstances for our problems. "Someone else" – the competitors, the press, the changing mood of the marketplace, the government – did it to us. Systems thinking shows us that there is no outside; that you and the cause of your problems are part of a single system. The cure lies in your relationship with your "enemy".*[108]

2.6.2 Qualitative Case Study

I have chosen to use a qualitative case study, since I thought it offered the best possibilities to achieve understanding. The unit of analysis in the case study is the flow of primarily materials. The whole supply chains are included, but focus is on the system that includes suppliers who deliver direct or indirect to the construction sites, and other actors involved in the supply activities. A consequent systems perspective has been used to structure the work and the data in the case. The delicate discussion of where to draw the boundaries of the system – and the case – is developed later in this chapter.

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[107] Churchman, C W (1968), "*Systemanalys*", Rabén & Sjögren

[108] Senge, P (1990), "*The Fifth Discipline – The Art & Practice of The Learning Organization*", Random House Business Books

In terms of validity, that is that the "right" thing is investigated in the research work, the chosen method fits with the research question. And to assure reliability, triangulation in data collection in the case study was used. Further the studied phenomena and environment were compared to earlier studies. This comparing and relating to earlier work includes both work of my own and others.

In a reflective manner, understanding of the phenomena has been strived for in the case study in order to understand the problems before trying to solve them.

2.6.3 Systems Approach

Substantially inspired by primarily Checkland and Senge a systems methodology is systematically used in this thesis.[109] A serious attempt is made not only to say that systems thinking sounds nice and then just leave it. The ambition is to use the systems methodology as a thesis structure, guiding both the author and the reader through the case and the research. With the limitations of a more rigid systems view, such as General Systems Theory, in mind, a slightly modified variant of Checkland's methodology will be used. The methodology is more like a methodological framework than a cook book recipe. The systems model appears to be useful and appropriate in the context of logistics; especially attractive is the emphasis on holism. The model will be used as a systems structure in the thesis, consisting of a descriptive part and an analysis where efforts will be made to use the model systems language systematically.

Models presented are of course just models describing reality. The real system that has been studied is the case study Bo Klok and its supply chains, and in this environment the relevant system's root definition has been sought. The system will initially be analyzed as a closed system where the actors have relations to one another, but not to anyone outside the system borders. The systems environment is in the model out of the system's actors' possibilities to change or influence.

The actors in the Bo Klok system have multilateral relations in business networks. But for the purpose of the studied system in this project, they are modeled with the relations that are of relevance in this context; they will constitute the defined system.

Different system levels will be examined, though the main study has the supply chain perspective/level. It is a delicate question who is the customer in the studied system, and special attention will be paid to this, since the end

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[109] Checkland, P (1993), "*Systems thinking, systems practice*", Wiley & Senge, P (1990), "*The Fifth Discipline – The Art & Practice of The Learning Organization*", Random House Business Books

customer, the consumer, is extremely important from the logistical perspective in the study.

The defined root system must include (or consciously exclude)[110]:

- Customers
- Actors
- Transformation process
- Meaning (Checkland: Weltsanschaung)
- Owners
- Environment

The customers are the beneficiaries (or the victims) of the system and a group that will be given special attention in the context of the thesis. The actors in the system needs no further explanation; the transformation process is what the system does; the meaning is what the system is experience as its meaning; the owners are the ones who could destroy or stop the system; the environmental constraints are the influence to which it is subject.

Checkland's systems methodology consists of seven steps in chronological sequence. That is a suitable way of describing it, but it does not have to be followed. Backtracking and iteration is not only possible, it can be effective. The steps are here arranged in a circle, and the arrangement and the presentation of the case data will follow a consequent model structure *(Figure 10).*

[110] Checkland, P (1993), "*Systems thinking, systems practice*", Wiley

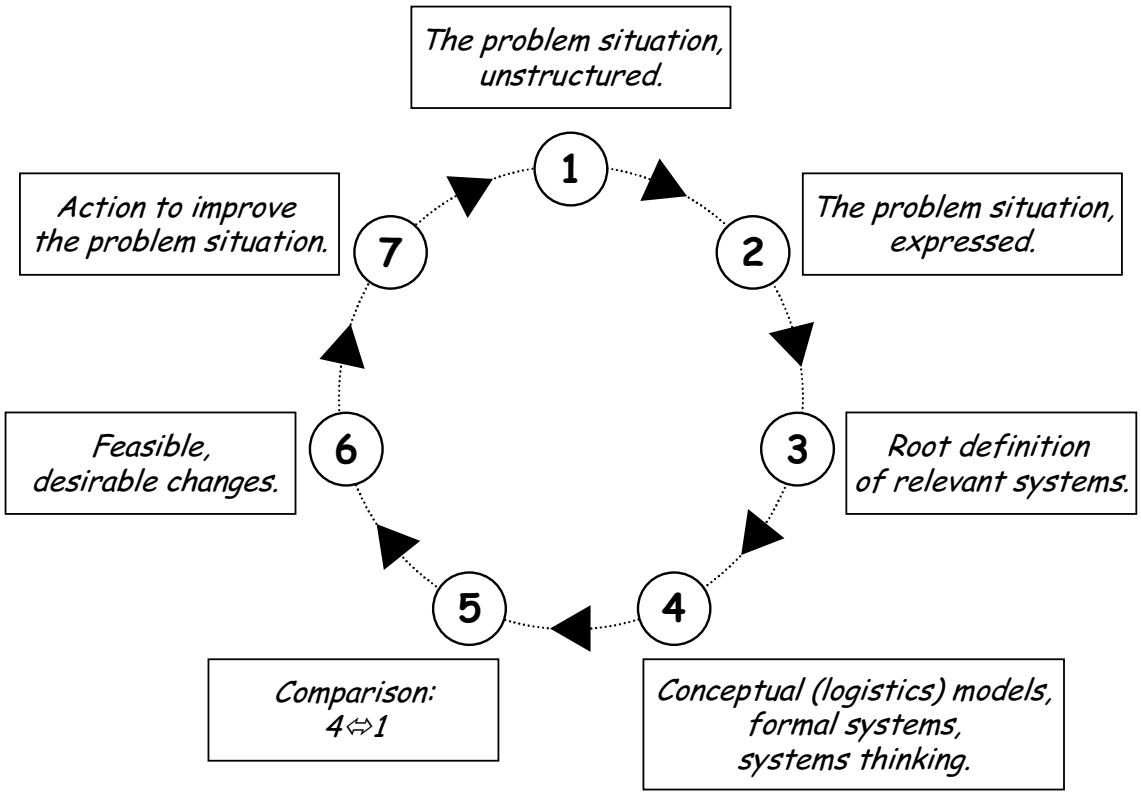


Figure 10: The systems methodology used in the thesis.[111]

This structure's implications are further elaborated in chapter 4, *Case Study*. I am probably involved in systems analysis as well as systems theory and systems construction in my models.[112] In the thesis the ambition is to manage the systems ideas in two rotations in the modified systems model. The first one and a half rotation is the describing part, what has happened in the studied case, and then the analysis consists of the half rotation that is left.

The steps 1 and 2 consist of an expression phase, where a description of the situation in the case is given. This can contain both a description of the structure of the system and the process in the system, and how they relate to each other.

Step 3 is an important step where interesting systems or sub-systems in the system are defined. Focus is on what they *are*, not what the system does. These defined systems are called *the root definitions* of the system.

In step 4 conceptual models are made and tested. The conceptual model is an account of which activities that must be done in order to be the named system in the previous root definition. In order to improve validity, the conceptual models are pre-analyzed in the light of general systems thinking and previous understanding from the specific field.

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[111] Developed from Checkland, P (1993), "*Systems thinking, systems practice*", Wiley

[112] Arbnor, I & Bjerke, B (1994), "*Företagsekonomisk metodlära*", Studentlitteratur

Then it is time for a comparison between the conceptual model and the previous expressed problem. The main role of this stage is to open up a debate about change.

Finally, in the 6th step changes in structure, procedures or attitude are discussed with representatives of the system. Agreed changes are then implemented in an action research approach.

The methodology consists of two kinds of activities. Step 3 and 4 are systems thinking activities, while the rest of the steps are involving the studied (real) system and more or less affecting people in the problem situation *(Figure 11)*.

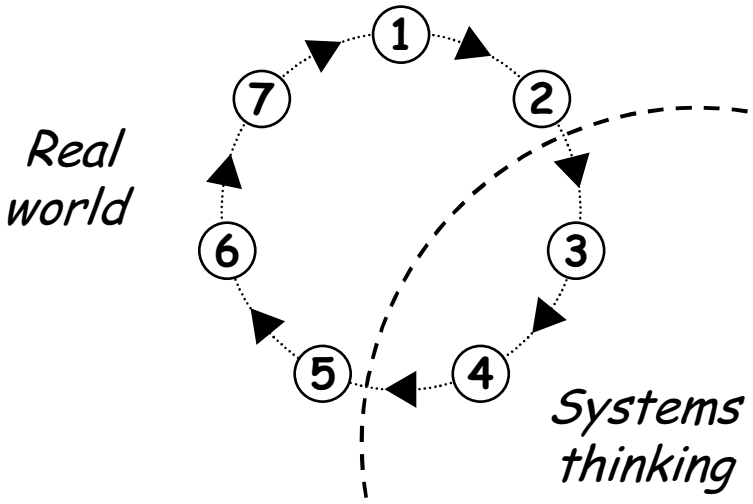


Figure 11: Two kinds of activities in the model.

The terminology in the thesis is thus consciously to a large extent a systems language. This calls for attention, since it might cause some confusion when it comes to contradictions between the systems language and for example more or less common and defined process terminology.

2.6.4 Emancipation and Semi-critical Theories

Habermas describes, according to Alvesson, three different interests for creating knowledge: A technical, a history-hermeneutic and an emancipatory interest. The latter strives for identifying sources of misunderstandings and ideological perceptions.[113] Structural as well as unaware sources of social and psychological phenomena must be investigated. These aspects are also brought up by Arbnor and Bjerke, but in a systems context more in terms of systems culture or systems environment.[114]

All research is, in a sense, critical.[115] But critical theory attracts me, and I see it as an intellectual challenge (and obligation) to question "the system".

[113] Arbnor, I & Bjerke, B (1994), "*Företagsekonomisk metodlära*", Studentlitteratur

[114] Ibid

[115] Alvesson, M & Deetz, S (2000), "*Doing Critical Management Research*", Sage

Probably I am not really working with critical theory, but I think it is related and worth discussing, since I "try to see the hidden structures within a society (system) that limit people from considering and creating a 'better society' (system)".[116] Emancipation is also an important element in critical, normative science.[117]

The emancipatory interest in critical theory, or similar research in a critical tradition, could be connected to Marx and even Freud. From a systems level perspective, one might say that Marx studied the society level while Freud was interested in the individual level. They were both driven by emancipation, and Marx was not satisfied with describing the system that he studied, he also wanted to change it. And so do I, even though the system I study merely is the construction industry in Sweden! Eriksson also discusses emancipation as incentive in context of research in the construction industry.[118]

The research described in this thesis could maybe not be classified as pure critical theory (is there such research?), since social phenomena are not in focus. But I do see the point in that, as Alvesson says, critical theory not treats the problem as a limited phenomena, which could be treated with social engineering. It is more related to the combination of totality-subjectivity. Alvesson and Sköldberg argue for the researcher to accept the full meaning of inter-subjectivity and to admit the consequences instead of trying to hide them.[119]

Influences from critical theory in my research are the elements of questioning and the problematizing research position that is deliberately chosen since it attract my personality. To me it would in many ways be a naive and outdated statement that the research stance is objective and neutral; on a scale from conserving the system to question it, or even deliberately try to change it, my research is definitely more towards the critical side.

To me this means that my research is also partly normative; the outcome includes an action plan and imperatives[120], based on my view as logistician, of how things could and should be managed in the studied environment.

An illustration to the discussed area might be Näslund[121]. In an article he treats the middle manager's vulnerable and struggling situation when there is a gap

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[116] Flint, D (1999), Handouts NOFOMA PhD Course in Lund 1999

[117] Denzin, N, K & Lincoln, Y, S (1994), "*The Handbook of Qualitative Research*", Sage Publications

[118] Eriksson, J (1994),"*Forskning, utveckling, nytta – om nytto- och relevansbedömningar av BFR-stödd forsknins- och utvecklingsverksamhet*", Byggforskningsrådet

[119] Alvesson, M & Sköldberg, K (1994), "*Tolkning och reflektion*", Studentlitteratur

[120] Wallén, G (1996), "*Vetenskapsteori och forskningsmetod*", Studentlitteratur

[121] Näslund, D (1999), "*Middle Managers in a Process Management Environment, Bridiging the Gap Between Strategy and Operations – A Process Based Framework*", Department of Design Sciences, Logistics, Lund University

between strategy and operations. And this is logistics research, and it is about a group that the author takes a stand for. Isn't this critical theory inspiring?

As will be developed in the frame of reference, the research related to the Swedish construction industry today shows little or no activity in the field of logistics. A lot of the research seems to be focused on construction materials in general and concrete in particular[122]. So a lot of the research traditions are quantitatively oriented and often focused on the product, not the process.[123] All research is of course financed in one way or another, but this is a background that must be considered when one tries to understand the implications of emancipation. It is therefore - in my opinion - naive not to consider the political aspects of a lot of today's construction research in Sweden. Isn't there a certain likelihood that one might predict the result when a researcher financed by for example the Society of Concrete Elements (with the very purpose to contribute to and increase the use of concrete elements) is comparing pre-cast to on site cast concrete?

It is not only a question about methodology in terms of technical and, hopefully, philosophical issues when discussing construction research. It is also necessary to be aware of the political implications *(Figure 12)*. This in order to justify the - probably questioned - discussion about emancipation and critical theory. But of course, it might be a question of tactics, whether these reflections should be left out or not from the publications.

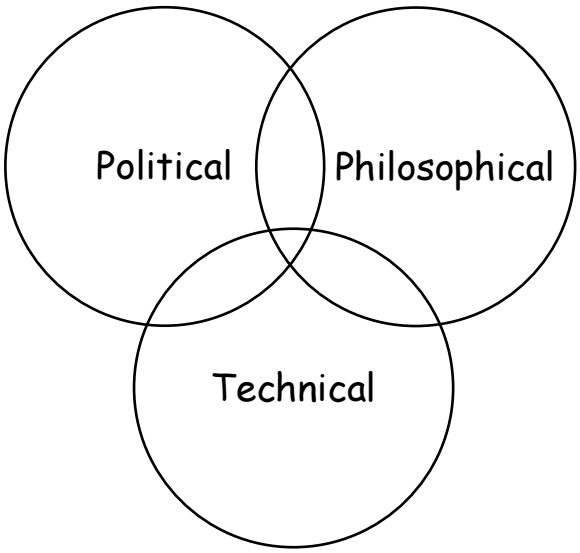


Figure 12: Main aspects of management research.[124]

In this context it might be worth reminding that the research, as well as its funding, that is being done in Sweden has been criticized.[125] There are

[122] SVR (1988), "*Bygg FoU på de tekniska högskolorna 1987*"

[123] Ibid

[124] Easterby-Smith, Thorpe & Lowe (1991), "*Management research*", Sage

[125] McKinsey Global Institute, *"Sweden's Economic Performance",* (1995)

different limitations and disadvantages in the present research approaches in the Swedish construction industry.[126]

This is an important part of qualitative research, which often seems to be missing in today's contemporary research in the Swedish construction industry. A non-existing debate today is the one problematizing the research that is being carried out by so called *industrial Ph.D. students*. A company employs the student and this type of research has been more and more frequent during the last years, e.g. in the national Competitive Building Research Program.[127] If the research methods used could be regarded as qualitative, this calls for reflection. Political implications could be described or be left out from the thesis, but pretending that such aspects do not affect the research work must be seen as naive.[128]

However, the contemporary situation of logistics as a topic in the Swedish construction industry of today creates a desire to show the construction companies the use of research. This is sound enough, but might be characterized as a pedagogical challenge, often trying to explain logistical benefits to non-logisticians. This partly explains the initial difficulties in starting up a logistical research project in cooperation with construction companies at a time when they simultaneously are involved in - and actively financing - innumerous research projects about concrete[129]… This situation constitutes the somewhat critical relation between the researcher and the studied environment, and puts the researcher in what could be described as an underdog position. This causes a dynamic research that is not easily put in a model that splits research work into explorative, descriptive or explanative research[130]. The ambitions in the thesis is not only to explore, it is also to describe the explored phenomena, and partly to explain the reasons for them. The objective to interact with the research "customer", partly the companies but also the founders, and get the results accepted leads to an interesting mix that is not always uncomplicated to handle.

2.7 Data Collection

In the case study, mainly three different sources of information have been used: Interviews, observations and documents. Participatory observations as well as mapping activities by researchers have been taking place on site, and the construction process has been documented. Series of interviews have been

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[126] Henricsson, E & Jacobsson, S (1994), "*Strategisk studie av den europeiska byggsektorn*", BFR Report R31:1994

[127] http://compbuild.lth.se/

[128] Easterby-Smith, M, Thorpe, R & Lowe, A (1991), "*Management Research*", Sage Publications

[129] SVR (1988), "*Bygg FoU på de tekniska högskolorna 1987*"

[130] Rosengren, K E & Arvidsson, P (1992), "*Sociologisk metodik*", Almqvist & Wiksell Förlag AB

carried out with actors in all parts of the supply chains. In twelve interviews, primarily key persons have been interviewed as they have given their view of the project and answered to questions. They represent organizations that have been participating in the design and the implementing of the new ways for supply of construction materials to the case study projects. The interviews represent data from a broad spectrum: From strategic decisionmakers to designers and representatives of the production to other actors that handle material or information.

2.7.1 Interviews

In studies of explorative or descriptive nature, interviews are often seen as an appropriate method to collect information[131]. Interviews offer a possibility to systematically catch the respondents subjective interpretation of the studied phenomenon[132]. This highlights the rejection of the possibility to experience anything in an objective way; as soon as we use interviews as research method, we must accept the duality of mind and reality[133]. From what in terms of self-reflection might be a post-positivistic stance, it might be worthwhile to discuss the role of interviews. While positivists can view methods as mere techniques of more or less efficient data gathering, the interactionist is bound to view research itself as a symbolic order based on interactions[134]. The relation between the interviewees and the world they describe affects the communication as well as the language, and it is necessary to think twice before we claim that interviews give access to "facts" about the world. It is dangerous to accept all that might be said in interviews as "truths". This calls for rigor, awareness and reflection.[135] Thus this insight might be especially important for post-positivists like myself and many of my logistician peers to discuss. We believe that we are leaving the objectivistic paradigm, overwhelmed by the rich data that might be achieved from interviews. In the actors approach the researcher must always reflect whether it is the "truth" that comes out from an interview. Is there a truth out there?

The interviews in the study have been arranged as open, semi structured interviews, only driven by me if the interviewee himself/herself not talked. A prepared interview plan structure has always been supporting the interview, and in case the respondent has left out some aspects this is brought up by the interviewer. Often the statements of the interviewees have been repeated and concluded in order to avoid misunderstandings. The interviews have been

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[131] Rosengren, K E & Arvidsson, P (1992), "*Sociologisk metodik*", Almqvist & Wiksell Förlag AB

[132] Lantz, A (1993), "*Intervjumetodik*", Studentlitteratur

[133] Denzin, N, K & Lincoln, Y, S (1994), "*The Handbook of Qualitative Research*", Sage Publications

[134] Silverman, D (1993), "*Interpreting Qualitative Data – Methods for Analysing Talk, Text and Interaction",* Sage

[135] Alvesson, M & Sköldberg, K (1994), "*Tolkning och reflektion*", Studentlitteratur

done in the respondents' normal environment, to benefit from the advantages this brings, a fact that thus also has meant various interruptions.[136]

2.7.2 Observations

Dingwall refers to two basic methods of qualitative research. One is *asking questions* and the other is *hanging out.*[137] This discussion goes back to the qualitative traditions from anthropologists as Malinowski, who used participant observations[138]. There is a clear advantage to spend time hanging out, and there are possibilities to really take advantage of the benefits that a qualitative case study offers. Taste, smell and experience in order to really get to know the phenomena that are to be studied is the advise for the researcher. Evidently enough the belief in total objectivity of the researcher is rejected.

The observation also provides a possibility to avoid interview bias caused by what Silverman calls the *interview society*.[139] Respondents act and talk in interviews as they think they are supposed to in an interview situation. Instead it could be interesting to observe what is really going on in the case. What is said before and after the interviews, in the coffee rooms etc. Are the official policies known and respected out in the case environment or are they just cited by the manager in the interview,? A difference could be that where interviewers construct data, observers find it.[140]

This is an illustration of the need for triangulation, caused by the discrepancy between the actions and the interview answers in a case study. A site manager is interviewed about the material flow control:

> *"Today there will come two trucks later. The ones out there? Well, I do not know anything about them."*[141]

During my time visiting the case study projects I have often taken photos to illustrate interesting phenomena. Six various projects have been studied on site, four of them during the production phase. In one selected case participatory observations during a number of days were done in order to achieve a better understanding of certain phenomena.

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[136] Lantz, A (1993), "*Intervjumetodik*", Studentlitteratur

[137] Dingwall, R (1997), "*Methodological Issues in Qualitative Research, Account, Interviews and Observations in Context and Method in Qualitative Research",* Miller & Dingwall, Sage publications

[138] Denzin, N, K & Lincoln, Y, S (1994), "*The Handbook of Qualitative Research*", Sage Publications

[139] Silverman, D (1993), "*Interpreting Qualitative Data – Methods for Analysing Talk, Text and Interaction",* Sage

[140] Dingwall, R (1997), "*Methodological Issues in Qualitative Research, Account, Interviews and Observations in Context and Method in Qualitative Research",* Miller & Dingwall, Sage publications

[141] Olsson, F & Larsson, E (1999),*"Godsflöden och transporter i byggindustrin",* Naturvårdsverkets förlag, Rapport 4954

2.7.3 Documents

In the case study attention has been paid both to what has been written and what has not been written. In the construction projects in the case study, documents such as blue prints, bills of quantities, consignment notes, plans of deliveries, suborder specifications etc have been gathered.

A problem in the case study – which effects are difficult to estimate – is the fact that a lot of strategic information by the actors is considered to be secret or outside the scope of the study. This could mean that there actually exists a secret text, or that there is an embarrassing absence of such a document. Statements about those kind of existing documents have been taken into careful consideration.

Case actors' relations to the documents have also been studied. When a document is brought out in or out of its original context, it might be given a new meaning.

2.8 Literature Studies

Repeated sometimes more, sometimes less systematical literature studies have during the research work been combined with a continuo search for interesting literature and publications. The focus has been primarily on contributions treating the Swedish construction industry, but as a researcher in the logistics field, opportunities to get in contact with international researchers have also been used.

One major difficulty has been that a lot of the existing knowledge is practitioners' knowledge and is thus not, or insufficiently, described. Some of the researchers who have been working in the field seem to be influenced by the practitioners to such an extent that the resulting usability of their work is unfortunately reduced.

The results of the literature studies reveal a lack of knowledge of how logistics in general could be systematically used in the construction industry, see *3.3.5 Literature review and analysis.*

2.9 The Research Process

The department of Logistics, Lund University, has a history of research in the Swedish construction industry. Valuable experience is built up by for example Horstmann[142] and Jarnbring[143], but also even earlier by Sörås[144] and

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[142] E.g. Broms, Horstman & Paus (1987), "*Rationell distribution av byggmaterial",* BFR-rapport R72:1987 and Horstman, P & Paus, K (1990), "*Leveransservice och datorisering inom byggbranschen*", TFB-rapprot 1990:10

[143] Jarnbring, J (1994), "*Byggarbetsplatsens materialflödeskostnader*", Rapport 94:01, Institutionen för teknisk logistik, LTH

[144] Sörås, A (1973), "*Samband mellan byggelements transporterbarhet och transportmedels egenskaper och ekonomi*", Inst. för Transportteknik, LTH

Bengtsson.[145] I came to the department with the ambition to build upon that experience, and my main driving forces were a huge interest in the possibilities for improvement in the construction industry and affection to logistics. My interest in logistics started during my own graduate studies. During the work with my M.Sc. I was amazed by the potentials not used, and the fragmented processes out in the leading Swedish construction industries.[146] An urgent need for integration seemed obvious to me, and the purchasing patterns and the corporate culture made an outdated impression. As the firms according to my opinion also seemed quite unwilling, uninterested or merely unable to learn more about how they could develop their business, I was instead attracted to the research environment where it seemed possible to develop new thinking. The corporate culture in the construction companies at the time also made me long for a climate more beneficial for intellectual freedom and growth.

My own pre-understanding was also founded by experiences during my studies and during my work experience in the industry. For example I participated in numerous meetings in various construction projects and the most important experience I got was when working full time for two years as a project manager.[147]

Initially the objective of the research project was to build upon a previous pilot study from my department at Lund University.[148] Our efforts to start up this research are further described in *2.3.2, Interesting failures*.

Mapping the activities in a research process could be seen as nothing but a reconstruction in order to give an image of a - in reality vague - strategy. An illustration might nevertheless offer an overview if it is done with reflection and consciousness *(Figure 13)*. But a very detailed mapping trying to determine the exact order has been avoided here.

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[145] Bengtsson, B P-O (1977), "*Byggbranschens materialtransporter. En studie av nuläge med förslag till utvecklingslinjer*", Inst. för Transportteknik, LTH

[146] Hall, M & Olsson, F (1996), "*Miljöanpassat inköp*", Inst. för byggnadsekonomi, LTH

[147] The largest project was *The Students' Union House* in Lund, 1992-1994.

[148] Fransson, H (1996), "*Byggmaterialets övergripande struktur och styrning*", Pilot study, Institutionen för teknisk logistik, LTH

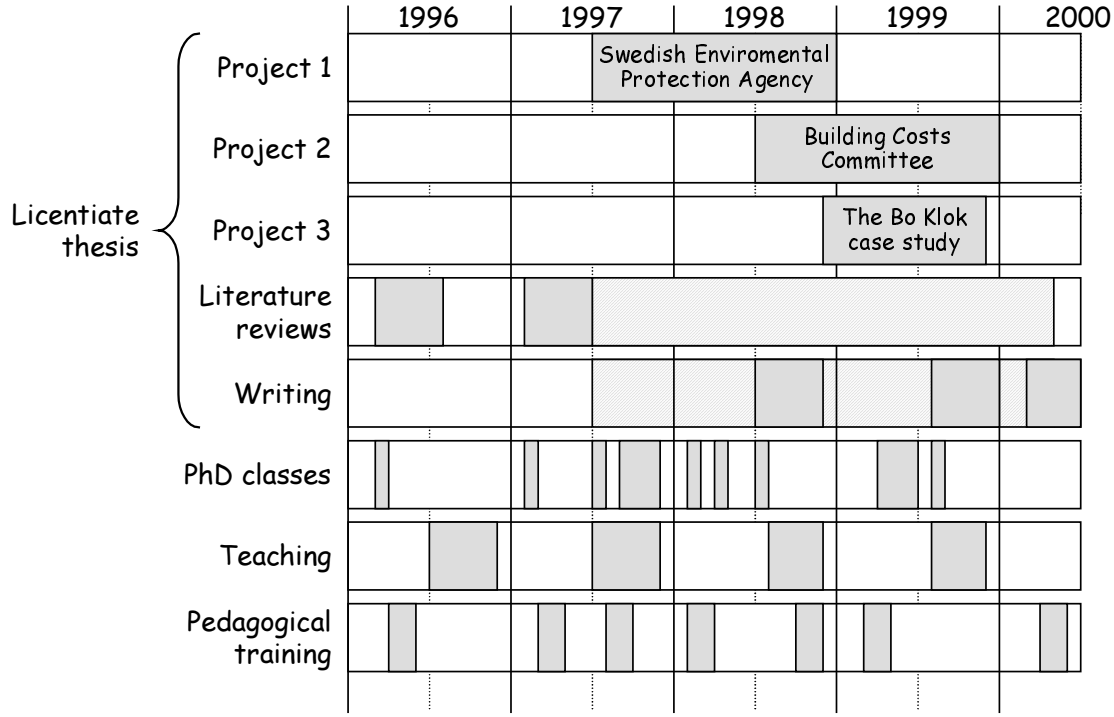


Figure 13: The research process.

Besides the two major projects for the Swedish Environment Protection Agency and the Building Costs Committee, one paper[149] and one research report[150] that got a lot of attention have been published.

An interesting and stimulating part of my time at the department has been the teaching; I have been responsible for the course *Logistics in the construction industry*.[151] The course is unique in the sense that it is a logistics course developed for Civil Engineering students with management specialization, the only such course in Sweden. Each year the students carry out projects in close cooperation with the local construction industry, and supervising such projects each year generates a continuos and varied input of logistics problems in the construction industry of today. About ten projects are completed every year, where logistical problems are found, analyzed and treated. Independent and critical thinking is stressed in the teaching of the course.

Key actors in the Swedish construction industry are assigned as appreciated key note speakers in the course, and studytrips are made to provide examples of the environment in the various parts of the supply chains. So this means that the course not only provides me with a stimulating challenge to create the best possible conditions for learning, I also get a continuos update on the state of art of logistics in the construction industry.

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[149] Olsson, Larsson & Schmidt (1999), "*The Continuos Challenge of Process Orientation in the Construction Projects*", NOFOMA 1999, Proceedings of the 11th Annual Conference for Nordic Researchers in Logistics

[150] Brisvall, Persson & Olsson (1999), "*Bygglogistik i samband med Bo01 i Malmö*", Teknisk logistik, LTH

[151] MTT 202, "*Logistik i byggprocessen*", http://www.tlog.lth.se/courses/lb/

A number of M.Sc. theses, treating logistical aspects in the construction industry, has also been under my supervision.

2.10 Summary of the chapter

The research work presented in this thesis can only partly be described as engineering or natural science; it has many elements of social science. This makes the awareness of various methods as well as the methodological choices that have been done important to the study.

Considering the research field and the research question, systems theory have been used in a primarily qualitative case study to conduct the research work. The main case was chosen since it provided a unique and interesting environment from the researcher's perspective of pre-understanding. Mainly interviews, observations and document studies have been used to collect data in the case.

Awareness is the antidote for reduced validity when emancipation from mental models is a driving force for the creation of knowledge.

3. Logistics in Construction – a Frame of Reference

*A frame of reference is developed for the defined research field logistics in construction (*Figure 14*)*[152]*. Logistics and supply chain management is discussed and two theoretical models are elaborated.*

A literature review of primarily Swedish publications in the field is presented and discussed, and finally the review is summarized.

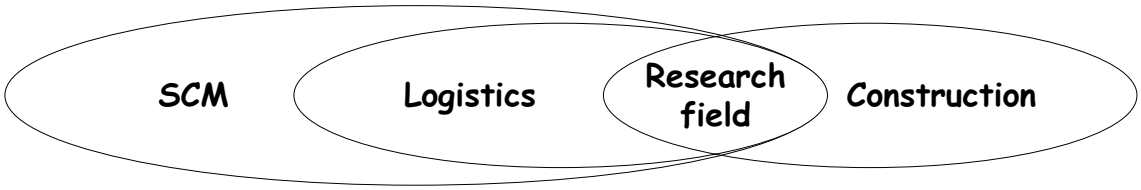


Figure 14: The research field in the thesis.

3.1 Logistics and Supply Chain Management

3.1.1 Logistics – a Dynamic Field

As an established research subject, logistics is young, and maybe it is still seen as a novelty by some. The meaning of logistics is not clear to everyone and the meaning is continuously changing in the young but maturing discipline.

The term *logistics* was likely first used in the environment of the military, where there are some doubts whether the word stems from ancient terms for skills in calculating or reasoning, if the origin is an old Roman military title or if it is an expression developed from French. The latter is supported by the fact that Napoleon's theorist and biographer used the term for military administration.[153]

Logistics turned out to be a crucial factor during the Second World War, and logistical management concepts were given more and more attention in business after the war. Increasing competence led to a continuos challenge and need of reducing costs, and logistics has now developed into an important tool for realizing a more effective and efficient use of the companies' capital investment by reducing costs in the material flow and increasing incomes from improved customer service.[154]

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[152] A deeper discussion about the relations between logistics and supply chain management is conscously avoided in the thesis.

[153] Aquilon, M (1997), "*Cultural Factors in Logistics Management*", Department of Engineering Logistics, Lund University

[154] Persson, G & Virum, H (1996), "*Logistik för konkurrenskraft*", Liber-Hermods

The meaning of the term logistics has changed, and expressions for all or parts of the activities normally included in modern logistics have been for example business logistics, physical distribution, materials logistic management, materials management, physical supply, logistics of distribution, marketing logistics, inbound logistics and total distribution.[155]

As logistics usually is connected with key activities as distribution and warehousing, a rather relaxed and still functional definition is:

The art of efficient material flows[156]

Integration, holism and flows are frequent and central terms among logisticians. And a coordinated control of the flows to, in and out of the company is emphasized in logistics.[157] An important model for discussing the relation between the different parts and activities in the company in order to create customer value is the *value chain* introduced by Porter[158].

The definition of logistics used in this thesis is the definition:

> *Logistics is the part of the supply chain that plans, implements, and controls the efficient, effective flow and storage of goods, services and related information from the point of origin to the point of consumption in order to meet customers' requirements.*[159]

The attractive ambition to use a holistic approach also means conflicts about how to handle what seems like a logistics curse: What could be demarcated? If everything more or less is logistics, it does not contribute to the efforts to find the very essence of logistics, a subject discussed by for example Arlbjörn and Halldorsson.[160]

There is a huge stream of publications concerning logistics and supply chain management available today. In journals and on conferences new ideas and concepts are presented all the time. This also means a development of the field and a continuos discussion about the content, demarcations and possibilities. Also methods and theory are areas of discussion among university graduates.

But so far, this development of logistical knowledge has been directed almost only to the stationary industry. At for example the annual Council of Logistics

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[155] Bowersox & Closs (1996), "*Logistical Management. The Integrated Supply Chain Process*", McGraw-Hill

[156] Persson, G & Virum, H (1996), "*Logistik för konkurrenskraft*", Liber-Hermods

[157] Ibid

[158] Porter, M (1985), "*Competitive Advantage – Creating and Sustaining Superior Performance*", Free Press

[159] Council of Logistics Management (2000), "*1999 Year end review*"

[160] Stentoft Arlbjörn, J & Halldorsson, Arni (1999), "*Logistics Knowledge Creation: Reflections on content, processes and context*", Proceedings from the NOFOMA Conference in Lund 1999

Management (CLM) Conference, the construction industry has rarely been discussed.[161]

Logistics is the underpinning thought in this thesis, and logistics could be described as the meta-theory that is used.

3.1.2 Supply Chain Management

As logistics primarily deals with the flows to, in and out of the companies with an intra-organizational perspective, supply chain management is a lately and further developed approach that deals with the inter-organizational view of logistics *(Figure 15)*. How to use all the involved companies and their resources in the most effective and efficient way in order to meet end customer demands.

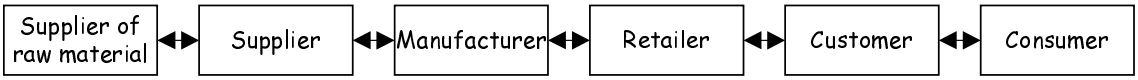


Figure 15: A schematic supply chain.

Supply chain management concepts have been introduced during the 1990s, and supply chain management is often used as synonym to logistics or rather logistics management.[162]

Holmberg defines a supply chain as:

> *… a set of organizations performing activities with the purpose of satisfying the ultimate consumer.*[163]

Supply chain management provides a more clear statement that it is a question of a whole chain of organizations, compared to what is meant in logistics. Various definitions have been discussed by for example Bechtel and Jayaram[164], and Otto and Kotzab[165] who says that the variety of definitions attempts are showing that supply chain management does not offer a uniform perspective on the supply chain.

Mattsson emphasizes that to the traditional logistics definitions must be added that:[166]

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[161] An exception was CLM 1998 in Anaheim, where the construction industry was the subject for a minor special track within the theme European logistics

[162] Mattsson, S-A (1999), "*Improving supply chain efficiency and effectiveness*", Växjö Universitet

[163] Holmberg, S (1997), "*Measurements on an integrated supply chain*", Department of Engineering Logistics, Lund University

[164] Bechtel, C & Jayaram, J (1997), "*Supply Chain Management: A Strategic perspective*", International Journal of Logistics management, Vol 8: No 1/1997

[165] Otto, A & Kotzab, H (1999), "*How supply chain management contributes to the management of supply chains*", NOFOMA Proceedings 1999

[166] Mattsson, S-A (1999), "*Improving supply chain efficiency and effectiveness*", Växjö Universitet

- The whole supply chain from original manufacturer of raw materials to final consuming customer is considered
- The supply chain must not be viewed from a single company's perspective, but also from a total perspective
- Cooperation and integration must be emphasized
- Both flows of material and services are considered
- Also other types of non-material interchange between companies besides information that are relevant for the material flow are considered.

Business processes crossing organizational borders, discussed by Rummler and Brache[167], are included in the definition by Cooper et al:[168]

> *Supply chain management is the integration of business processes from end user through original suppliers that provides products, services and information that add value for customers.*

A theoretic supply chain model valid for the thesis is, as the first step of the five-step research approach used in the thesis, now developed. The darker part in *Figure 16* is the development of this theoretical supply chain management concept.

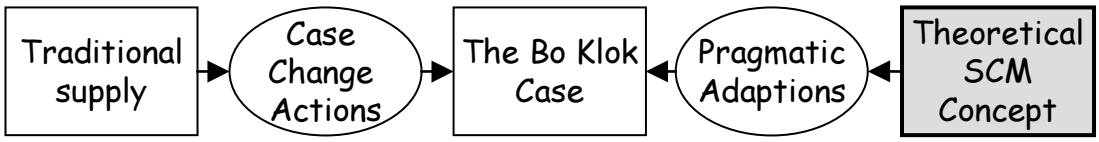


Figure 16: Development of a theoretical supply chain concept for the thesis.

Out of primarily Otto and Kotzab's critical review trying to determine and condense what supply chain management really is, a set of criteria, or principles, has been determined constituting supply chain management *(Table 1)*. The terms should be seen in a specific supply chain management context.

[167] Rummler and Brache (1995), "*Improving performance. How to manage the White Space on the Organization Chart",* Jossey Bass

[168] Cooper, Lambert & Pagh (1997), "*Supply Chain Management: More than just a new name for logistics*", International journal of Logistics Management, Vol 8: No1/1997

SCM Principle	Principle's framework	Aiming at	Applying to
Compression	• Reducing the number of nodes, members or actors in the chain or • Reducing the physical distance between any two nodes.	Costs	Structures
Speeding up	Reducing the amount of time necessary to move between any two nodes in a chain or network or between any two stages in a process.	Time	Processes
Collaboration/ Cooperation	Increasing the intensity and scope of cooperative behavior between two or more independent decision-making units	Costs Service	Relationships Planning Scheduling Execution
Integration	Reducing the penalty in time, effort, cost or performance to move between any two activities in a process or between processes. (Sequentially, vertically or horizontally)	Time Costs	Processes
Optimization	Maximization of the value of a target function through the use of quantitative methods.	Time Costs	Planning Scheduling
Differentiation/ Customization	Increasing the specificity and thus the effectiveness of a subject towards a given purpose	Costs Service	Structure Processes Planning
Modularization	Reducing the penalty in time, effort, cost or effort to replace a particular segment of a chain	Time Costs	Products Processes
Standardization	Reducing the magnitude of variation of a certain parameter of an object over time.	Costs	Material flows Order flows
Postponement	Moving the product differentiation closer to the time and locus of consumption	Service	

Table 1: Criteria for supply chain management. (Developed from Otto and Kotzab)

The original supply chain management criteria from Otto and Kotzab have been slightly modified, but the point here is – as stated before - not to further develop or penetrate the supply chain management concept. The criteria

could be discussed or questioned, but they are seen as an appropriate set of terms for the purpose of this study.

A pre-understanding of the general supply chain performance in the construction indicates, however, that a theoretical model focused on criteria for supply chain management might be hard to fully use. If the criteria do not exist or are found to be difficult to detect, a complementing theoretical model is needed.

So in order to be able to discuss a movement from *traditional supply* towards *supply chain management*, a comparison between the characteristics of the two is introduced as a complementary model for the thesis *(Table 2).* In a comparison by Paulsson et al[169] (derived from Coyle et al[170]), traditional forms of material supply companies in the supply chain are described as trying to optimize the own functions as e.g. stock levels. The flow is interrupted as organizations are minimizing the own company costs and information is kept within the companies. Risk calculations are done with focus on the own company, and planning is also oriented to the own company functions. The inter-organizational relations are thus also focused on keeping low company costs.

In the supply chain management based company, Paulsson et al[171] describe the flow of goods as visualized and not interrupted. The company costs are considered with the consumer in mind. Information and risks are shared among the companies in the supply chain, and planning and relations between the companies are colored by partnership.

[169] Paulsson, Nilsson & Tryggestad (2000), "*Flödesekonomi – Supply Chain Management*", Studentlitteratur

[170] Coyle, Bardi & Langley (1996):" *The Management of Business Logistics*", West Publishing Company

[171] Paulsson, Nilsson & Tryggestad (2000), "*Flödesekonomi – Supply Chain Management*", Studentlitteratur

Factor	Traditional supply	Supply chain based supply
Warehousing	Company based	Supply chain coordinated
Flow of goods	Interrupted	Continuos/visible
Costs	Company minimized	Total cost for end customer
Information	Company controlled	Shared
Risks	Company focused	Shared
Planning	Company oriented	Supply chain team oriented
Interorganizational relations	Company focus on low cost	Partnerships focusing on the total costs for the end customer

Table 2: Comparison between traditional supply and supply chain based supply. (Paulsson et al from Coyle et al.)

In the literature various expressions similar to supply chains such as marketing channels, value streams, value systems, demand chains etc can be found. But it is the terms *supply chain* and *supply chain management* that will be used in this thesis. The aim is here to develop a useful theoretical framework in order to determine whether a certain context, e.g. the case that have been studied, could be described as supply chain management or not.

Holmberg's simplification to partial supply chains is realistic since it often turns out to be too complicated to include all the raw material suppliers *(Figure 17)*.[172] Further the ultimate consumer is often not really included in the chain, even if the consumer is the lodestar for the efforts in the chain.



Figure 17: Partial supply chain.

But a partial supply chain can of course include actors as retailers and other intermediaries. Paulsson soundly claims that the pure supply chain theory, were all actions in the chain are coordinated optimally to fulfil consumer needs, is a utopia, an unreachable vision.[173] But this does not mean that supply chain management is irrelevant – quite the opposite. By thinking in terms of flows, and by working in the direction of the vision of supply chain management, the direction of the development for individuals as well as companies can be changed.

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[172] Holmberg, S (1997), "*Measurements on an integrated supply chain*", Department of Engineering Logistics, Lund University

[173] Paulsson, Nilsson & Tryggestad (2000), "*Flödesekonomi – Supply Chain Management*", Studentlitteratur

3.1.3 Process Orientation

Rummler and Brache early discussed business processes as they reacted against what they called the silo phenomenon.[174] The traditional vertical organizations with structures that could be seen as tall, thick, windowless structures, led to the fact that managers were unable to see the result of their work in a broader perspective, and more seriously, they were unable to identify what added customer value. Hence the managers within a company were not aware of what created value for the customer, and even if they reached nice results within their part of the organization, they were not efficiently contributing to what the customer in the end was depending of: customer satisfaction.

Melan identifies processes as:

A bounded group of interrelated work activities providing output of greater value than the inputs by means of one or more transformations.[175]

Ljungberg widens the definition to:

A repetitively used network of orderly linked activities using information and resources for transforming inputs to outputs, extending from the point of identification to that of the satisfaction of the customer's needs.[176]

The emphasis on the customer and the holistic approach is what is common for most of the found definitions, and Näslund et al call this *process logistics*, and claim that logisticians are well suited to contribute in this area – outside the field of traditional logistics - with their logistics know-how.[177]

In a paper with the title *The Continuos Challenge of Process Orientation in Construction Projects,* the potential for the identification and management of business processes in the construction industry is discussed.[178] This thesis is written in awareness of business process concepts, but the approach is not the process management view. Considering the problem and the problem environment, a flow oriented (supply chain management) approach has been chosen.

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[174] Rummler and Brache (1995), "*Improving performance. How to manage the White Space on the Organization Chart",* Jossey Bass

[175] Melan, E H (1993), "*Process management. Methods for improving products and service*". McGraw Hill

[176] Ljungberg, A (1998), "*Measurement Systems and Process Orientation*", Department of Engineering Logistics, Lund University

[177] Näslund, Larsson & Holmberg (1999), *Managing and Improving Processes*" *in Towards Bridging the Gap Between Strategy and Operations – A Process Based Framework",* Department of Design Sciences, Logistics, Lund University

[178] Olsson, Larsson & Schmidt (1999), "*The Continuos Challenge of Process Orientation in the Construction Projects*", NOFOMA 1999, Proceedings of the 11th Annual Conference for Nordic Researchers in Logistics

3.1.4 A Flow Oriented Approach

Flow orientation could be seen as a basic logistic approach, where the effective and efficient creation of customer value is more important than the characteristics of the functions that are involved. In a construction industry context this means that the emphasis is on the flows that create value rather than a myopic view of the construction site.[179] The flow orientation embraces the general thoughts in supply chain management together with expressions as lean production, lean enterprise and related concepts derived from the material supply approach pioneered by Toyota.[180]

A flow-oriented approach could be seen as the stage before a more strict process management approach, but it is to a large extent a question of the same type of logistics management thoughts. The optimal flow is more to be seen as a vision than a goal. It is by working towards a smooth flow in order to meet customer demands that the actors can create competitive advantage. The expression *flow orientation* rather than *flow focus* is an expression for this difference.[181]

3.2 Construction

3.2.1 The Construction Process

In literature it is not clearly defined how construction is being performed. A common expression in the Swedish construction industry is "the construction process". This is also the direct translation of a publication used for higher education[182], and the expression is used in another well spread book for education purposes.[183] The expression seems to be commonly accepted among the practitioners as well as researchers, but what it exactly stands for seems a little unclear. From a logistical perspective the use of the word "process" can be confusing, since it is not clearly defined, and does not seem to be what is defined by e.g. Ljungberg.[184]

In *Figure 18* the production phase is shown as a house under construction, since this is the phase most people refer to when the construction industry is discussed. The terminology of the phases is not clearly defined and the phases

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[179] Olsson, F & Larsson, E (2000), "*Flödesorienterat byggande – lägre boendekostnader med hjälp av helhetssyn på byggindustrins materialflöden",* Byggkostnadsdelegatioen & Avd. för teknisk logistik, LTH

[180] Womack, J P & Jones D T (1994), "*From Lean Production to the Lean Enterprise*", Harvard Business Review, March-April 1994

[181] Olsson, F & Larsson, E (2000), "*Flödesorienterat byggande – lägre boendekostnader med hjälp av helhetssyn på byggindustrins materialflöden",* Byggkostnadsdelegatioen & Avd. för teknisk logistik, LTH

[182] Institutionen för byggnadsekonomi, LTH, "*Byggprocessen*", 1999

[183] Söderberg, J (1998), "*Att upphandla byggprojekt*", Studentlitteratur

[184] Ljungberg, A (1998), "*Measurement Systems and Process Orientation*", Department of Engineering Logistics, Lund University

could also be divided into four main stages: investigation, conceptual design of product, production and product use.[185]

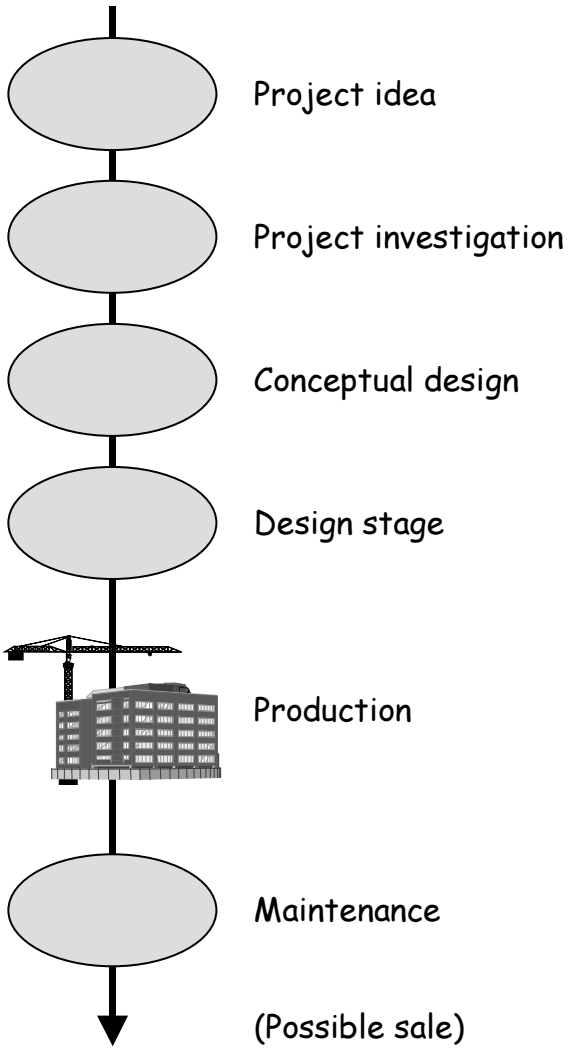


Figure 18: Phases in the "construction process".

Similar models have lately been called *the value chain*, likely inspired by Porter[186], by some of the companies in the industry.

A lot of the literature is describing what is happening among the practitioners, but a critical perspective is often missing. The construction activities are often mapped with a focus on the stages in the designing phase and production phase, but the connection to the production inbound logistics, e.g. in terms of transports, warehousing, supply chain management or logistics in general, is nearly never included.[187]

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[185] Tekniska nomenklaturcentralen (1994), "*Plan- och byggtermer*", Byggforskningsrådet & TNC

[186] Porter, M (1985), "*Competitive Advantage – Creating and Sustaining Superior Performance*", Free Press

[187] Olsson, F & Larsson, E (1999), "*Godsflöden och transporter inom byggindustrin – Studie av förutsättningar och reducerad miljöbelastning",* Naturvårdsverkets förlag, Rapport 4954

3.2.2 Project Focus

What is special about a construction company is that the production is carried out in projects. And for every new project a new organization is set up.[188] The projects are then during the production relatively independent from the rest of the contractor's own organization.[189]

The project focus is a limitation that restrains the companies' abilities to develop themselves. And new ideas from the headquarters in order to develop the business have problems to reach out to the projects.[190] Every single project has to be profitable, and Larsson describes the business as decentralized and shortsighted.[191] The short term planning means that the business improvement and development can only be possible in short steps. And the short term project focused demand on profitability means that actions aiming for long term profits are harder to accept than short term, on site problem solving. The problem from an innovative implementation perspective is then that site managers are reluctant to try new solutions because they are continuously trying to reduce economic risks for the project. Also Dubois and Gadde see the focus on efficiency in individual projects as an explanation to why we do not see more integrating routines in the business relations.[192]

But in order to give the construction industry credit, Salaj argues that the stationary industry could probably learn a lot from the construction industry when it comes to decentralized and flexible projects.[193] Kristoffersson too admits that a construction site is a dynamic and fast changing environment with many actors in complex relations, but that the efficiency and effectiveness in the projects suffer from the great number of participants.[194]

Naim, however, states that the main obstacle to change in the construction sector is attitude. Despite exceptions, the construction sector generally sees its own environment as "one-offs" with little repeatability, and thus considerable knowledge is lost as companies move from one project into the next.[195]

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[188] Rogberg, M (1995), "*När kvalitetsidéerna möter praktiken*", IMIT

[189] Salaj, B (1990), "*Effektiviteten i 90-talets byggande*", BFR-rapport G4:1990

[190] Kristoffersson, A (1995), "*Ledning för effektivare byggproduktion – former för samverkan på byggarbetsplatser*", Inst. för byggandsekonomi, LTH

[191] Larsson, B (1992), "*Adoption av ny teknik på byggarbetsplatsen*", Institutionen för byggnadsekonomi och byggnadsorganisation", CTH

[192] Dubois, A & Gadde, L-E (2000), "*Supply Strategy and Network Effects – Purchasing behaviour in the construction industry*", IMPSERA Workshop, Jönköping 2000-03-31

[193] Ibid

[194] Kristoffersson, A (1995), "*Ledning för effektivare byggproduktion – former för samverkan på byggarbetsplatser*", Inst. för byggandsekonomi, LTH

[195] Naim, M M (1997), "*Lessons for construction from manufacturing systems engineering*" Logistics Technology International 1997

3.2.3 Corporate Culture

A special corporate culture is often mentioned, and is by Björklöf described as a world of its own. The erection of the construction is central and what happens before or after is of less importance.[196] The fact that the construction is proceeding is seen as more important than how it proceeds, and unexpected complications that would be described as crisis in other industries are warded as a part of the everyday work. Storhagen and Lindqvist refer to this as site blindness: The actors on the construction site are so used to the chaotic handling of materials on site, that they do not experience the situation as a problem.[197]



Figure 19: Construction materials on the site.

Aspects of construction corporate culture relating to management, responsibility, incentives etc are deeply rooted in values and traditions.[198]

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[196] Björklöf, S (1986), "*Byggbranschens innovationsbenägenhet*", Ekonomiska institutionen, Linköpings Universitet

[197] Storhagen, N G & Lindqvist, P (1998), *"Emballage och lastbärare på byggarbetsplasten"*, MTC, ABA kopiering AB

[198] Borgbrant, J & Hansson, F (1995), "*3T-arbetet vid Skanska Syd AB – en utvärdering*", Inst. för byggnadsekonomi, LTH

The corporate culture and the implications for pro-active logistics, where active actions in order to deliberately change the conditions of the material flow, instead of accepting the conditions, are sparse are also described by Olsson and Larsson.[199]

3.2.4 Customer Orientation

There has been a dramatic change on the Swedish market since the construction industry experienced radical changes in the production environment during the 1990s. Fernström among others describes the changes and the new demands that these changes raise on the construction companies.[200] From an extremely regulated market, where many construction companies maybe were focusing as much on circumventing regulations as they did on winning the market, to a situation where the companies suddenly had to act[201]. The effects on the market, caused by a whole industry adapting to the business environment, are documented in a both formal and quantitative way[202]. The effects of weird behavior, purchasing patterns, negotiation forms, lack of competing and so forth are also colorfully - but alarming - described by Grennberg.[203]

From a general logistical view, one way to see the changes on the housing market - the reducing regulations and subsidies, the increasing role of quality, and finally and maybe the most important a more clear and evident customer focus - is as a slow general shift in production system.[204] The shift is from a push system to a more pull-oriented system/market.

In a push system the production is planned and controlled without any special concerns of the customers *(Figure 20)*. The general idea that all products would be sold on the market almost regardless of quality or concerns about the individual customer, was a reality on most early industry markets when competition was low.[205] This is quite like how many authors describe the former Swedish construction market.

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[199] Olsson, F & Larsson, E (1999), "*Godsflöden och transporter inom byggindustrin – Studie av förutsättningar och reducerad miljöbelastning",* Naturvårdsverkets förlag, Rapport 4954 and Olsson, F & Larsson, E (2000), "*Flödesorienterat byggande – lägre boendekostnader med hjälp av helhetssyn på byggindustrins materialflöden",* Byggkostnadsdelegatioen & Avd. för teknisk logistik, LTH

[200] E.g. Fernström, G (1990), "*Byggbranschen på 90-talet – kris eller tillväxt*" and (1992), "*Byggbranschen på 90-talet – förnyelse och samverkan*", Byggförlaget

[201] McKinsey Global Institute (1995), *"Sweden's Economic Performance"*

[202] Swedish Competition Authority, "*Konkurrensen i Sverige under 90-talet –problem och förslag*", Konkurrensverket Rapportserie 2000:1

[203] Grennberg, T (1998), "*Ta bort krökarna i byggsvängen*", Torsten Grennberg AB

[204] Olsson, F & Larsson, E (2000), "*Flödesorienterat byggande – lägre boendekostnader med hjälp av helhetssyn på byggindustrins materialflöden",* Byggkostnadsdelegatioen & Avd. för teknisk logistik, LTH

[205] E.g. Persson, G & Virum, H (1996), "*Logistik för konkurrenskraft*", Liber-Hermods

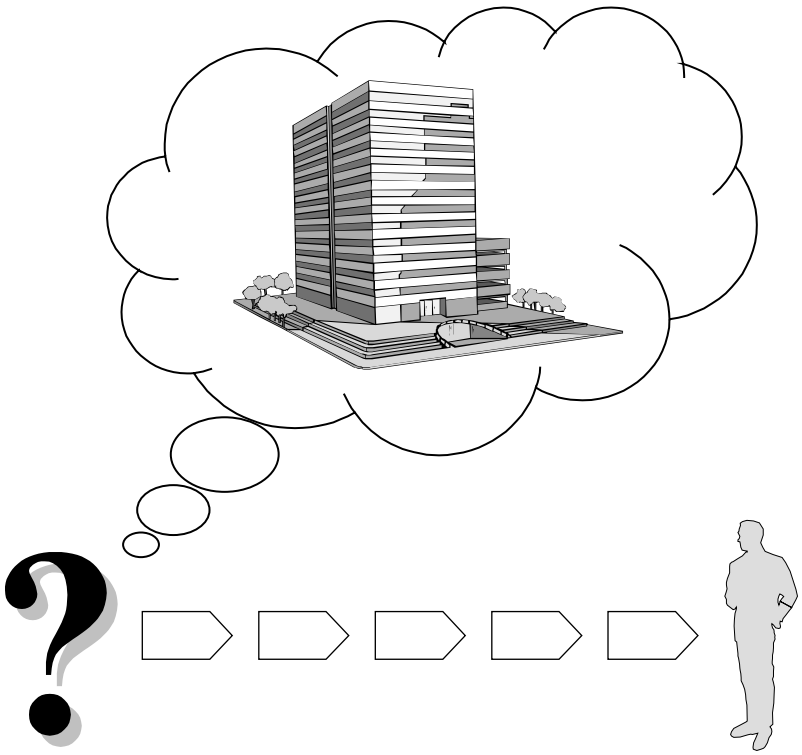


Figure 20: Construction as a push system.

The customer orientation in such a system is weak, and the production is neither based on consumer needs nor demands.

Today there is still a lot of regulations left, though most of the direct subsidies are gone. When it is the actual demand from the ultimate customer that triggers the production, then it is more like a pull system[206] *(Figure 21)*. But on the Swedish market, the more customer oriented industry only seems to cope with the market where extremely expensive dwellings are demanded. Salaj argues that flexibility and coordination are now more important than large scale thinking and acting.[207] A major challenge appears to be to provide products that meet the very basic demand that is the most crucial to most of the customers; products that they can afford.[208] The inability to offer such housing on the market is alarming and should act as a challenge to the industry. But the unwillingness to even try is more confusing: It is hard to detect any sign of serious efforts to significantly reduce costs systematically on the Swedish market for residential housing - with the exception of the Bo Klok project.[209]

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[206] E.g. Persson, G & Virum, H (1996), "*Logistik för konkurrenskraft*", Liber-Hermods

[207] Salaj, B (1990), "*Effektiviteten i 90-talets byggande*", BFR-rapport G4:1990

[208] E.g. emphasized by Skanska's CEO

[209] Olsson, F & Larsson, E (2000), "*Flödesorienterat byggande – lägre boendekostnader med hjälp av helhetssyn på byggindustrins materialflöden",* Byggkostnadsdelegatioen & Avd. för teknisk logistik, LTH

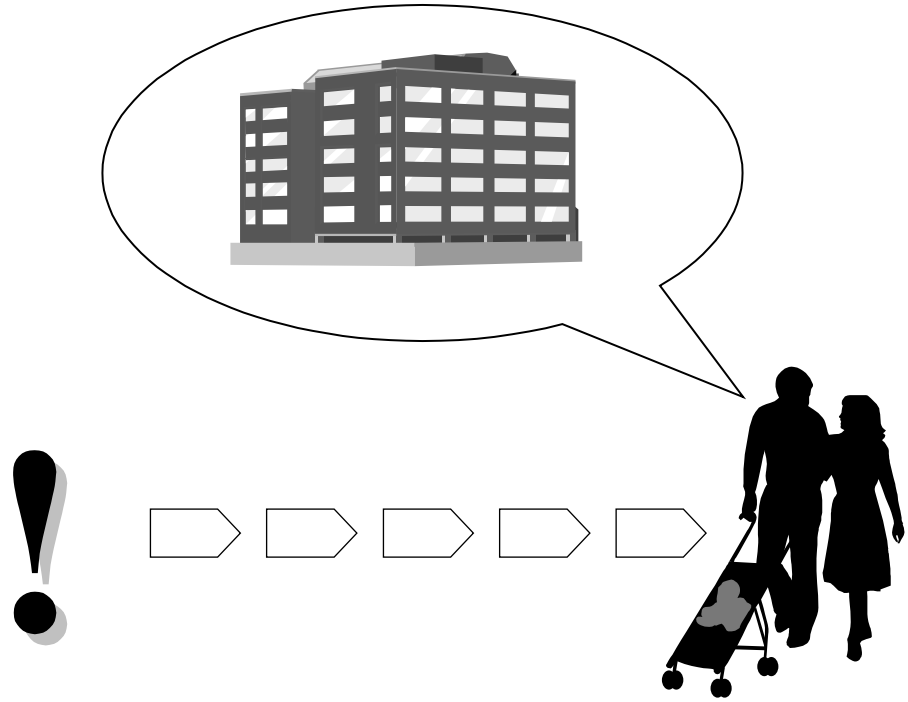


Figure 21: Construction as a pull system.

When an increasing customer focus is discussed here, it is a growing interest for the needs of the consumer that is meant. The consumer is the ultimate customer, e.g. the family that is paying of their total income for housing. Of course a client often is acting as a customer in a construction supply chain. And the contractors on site often see themselves as customers regarding the material supply, and so do the subcontractors; in all relations between companies a supplier and a customer could be pointed out. But in a supply chain perspective the ambition is to strive for creating customer value for the end consumer.

A challenge for the construction industry is now to understand the consumer needs, in order to offer the right products. During the time of plentiful subsidies, the quality of customer orientation was not considered to be that important. Fulfillment of the demands of the client has been the task, and the more customer-oriented construction companies sometimes now humorously see clients as the "deputy customer".

3.3 Logistics in the Construction Industry[210]

3.3.1 Literature Review

Literature studies reveal that there are few systematical studies that can be found on treating logistics in the construction industry. The lack of quantitative as well as qualitative data is notable. Recent pilot studies investing

[210] Focus is on the Swedish construction industry, but international references also appear in the text.

the area confirm this conclusion,[211 & 212] as well as literature reviews by Jarnbring[213], Olsson[214 & 215] and Hansson[216]. Jarnbring writes that of the results that could be found, there are few studies that have been done in a scientific way or have resulted in a scientific publication. And many of the results are surrounded with secrecy since they have been done as internal reports within companies. Investigations done in the context of this thesis indicates however unfortunately that the secrecy rarely hides interesting information; the companies and their representatives are merely trying to hide a maybe embarrassing lack of knowledge.

But there are publications of various types, from scientific to extremely practical ones, touching the research topic or in one way or another relating to the research question it this thesis. This literature review will try to cover the field, and show what has been done of relevance for the research question in primarily the Swedish construction industry. There is no explicit analysis whether the publications provide a substantial contribution to construction research in general; the objective of the review is more to investigate to what extent logistical thinking is represented.

There once was a trend in the Swedish construction industry that paid interest to logistical – or at least similar - questions. During the 1960s and 1970s, at the time of the extensive national housing program, the national research programs and the big construction companies were developing knowledge in order to increase productivity.

In for example a report from the national construction research program from 1960, distribution patterns and distribution costs are examined.[217] An interesting observation from this period is that the larger construction companies had central departments who worked with logistical issues or at least transport questions. Continuous cooperation between national research institutions and the construction companies existed, and there seem to have

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[211] Statens Byggeforskningsinstitut (1995), "*Logistik i byggeriet*", SBI-rapport 256

[212] Fransson, H (1996), "*Byggmaterialets övergripande struktur och styrning*", Förstudie, Institutionen för teknisk logistik, LTH

[213] Jarnbring, J (1994), "*Byggarbetsplatsens materialflödeskostnader*", Rapport 94:01, Institutionen för teknisk logistik, LTH

[214] Olsson, F & Larsson, E (1999), "*Godsflöden och transporter inom byggindustrin – Studie av förutsättningar och reducerad miljöbelastning",* Naturvårdsverkets förlag, Rapport 4954

[215] Olsson, F & Larsson, E (2000), "*Flödesorienterat byggande – lägre boendekostnader med hjälp av helhetssyn på byggindustrins materialflöden",* Byggkostnadsdelegatioen & Avd. för teknisk logistik, LTH

[216] Hansson, F (1999), " *Materialadministration med datorstöd i byggprocessen*", Avdelningen för byggnadsekonomi, LTH

[217] Holm, P (1960), "*Distributionsvägar och distributionskostnader för byggnadsmaterial",* SNB, Rapport 65

been a mutual ambition to build up knowledge on the subject.[218] A lot of M.Sc. theses were written from a quite practical perspective on transportation and materials handling[219], and also theses treating transport issues can be found from this period.[220]

Notable from that time is a somewhat different attitude from today towards the problem area, almost like another paradigm. There was obviously a more general opinion that it was worthwhile to spend time on studying the phenomena. But the tradition, in which these reports were written, seems to have ended in the late 1970s. Cyrén gives one explanation for this in his investigations of feedback and follow-up systems in the Swedish construction industry during three decades.[221]

During a sequence of years of strong growth and faster development in the construction industry, interests in new solutions and new technique grew. The companies experienced that they had to do follow-ups to improve their solutions. Cyrén describes how, after a time, this work stopped in the mid 1970s. When the companies had to reduce their staff, the departments for the follow-up lost their jobs. Moreover the systems that were developed in the companies were however mostly designed to fit large-scale production and repetitive projects. This kind of construction projects became unusual on the Swedish construction market in the mid 1970s.[222]

A new interest in purchasing and materials administration grew from the mid 1980s. The national research programs supported this kind of work. One report treated the possibilities for computer use and various service elements.[223] The prerequisites for implementing computer aid have changed, but the discussion about service elements is still interesting. And the problem to change the behavior among the construction companies was described by Hultman and Hjelte.[224] The authors see great opportunities in materials

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[218] E.g. Armerad betong AB (1972), "*Samordning Transport-Byggplanering*", Statens råd för byggnadsforskning, CTH and Skånska Cementgjuteriet AB (1972), "*Transporter från byggnadsplatsen*", Projekt E902

[219] E.g. Appelbom & Berglund (1973), *"Byggmaterialterminaler",* Institutionen för transportteknik, LTH, Lindström, Lorentzon & Lundin (1970), "*En kartläggning av den nuvarande byggmaterial-disributionen och kostnaderan härför*", Företagsekonomiska instituionen, Göteborgs universitet and the list of masters thesis in Bengtsson, B (1977), "*Byggbranschens materialtransporter*", Instituionen för transportteknik. LTH

[220] E.g. Sörås, A (1973), "*Samband mellan byggelements transporterbarhet och transportmedels egenskaper och ekonomi*", Inst. för Transportteknik, LTH & Bengtsson, B P-O (1977), "*Byggbranschens materialtransporter. En studie av nuläge med förslag till utvecklingslinjer*", Inst. för Transportteknik, LTH

[221] Cyrén, O (1993), "*Uppföljningsarbetets upp- och nedgång under tre decennier*", Avd. för byggnadsekonomi och byggorganisation, KTH

[222] Ibid

[223] Horstman, P & Paus, K (1990), "*Leveransservice och datorisering inom byggbranschen*", TFB-rapprot 1990:10

[224] Hultman & Hjelte (1990), "*Materialadministration i svenskt byggande*", BFR Rapport R74:1990

management, but they strictly see it as an administration problem. Distribution aspects of the construction process were highlighted and treated in a report, where the focus was the changing conditions on the market from large scale projects to smaller maintenance and reconstruction projects.[225]

Brief reports were published in this trend. Some of them have a very hands-on-attitude towards the problems, while others have a more theoretical concept. A report worth mentioning is written by Knöös and Larson.[226] They state that it would be possible to control the material flows in the field of construction as well as the actors in the stationary industry do. They argue that lead-times could be reduced, deliveries could be more precise, and losses and damages could be reduced as well as capital costs. The words *logistics* and *flow* are used in the text with a remarkably clear and ambitious concept.

Flow is also a frequently used term in a report that claims that it maps the material flows in the construction industry.[227] But an uncontrollable ambition to present quantitative data reduces the interest for the reader. Wild assumptions are frequent and flows are discussed without mentioning transports.

The most discussed contribution, and the one that probably had the biggest impact on the construction industry at the time, was the book titled "Räta ut byggsvängen" by Asplund and Danielsson. It clearly showed the benefits of materials management in terms of cost reduction.[228] It led to lots of seminars, education and changes in the purchasing patterns. At the time minor contributions, mainly directed to practitioners, were written.[229 & 230] The important difference between price and costs is discussed and is from this time at least theoretically accepted in the Swedish construction industry, opening up for treating concepts of total costs and logistics ideas.

A collection of reports treats aspects of the material flow, but seem to be captured in the existing structures. There is probably a need for solutions that reduce the less desirable effects from e.g. weather conditions on the construction process and materials on site, but it is a risk that this kind of knowledge consolidates the existing mental limitations of pro active handling.[231 & 232] A maybe more interesting documentation is the analysis of

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[225] Broms, Horstman & Paus (1987), "*Rationell distribtuion av byggmaterial*", BFR Rapport R72:1987

[226] Knöös, P O & Larson, F (1991), "*Byggmaterialflödet. En verkstadsindustriell ansats för flödesutveckling i byggindustrin*", BFR rapport R8:1991

[227] Jacobson & Widmark AB (1996), "*Kartläggning av materialflöden inom bygg och anläggningssektorn*", Naturvårdsverkets förlag, Rapport 4659

[228] Asplund, E & Danielsson, U (1991), "*Räta ut byggsvängen*", SBUF, Byggförlaget

[229] Holgersson & Wootz (1991), "*Byggmaterialmarknaden, MA-perspektiv på fyra delmarknader",* Byggförlaget

[230] Asplund, E & Danielsson, U (1986), "*MA-Bygg, idéer och reflektioner om materialadministration*" SBUF, Byggförlaget

[231] Eriksson, B (1995), "*Utveckling av fältverkstäder*", FoU Väst Rapport 9501

materials use on the construction sites. Larsson investigated the sites in the early 1980s and found out that 15 % redundant material or more was bought.[233] The variation in the over-consumption was found to be extensive and notable was also that the construction companies had very little knowledge about the actual consumption. In mid 1990s Lindhe reinvestigated the field, and she showed that the over consumption on the sites had been reduced to 1-12 %.[234] The investigations could have been even more interesting if they had offered more of methodological discussion and critical thinking.

But in the stream of scientifical publications during the 1990s, it is hard to find a logistical focus while quality has been more and more discussed. Rogberg discusses how the quality concepts are used in the Swedish construction companies[235], and Kadefors treats quality management and communication[236]. Important contributions to the quality field in this environment are Josephsson[237] and Josephsson and Hammarlund.[238] Causes for quality problems are discussed, and seven construction projects are examined. Interesting from a logistical point of view is that in the authors' classification *materials management* and *deliveries* are some of the major causes of quality problems in the studied projects. Quality matters are more or less scientifically described and analyzed in the annual publication SFK-Bygg, but there always seem to be a risk in quality management to be reactive, instead of pro active.[239]

Relating to the quality area is a M.Sc. thesis on the disturbances in the materials handling[240] and a similar report on disturbances in the material flow.[241] Especially the latter presents interesting models and represents logistical thinking. The authors claim that a reduction of 2.5 % of the materials costs could be achieved if disturbances could be avoided.

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[232] Asplund, E & Moström, L (1996), "*Vägen till det väderoberoende byggandet*", FoU Väst Rapport 9607

[233] Larsson, B (1983), "*Materialförbrukningen på byggarbetsplatsen*", Department of Building Economics and Construction Management, CTH

[234] Lindhe, N (1996), *"Effektivare materialanvändning på byggarbetsplatsen",* FoU-Väst, Rapport 9603

[235] Rogberg, M (1995), "*När kvalitetsidéerna möter praktiken*", IMIT

[236] Kadefors, A (1992), "*Kvalitetsstyrning och kommunikation i byggprojekt - analys av ett praktikfall*", Inst för byggnadsekonomi och byggnadsorganisation, CTH

[237] Josephsson, P-E (1994), "*Orsaker till fel i byggandet*", Inst. för byggnadsekonomi och byggnadsorganisation, CTH

[238] Josephsson, P-E & Hammarlund, Y (1996), "*Kvalitetsfelkostnader på 90-talet",* Institutionen för byggnadsekonomi och byggorganisation, CTH

[239] E.g. SFK-Bygg (2000), "*SFK-Bygg Årskrönika 1999"* (SFK-Bygg is a division of Svenska Förbundet för Kvalitet)

[240] Asp, K & Larsson, P (1987), "*Störningar i byggplatsens materialhantering*", Inst. för byggnadsekonomi och byggnadsorganisation

[241] Arnlund, P & Franzèn, M (1998), "*Störningar i materialflödet till byggarbetsplatsen – en verifikation av kostnader och orsaker*", Transportteknik, CTH

Hörndahl uses a network approach to analyze distribution patterns and the role of intermediaries.[242] The traditional terminology and the role of the intermediaries is questioned since it in distribution is a question of connected activities. He does not use the supply chain terminology, but he uses *activity chains*.

Other interesting, but from a logistical point of view peripheral, publications are contributions concerning e.g. the problems to adopt new production techniques on the working sites[243]. It is worthwhile to think about in a historical context[244] and the from a supply chain perspective partly interesting analysis of the relation between clients and contractors[245]. From a working environment perspective, Hallgren argues that systems for managing and controlling material flows on the construction site would reduce the risks of injuries.[246]

More interesting are in this respect a few publications treating the environmental aspects of the material flows in the construction industry. A study of the packaging systems and load carriers used in the Swedish construction industry reveals a lack of standards, and shows how difficult it is to change the situation since no one has an overall control of the flows.[247] The extensive volumes of waste produced by the construction industry were analyzed in another publication, colored by logistical thoughts.[248] The authors call for a pro active thinking, and one conclusion is that the best waste on the site is the waste that never appears.

A number of books have been written describing problems and opportunities for the industry in the 1990s. Fernström has been working with management training and has been leading workshops at IFL (Institutet för Företagsledning). His reflections of how the industry is doing and what must be done in order to be successful are published in a series of books.[249] Maybe it is primarily the first two books that are the most interesting, and they describe

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[242] Hörndahl, R, (1994), "*Mellanhänder i distributionen*", Inst. för Industriell marknadsföring, CTH

[243] Larsson, B (1992), "*Adaption av ny produktionsteknik på byggarbetsplatsen",* Inst. för byggnadsekonomi och byggnadsorganisation, CTH, Rapport 30

[244] Marmstål, F & Nordberg, N (1992), "*Byggarna och maskinerna*", Byggförlaget

[245] Kadefors, A, (1997), *"Entreprenör-beställarrelationer i byggandet" Inst. för byggandsekonomi och byggnadsorganisation,* CTH

[246] Hallgren, L-E (1996), "*Åtgärdsstategier för att minska rikserna för arbetsskador inom byggproduktion med fokus på leverans, mellanlagring och hantering av byggmaterial*", Inst. för Miljöskydd och Arbetsvetenskap, SBUF

[247] Storhagen, N G & Lindqvist, P (1998), *"Emballage och lastbärare på byggarbetsplasten"*, MTC, ABA kopiering AB

[248] Asplund, E, Danielsson, U & Moström, L (1994), "*Byggandet i kretsloppet*", Byggförlaget

[249] Fernström, G (1993), "*Nya spelregler för internationalisering*", (1996), "*Ett epokskifte. Samverkan för framgång i bygg- och fastighetsbranschen*", Fernström, G & Kämpe, P (1998), "*Industriellt byggande växer och tar marknad*", All published at Byggförlaget

the changes of the Swedish market during the 1990s.[250] In spite of the interesting reflections, the scientific value is limited. He argues for the need for improved productivity, cooperation, internationalization etc. It is almost remarkable that the state of the industry could be described in a number of volumes, almost without explicitly mentioning logistics. This is probably partly explained by the fact that most of Fernström's ideas are reflections from his seminars and thus represents the managers' view of the world.

Sandberg writes another interesting description of the market, and in many ways he captures the piquant connections between politics and the construction market.[251] This is interesting when the driving forces of the productivity are sought for.

Larsson investigated the conditions for implementing new techniques at the building site, and not surprisingly he finds the site manager to be a key actor[252]. He shows how the site manager often works under hard pressure since the time schedules are tight and disturbances in the production are frequent. It is the site manager who decides when and why to use new solutions and adopt new technology, simultaneously as it is his responsibility and daily work to deal with the problems on the site. There are always problems on the construction site that the manager have to give priority, and thus he is not putting his efforts into solving problems outside the site, or implementing new techniques that could avoid the on site problems. This can partly be the explanation for the mental resistance in the industry for pro-active logistics.

Jarnbring is the author that seems to bring the modern logistics concept into the stream of publications.[253] He studied construction sites and tried to determine the material flow costs on the sites by doing observations and various types of measuring on site. Jarnbring stresses that the biggest potential in cost reduction is likely the delivery of construction materials direct to the place where it is to be used. This was unfortunately rare in his studies. The basic factor for improvement is according to Jarnbring that the site personnel themselves are working actively towards changing the primary parameters affecting the material flow instead of regarding them as fixed conditions and trying to optimize a solution from them.

In an attempt to build on Jarnbrings work, Fransson made an interesting but somewhat fragmentary contribution with another pilot study, where representatives of companies in various parts in the supply chains of

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[250] Fernström, G (1990), "*Byggbranschen på 90-talet – kris eller tillväxt*" and (1992), "*Byggbranschen på 90-talet – förnyelse och samverkan*", Byggförlaget

[251] Sandberg, N-E (1997), "*Byggkraschen*", Ekerlids Förlag

[252] Larsson, B (1992), "*Adaption av ny produktionsteknik på byggarbetsplatsen*", Institutionen för byggnadsekonomi och byggnadsorganisation, CTH

[253] Jarnbring, J (1994), "*Byggarbetsplatsens materialflödeskostnader*", Rapport 94:01, Institutionen för teknisk logistik, LTH

construction material were asked in multiple interviews about their view of the potential of logistics.[254]

Hansson writes about the possibilities for improved materials management (the abbreviation MA is used in Swedish) with computer technology.[255] The possibilities to use CAD connected to the layout planning of the site are the focus, but a lot of interesting observations is reported from the attitude toward purchasing and planning in the industry.

A contribution worth special attention is a report from the national Danish research program for the construction field.[256] The report stresses the potential for logistics but is focusing on trying to establish an understanding for the logistics terminology and the very word logistics. In contrast to the ad hoc-solutions that are common on the construction sites, the report highlights the likely potential for pro-active logistics in the construction industry. An interesting suggestion is that the industry should try to develop a sort of standard for a design process that is adequate from a logistics point of view.

Also a true logistical approach could be seen in a couple of Finnish contributions from the mid 1990s, where the idea is to introduce a framework for reengineering the "logistics chains" between the construction companies and the suppliers, based on attempts for software development[257] or activity based costing[258, 259]. The usability of the ideas however seems to be limited, but the approach is interesting.

A few pilot projects have been given much attention, since cost reduction has been successful. Especially two projects have got a lot of publicity.[260, 261] The overall conclusion is that the projects by careful planning and cooperation between the actors have been able to reduce the project costs. The importance of establishing a recognized common objective among the actors is also stressed. From a logistical point of view the documentation is unfortunately

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[254] Fransson, H (1996), "*Byggmaterialets övergripande struktur och styrning*", Förstudie, Institutionen för teknisk logistik, LTH

[255] Hansson, F (1999), "*Materialadministration med datorstöd i byggprocessen",* Avdelningen för byggnadsekonomi, LTH

[256] Statens byggeforskningsinstitut (1995), "*Logistik i byggeriet*", SBI-Rapport 256

[257] Nyman H (1994), "*Developing a logistics tool using the prototyping method*", IIA Research Center

[258] Wegelius-Lehtonen, T (1994), "*Measuring and er-engineering logistics chains in the construction industry*", IIA Research Center

[259] Wegelius-Lehtonen, T (1994),"*Case examples of partnering in the construction industry*", IIA Research Center

[260] Andersson, N & Borgbrant, J (1998), "*Hyreskostnad, förvaltning och produktion i harmoni*", Inst. för Väg- och vattenbyggnad, LTU

[261] Nilsson, S (1999), "*Svedalamanualen- Ny byggherreroll i bostadsprojekt",* Byggkostnadsdelegationen and Persson, M (1999),"*Ny byggprocess – Svedalamodellen. Slutrapportering byggskedet.",* Byggnadsekonomi, LTH

sparse, but it is mentioned that special attention were given to the handling of materials on site, purchasing quantities and so forth.

Searching in the more international journals gives remarkably few hits. In the rare publications found, the purchasing perspective is frequent. Changing conditions and trends among the merchants of construction material are described, and the consolidation as a result of the need to reduce costs is one subject.[262] The present roles of the merchants in the supply chains are questioned. Interesting are contributions pointing out the potential for logistics and the need to coordinate the design and construction processes.[263] In spite of the, from a logistical point quite confusing, title *The role of logistics in the material flow control process,* this is an interesting article with a relevant approach. Other contributions seem too theoretical or too focused on operational levels.[264] An interesting systems perspective on the supply chain is presented by Naim, but the results tend to be very theoretical and oriented to operations analysis.[265] But the ambition to import concepts from the stationary industry, in order to improve productivity, often shows a lack of critical thinking.[266]

A concluding summary of the literature review is found in *3.3.5, Review summary and analysis.*

3.3.2 Flow of Goods and Transportation in the Construction Industry[267]

In an assignment for Sweden's Environment Protection Agency, a study was made of the transports in the construction industry. Three companies[268] were involved in the study and five different sites were used as multiple cases.

In this study it is also found that there are few publications covering the subject of logistics in construction. The construction companies had not so far been working with trying to reduce the environmental impact from their transports, neither had they tried to improve the efficiency of the transport

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[262] Agapidou, Flanagan, Norman & Notman (1998), "*The changing role of builders merchants in the construction supply chain*", Construction management and economics (1998), 16

[263] Agapidou, Clausen, Flanagen, Norman and Notman (1998), "*The role of logistics in the material flow control process*", Construction management and economics (1998), 16

[264] E.g. Naim, M M (1997), "*Lessons for construction from manufacturing systems engineering*" Logistics Technology International 1997

[265] Ibid

[266] Green S.D. (1999), "*The missing arguments of lean construction*", Construction Management and Economics, 17, 1999

[267] Olsson, F & Larsson, E (1999), Original title in Swedish: *"Godsflöden och transporter inom byggindustrin – Studie av förutsättningar för effektivisering och reducerad miljöbelastning",* Naturvårdsverkets förlag Rapport 4954

[268] The Swedish construction companies JM, NCC and Skanska

services. As a maybe somewhat late reaction to the general movement towards a sustainable society, the construction companies were in the study found to be more and more interested in their own effects on the environment. This had led to the adaptation of environmental management systems, but the transport issues had so far been left out of that work and the environmental impact had not been studied.

As the construction companies are working today, the study finds that the material supply and the transports related to the supply are not paid much attention. As receivers of goods the working sites differ from others, as the stationary industry. Several reasons are found for this, but one is that the production is heavily "production" oriented in opposition to "market" oriented, and that the flow varies in structure and intensity with the production characteristics. The managers at the construction site often see the handling of goods from the delivering vehicle as an important issue, while the interest for other aspects of the transport service is limited. Different types of material demand different types of transport systems, and the attitude to and the demands on the transport are affected by how the sender and the receiver regard the goods.

The traditional and most common way to buy construction material is to get it delivered to the site. The transport service is then included - and hidden - in the total purchase process of the material. This delivery condition is called "free on site", and is by most of the construction site managers regarded as a good solution. But by not paying explicitly for the transport *(Figure 22),* there is a risk that the transport service is considered to be free of charge. Even more serious is that the managers on site do not see themselves as transport buyers and thereby customers to this service, and consequently neither articulate needs or raise demands on the service.

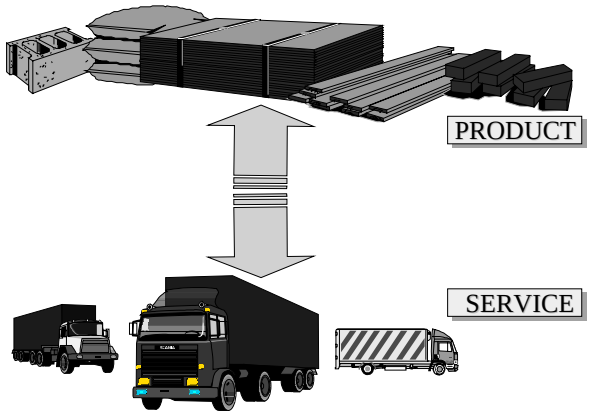


Figure 22: A separation between the product and the transport service offers possibilities to analyze the quality and price of the service as well as the price of the product.

In order to improve transport performance and to reduce the environmental impact, a customer driven development is needed, based on that demands are communicated to the ones that offer these services in competition with other

companies who offer and produce transport services. The actors – the contractors - that have the best conditions to start a change are thus not aware of their own role. In order to achieve such a development purchasing patterns should be changed, and it should be purchasing terms that reveal the various characteristics of the transport services that should be strived for *(Figure 23).*

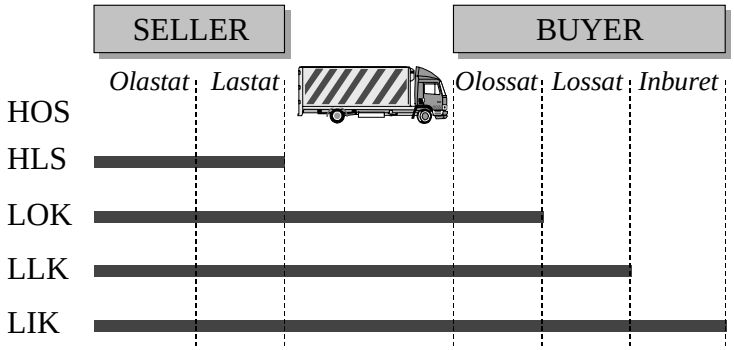


Figure 23: Defined terms of delivery.[269]

A general conclusion in the report is that the construction companies have a low level of competence, and none or few personal resources with distribution competence within their own organizations. The companies suffer from decentralization and heavy project focus, and the on site staff is focused on the production *(Figure 24).*

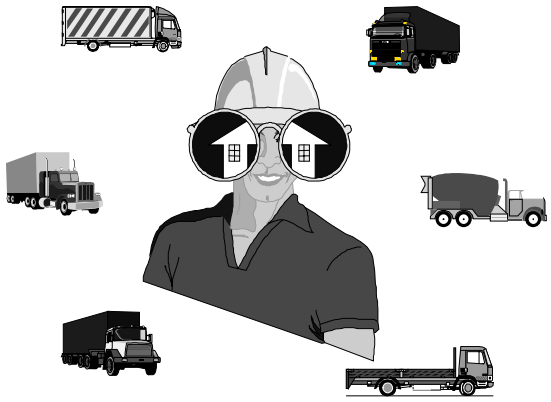


Figure 24: The construction companies and their managers are too focused on the production.

There is a lot to be won both from an environmental as well as an economic perspective, in a change leading to an increasing interest in transports.

It means however a lot of difficulties to analyze the material flows to and from a construction site. One major reason for this is that no follow-ups of the transports are done at the construction companies. In order to do such follow-ups, information must be structured and gathered, but routines, resources and administrative systems are missing to handle the information of the transports. Suppliers and transport companies have today neither guidelines nor a

[269] Entreprenörföreningen och Industrins Byggmaterialbrupp (1994), "*Leveransklausuler för byggbranschen"*

demand from the construction companies how such information should be handled.

Depending on production type and project type, materials are to a various extent bought by subcontractors. These material flows, that often make a substantial part of the total flow, are even harder to analyze.



Figure 25: Installation materials on the site.

And since the construction companies, even if they in a project are main contractors or general contractor, have little control of the total material flows on the site, they have today no possibility to take responsibility for the environmental impact of the project transports.

But the report states that there are good opportunities to improve the effectiveness and efficiency of transports to the construction industry and thus reduce the environmental impact. In the areas where positive results could be shown for both the economy and environment, is it less problematic to start working. The transports of the construction companies are luckily such an area. But in order to get started, the companies must improve their competence about their own transport needs. One important step is to start doing follow-ups of the transport work. In that way information necessary for quantitative treatment and measurement systems is created. The report also stresses that there are intimate relations between the way the companies manage their production and the prerequisites of the material supply. By

increasing the interest in inbound logistics there are thus also possibilities to change the terms of construction work on site in a beneficial way.

An observation protocol was developed for field study work in the five case studies in the study *(Appendix 1).* The efforts to observe and measure transports on site with these protocols in the study constitute valuable experience and an overall understanding of how the practical implications of the material flow - the physical distribution - works in the construction industry.

3.3.3 Flow Oriented Construction[270]

As an assignment for the Swedish Building Costs Committee, a report was written, to a large extent based on the Bo Klok-case that is described in this thesis. The report was a part of the committee's work for the Swedish government, aiming to investigating the possibilities to reduce the costs for residential housing. Since most of the content in the report is further elaborated in this thesis, it will not be more discussed here.

3.3.4 Industry Practice

There are almost no logisticians in the Swedish construction industry. As has been repeatedly shown in this and previous research, it is hard to find out data relating to logistical activities since there is no one to talk to about these matters; no one speaks the logistics language. There are no central logistical departments; all logistical activities are traditionally seen as operational activities that are managed ad hoc on site.

There are two major disadvantages for the researcher. Firstly, it is hard to find data among the practitioners because logistics activities are rarely documented and the general experience feedback is poor.

The other reason is not further developed here, since it probably calls for explanations on higher psychological level: Among top managers, there has been a tendency in the case studies and in other experiences, to claim that extensive logistics plans do exist, though as top secret information. Often, however, this information simply does not seem to exist. An explanation for this behavior might be that this reveals a management desire to be in control. But it causes problems for the researcher since there is often a communication problem in the heavily decentralized companies. There might very well be documents and policies in the companies, even though the local site manager honestly denies any knowledge of such information.

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[270] Olsson, F & Larsson, E (2000), Original title in Swedish: *"Flödesorienterat byggande – Lägre boendekostnader med hjälp av hehetssyn på byggindustrins materialflöden",* Byggkostnadsdelegationen & Teknisk logistik, LTH

Interesting practical logistical solutions have been seen out in some projects. However, these kinds of actions are not documented, and there is unfortunately a wish among the site managers to keep good ideas to themselves.[271]

In the mid 1990s Skanska started an interesting logistics project. More or less systematical investigations were done to find out more about the indirect costs in the purchasing process, and this work was linked to the internal education program. In a unique attempt Skanska decided to try out what could be achieved by having a special logistics manager on a project site. Five projects were chosen in which logistics managers started to work. New software for handling follow-up information was developed and tried out. This project was at the time top secret, and no external research was involved. Unfortunately the project seemed to end up in nothing, and the final reports by the local logistical managers were neither discussed nor evaluated.

3.4 Logistics in Construction - a Summary

The result of the literature review and investigations of the practice is foremost that a general systematic continuos increase of knowledge about logistics or flow management has not taken place in the Swedish construction industry, and has thus not either contributed to for example improved productivity.

The efforts that have been made relating to the research area in this thesis mainly seem to have been investigating transportation problems or purchasing patterns. The modern logistics perspective is missing, and investigations or projects aiming for pro active, holistic solutions have been sparse.

As the second step in the thesis research approach, the picture of traditional supply of construction material that has emerged from primarily the literature review, will be compared to the previously developed supply chain management criteria (*Figure 26).*

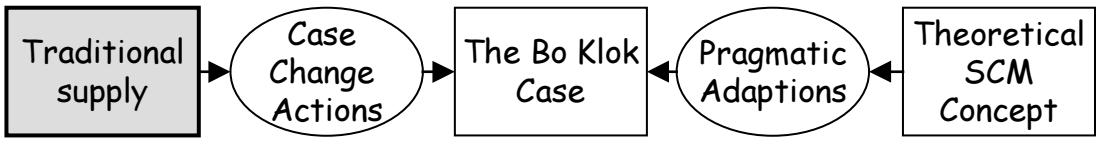


Figure 26: Comparing the traditional supply of construction material to supply chain management criteria.

Supply chain or supply chain management are expressions that are very rare in the context of construction. So the abilities to use supply chain management in the construction industry appears to have almost not been discussed. The need for integrative efforts seems obvious from the literature review, still no serious action has been taken in the matter. Since the supply chain management perspective and the very idea of even trying to manage supply

[271] Brisvall, J & Persson, J (2000), "*Bygglogistik i samband med Bo01 i Malmö*", Teknisk logistik, LTH

chains - with a small number of exceptions – were missing in the literature review, it is hardly surprising that the traditional supply of construction materials in Sweden today shows very little of the defined supply chain management principles. The literature findings in *Table 3* have been guided by generous interpretations.

SCM[272] Principle	Principle's framework	Findings in the literature review
Compression	• Reducing the number of nodes, members or actors in the chain or • Reducing the physical distance between any two nodes.	Fragments
Speeding up	Reducing the amount of time necessary to move between any two nodes in a chain or network, or between any two stages in a process.	Fragments
Collaboration/ Cooperation	Increasing the intensity and scope of cooperative behavior between two or more independent decision-making units.	Fragments
Integration	Reducing the penalty in time, effort, cost or performance to move between any two activities in a process or between processes (Sequentially, vertically or horizontally).	Fragments
Optimization	Maximization of the value of a target function through the use of quantitative methods.	No
Differentiation/ Customization	Increasing the specificity and thus the effectiveness of a subject towards a given purpose.	Fragments
Modularization	Reducing the penalty in time, effort, cost or effort to replace a particular segment of a chain.	No
Standardization	Reducing the magnitude of variation of a certain parameter of an object over time.	No
Postponement	Moving the product differentiation closer to the time and locus of consumption.	No

Table 3: Findings in the literature review used to compare traditional supply to the supply chain management criteria stated by Otto and Kotzab.

[272] SCM is frequently used abbreviation for supply chain management

The literature review also indicates that the supply in the construction industry in principle could be described as traditional supply, in terms of the factors originally stated by Coyle et al, see *Table 4.*

Factor	Construction industry supply
Warehousing	Company based
Flow of goods	Interrupted
Costs	Company minimized
Information	Company controlled
Risks	Company focused
Planning	Company oriented
Inter-organizational relations	Company focus on low cost

Table 4: The construction supply chain is essentially traditional.

For many of the contributions in the stream of publications, it is hard to detect any efforts of using or building upon earlier knowledge. The potentially fruitful close relation to practitioners seems to bring a risk into the research; systematical creation of knowledge is threatened, and most of the more or less logistical projects suffer from a lack of documentation and feedback.

The development of the frame of reference highlights a general trend in the stationary industry, reflected by the extensive logistics literature, which is the change in attitude towards flow management, e.g. supply chain management. More and more efforts are put into work in logistics areas. The modern company has a lot of employees working with logistics, and expensive and sophisticated computer systems are developed and sold to organizations in the stationary industry in order to proactively control the flows. This could be seen as a general movement from field 3 to field 1 in *Figure 27.*

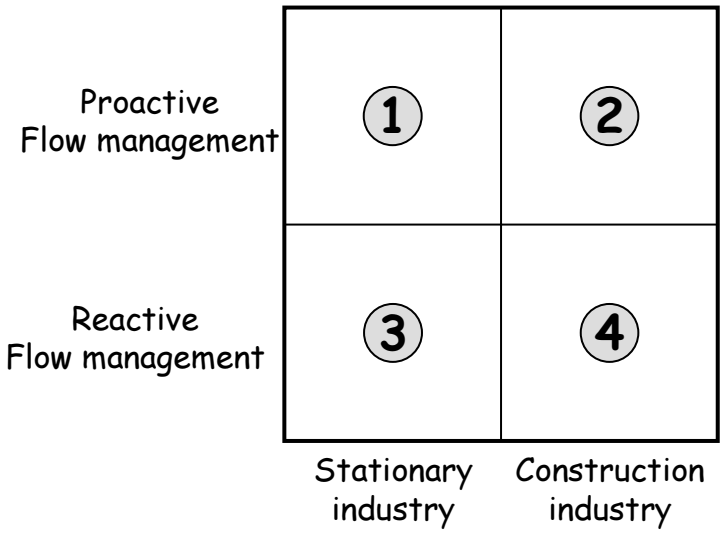


Figure 27: Flow management attitudes.

Any corresponding movements, from field 4 towards field 2, among the companies in the construction industry are however hard to detect. The trend found in the literature review indicates rather the opposite, seen over the last decades: The proactive approaches seen in the 1970s and 1980s are nowadays sparse. But still the frequent problems, consequences from an absence of pro-active flow control, are severe and quite well described.

Some publications could maybe be said to reflect movements from field 4 to 3, trying to create conditions for the construction industry similar to the conditions in the stationary industry.

4. An Unusual Construction Project - Case Description and Initial Analysis

In this chapter the case study in the thesis is presented in a chronological sequence. Reflections and initial analysis are added at relevant places in the text.

4.1 Case Introduction

The choice of the case study project Bo Klok, and the thoughts and efforts that preceded the choice, was described in *Chapter 2*, where also general case study reflections are to be found.

The case will be presented, described and analyzed in a systems methodology presented in *Chapter 2, Systems approach*, consisting of seven steps in chronological sequence *(Figure 28).* So presentation of the case is what is seen when the described kind of "systems glasses" are worn. This means that the steps in the model will be worked through, and the ambition is to manage the case study material two rotations in the model.

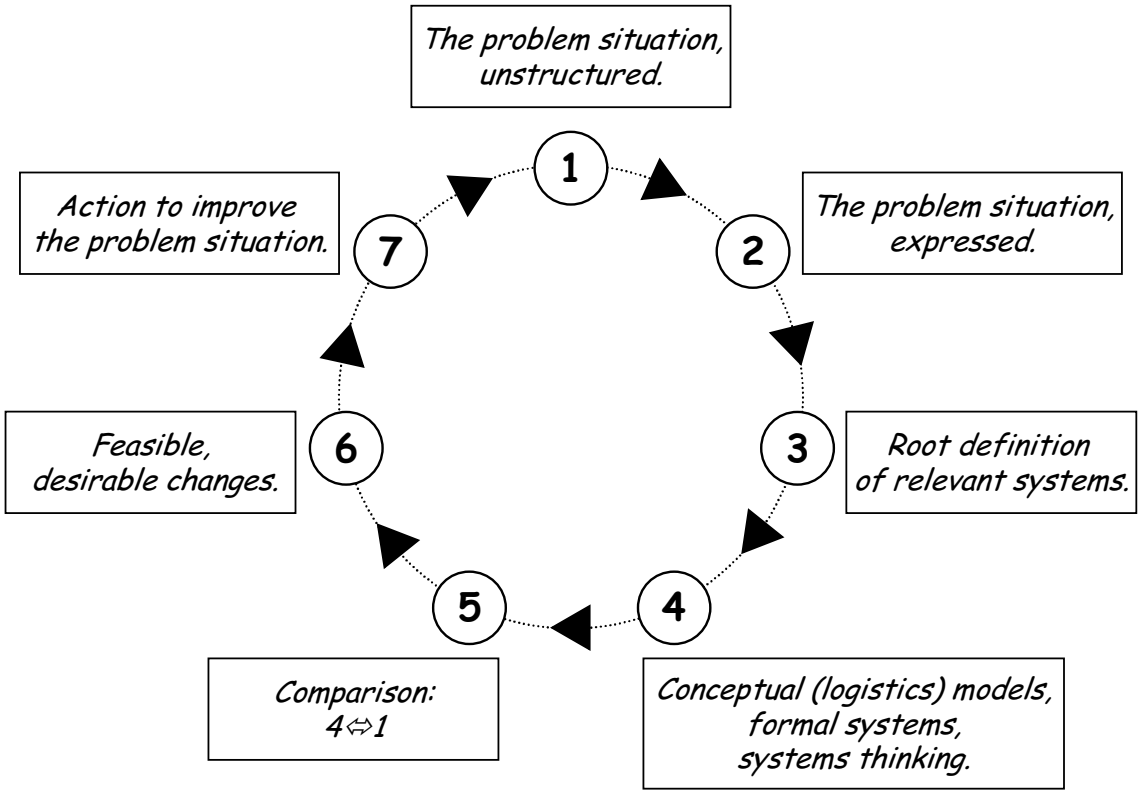


Figure 28: An outline of the systems methodology.

The first one and a half rotation is a primary a description of what has happened in the studied case (Step 1-7, 1-3). Then the analysis consists of the half rotation that is left, also containing describing parts (Step 4-7). To separate the case report from the reflections and analyzing comments, the case report is presented in normal text while the reflections are in *italics*.

The case description and the case reflections constitute step 3 and 4 respectively in the thesis approach, as shown in *Figure 29.*

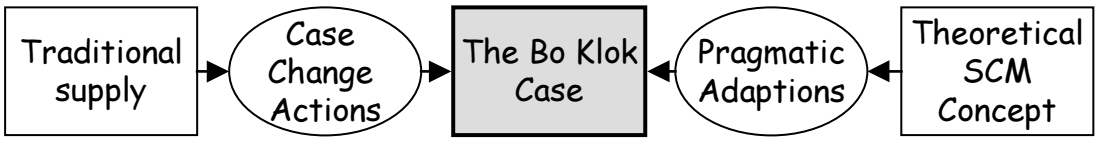


Figure 29: The case study's role in the over all research approach in the thesis.

The case description and the attached reflections upon flows, logistics and supply chain management serve the purpose to later enable an analyzing discussion about to what extent the actions in the case might be classified as supply chain management. The defined supply chain principles *(Table 5)* will be sought for in the case.

SCM Principle	Principle's framework
Compression	• Reducing the number of nodes, members or actors in the chain or • Reducing the physical distance between any two nodes.
Speeding up	Reducing the amount of time necessary to move between any two nodes in a chain or network or between any two stages in a process.
Collaboration/ Cooperation	Increasing the intensity and scope of cooperative behavior between two or more independent decision making units.
Integration	Reducing the penalty in time, effort, cost or performance to move between any two activities in a process or between processes (Sequentially, vertically or horizontally).
Optimization	Maximization of the value of a target function through the use of quantitative methods.
Differentiation/ Customization	Increasing the specificity and thus the effectiveness of a subject towards a given purpose.
Modularization	Reducing the penalty in time, effort, cost or effort to replace a particular segment of a chain.
Standardization	Reducing the magnitude of variation of a certain parameter of an object over time.
Postponement	Moving the product differentiation closer to the time and locus of consumption.

Table 5: The criteria will be highlighted when found in the case report.

The production environment is described as the systems environment, where the case study projects existed. These conditions of the production has been found to be general, and the external business environment in the case fits well with the conditions for trying to manage or control material flows described in earlier studies from the department of Engineering Logistics, Lund University. These conditions, mainly classified as traditional supply in the Coyle model in *chapter 3*, thus also fit with results published by other authors. The

possibilities that have been used in the case, as well as the difficulties to benefit from these possibilities, are known from earlier studies of the conditions of the material flows in the construction industry.

Six Bo Klok projects have in the case study been studied on site. The projects have been situated in Haninge, Helsingborg (2), Gävle, Älmhult and Örebro, see the map in *Figure 30*.

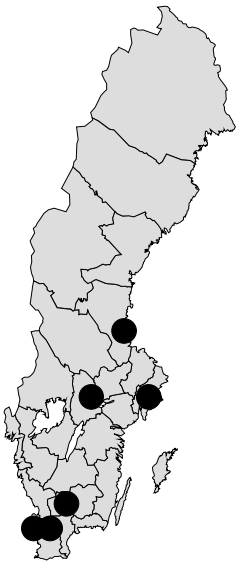


Figure 30: Location of the five studied project in the main case study.

Four of the projects have been studied during the production phase, and in one of the projects participatory observations were done to study the production during a number of days. Key suppliers have been visited and 12 deeper interviews have been carried out with key persons in the project (*Appendix 2*). Other sources of information, e.g. document studies, have also been obtained by being out in the case environment.

4.2 Creating a New Concept

4.2.1 Swedish Housing Market in the mid 1990s

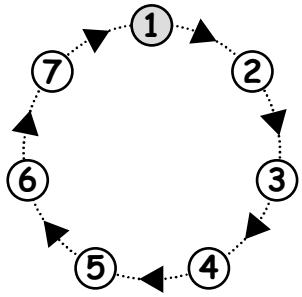


Figure 31: Stage 1 in the systems methodology; the unstructured problem situation.

During the 1990s, residential construction had almost exclusively been sited in central Stockholm. In the rest of the country, rents and prices on the market were considered too low to justify new projects from the producers'

point of view. Subsidies were reduced and the early 1990s were described as almost a catastrophe for the construction industry. Demand and employment fell dramatically in this cyclical downturn that appeared to be worse than experienced before, and the level of new residential housing was about 10 000 units per year compared to about 70 000 units a few years earlier.

In this environment, the Swedish construction company Skanska in partnership with IKEA started the Bo Klok project in 1995, the purpose being to create a product that the customer – meaning the final consumer – wanted to financially acceptable and affordable. Skanska, as an experienced construction company, would like to develop a market for its products, and furniture item company IKEA wished to increase the number of new households that were set up in Sweden, a number that has been significantly reduced during the 1990s. New households, where two people (or more) move together in a new apartment, are the ultimate customers for IKEA. The number of new households that is set up is to a certain extent depending on the extremely low production volume of new houses and apartments.

The goal for the project was to create a house that contained apartments that people with normal incomes could afford.

So the customer was the focal point from the outset. The potential end consumer was identified through thorough market investigations. This behavior sounds obvious enough, but has in fact been unusual in the construction industry, at least in Sweden.

The project costs were decided by the potential customers' financial situation, and this was studied carefully in cooperation with economists. In focus groups representatives of the target group provided the project with information. The starting point was thus not how much it would cost to produce the product; instead it was the customer, the actual demand and what the customer could afford. The customers were identified as:

- Students
- Single adults
- Older couples
- Anyone who wanted smaller housing to a low cost

How much this groups were willing - or able - to pay for their housing was the key input, but interest was also paid to what these groups appreciated the most and in what areas they were willing to forgo their own standard *(see Appendix 3).*

4.2.2 The Challenge

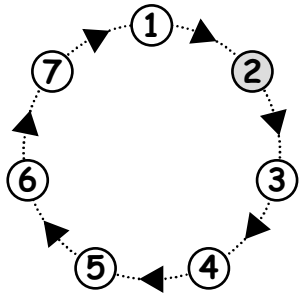


Figure 32: Stage 2; the expressed problem situation.

So at this stage an ultimate cost level for the products in the project was determined. The ambition was to offer 3-room apartments with kitchen (59 m^2) and 2-room apartments with kitchen (48 m^2) within the Bo Klok concept. A slogan for Bo Klok was later (1997): "Your new home for about 3 000 SEK a month".

This meant that the Bo Klok project had to produce residential housing for about half the average production costs in the Swedish construction industry at the time.

The fixed cost led to that Skanska as contractor, inspired by IKEA who focused on the economics of "the common people", now would be forced to reduce costs in many new areas. A fast and correct production phase would be necessary; there would be no room for mistakes, damages or losses. A holistic view on all the fragmentary construction activities would be needed, and all participants in the project would have to reduce costs substantially.

But normally there is no such cost transparency in a construction project. So it was not immediately possible for Skanska to analyze and control the total costs of the project, since there were large pieces of the whole, e.g. the costs for the subcontractors parts, that were unknown to their content. The general understanding of total costs was thus low.

In the early stages a smaller group was formed including the project manager from Skanska, an architect and a decorator from IKEA. The group experienced that they had a strong management commitment.[273]

The group consisted of three women – a rather unusual constellation in the construction industry heavily dominated by men. And it is back to this group that many of the interesting, new and unique solutions can be traced. It is notable that the members in the group were able and allowed to work very free and goal oriented with a clear top management commitment. In the construction industry

[273] This was later manifested by the presence of Skanskas CEO Melker Schörling and IKEA's founder Ingvar Kamprad on the project kick-off in the media.

today, it is very rare to find such projects, where employees are allowed to plan and work with the preparation and planning of a project.

The members of the group refer to the work as very interesting, that discussions were unconventional and that solutions always seemed to come up. The architect says that she experienced it as that she "finally had met a constructor that understood." She uses this phrase repeatedly to explain "that it is the reason why the houses were so good".

The core group had a small reference group with representatives from Skanska and IKEA. And as the project was discussed, a larger group within Skanska developed that contributed with ideas and competence. As the work to design the buildings and the apartments proceeded, contacts soon were established with potential material and systems suppliers.

So there was a recognition and consciousness about costs of the product connected to the housing costs for the consumer from the beginning among the persons that were engaged in the project. In close cooperation between construction competence, knowledge of decoration and expertise of the customer value in housing and architecture the Bo Klok project was formed.

4.2.3 Systems Definition

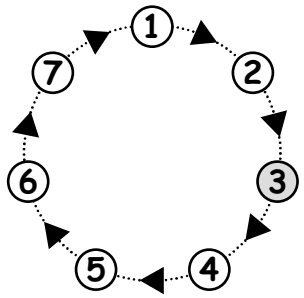


Figure 33: Stage 3; root definition of systems.

The root definition of the system in the case at this stage could be:

An organization led by Skanska, with companies in the construction industry and IKEA that designs, produces and sells housing on the Swedish market to people with normal income, such as adult singles, students and older couples.

So, in the systems definition, the customers *are the consumers, the identified groups of customers. Another definition could have been that it was the organizations in the construction industry that were the customers, and that might have been more correct in some of the conventional temporary projects. But in this project the customer focus was evident and clearly communicated.*

The actors *in the system are the organizations in the construction industry and IKEA. These actors include actors in the supply chains, such as material producers, transportation companies, but also designers, contractors and subcontractors. The*

transformation *in the system is the designing, producing and selling activities, were producing is the emphasized part. The implicit* meaning *of the system is perhaps to provide housing for the consumer, a goal that falls back on a long political tradition in Sweden, and also is close to the idea of IKEA to "make products for the common people". Skanska is trying to act as the* owner *of the system, while IKEA's role seems to be more passive. The major* environmental constrain *is the conditions on the Swedish market for producing houses.*

4.2.4 Development of a Concept

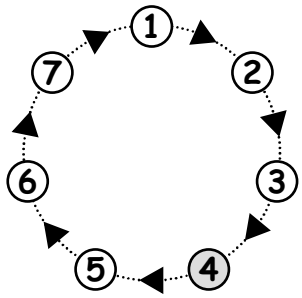


Figure 34: Stage 4 in the systems methodology; introducing conceptual models.

In the project model that was created by the project manager, a new, holistic ambition emerged in order to reach the desired cost level. The fixed cost led to a number of unconventional solutions for the project.

A high quality production phase was needed; there was no room for the conventional appearance of mistakes, damages or losses. To guarantee high quality and a short production time, an early decision was taken to develop prefabricated elements for the houses. The project managers had the opinion that in order to reduce costs the project must be "industrialized." Myresjöhus, a producer of family houses owned by Skanska, was chosen as a partner already in the early discussions. They had the technique to produce house elements, and they were now asked to participate in the project in the early design phase to contribute with their knowledge.

The project manager managed to bridge minor cultural differences that exist between the traditional construction industry and the small house producers. Exactly why Myresjöhus was chosen as supplier is not clear, but some of the actors say that since Skanska owned the company they had to participate. From the perspective of a producer of small houses, the production and selling elements to the Bo Klok project was probably not seen as an interesting business, since the profits were considered to be too low. Whole houses, ready to assemble, designed by the own company were preferred by e.g. Myrsejöhus. However in this situation Myresjöhus was invited to contribute with their knowledge, even if some actors explain their presence as if they had to because of owner demands.

Balancing the demands of effective and efficient construction with the value appreciated by the customers, Bo Klok was designed. One early challenge for

the architect was to limit the apartment size, an optimized use of the area was needed to keep down the costs. The architect had the ambition to use space and light to compensate for the reduction of the apartment areas. This was achieved by using an unusual ceiling height in the rooms: 2.60 m compared to normally 2.40. All apartments must further have daylight from three different directions. The windows were larger and the window seat was lower than in normal houses. These ideas were worked through in a series of drafts, as early results in the work between the three women. The architect brought knowledge and experience from an earlier project, "Allemanshuset". A house consisting of six apartments in two floors saw the day in the drafts. An external staircase led to the three upper apartments. This house was considered to be the biggest possible size in order to avoid being connected with the type of houses that were built during the national program from 1965-1975.

The architect refers to the mottos: "High quality to a low cost", "Housing for the big group with the small purse" and "A small scale product for a large scale production". She states that it from the beginning was an absolute demand not to reduce product quality. But it was, also from the beginning in the project, stressed that the houses within the project must be exactly the same to a certain extent, in order to enable an industrial production technique. The, according to the architect, normal uncontrollable desire among contractors and architects always to create and change was controlled in the project, a process managed by the project manager.

The belief that it was possible to produce nice products with an industrialized approach is interesting from a Swedish perspective. Since the days of the national housing program (1965-1975), the industrialized production of houses has had bad reputation. Here it was early determined that the repeated production in an industrial approach was not only possible. It was regarded as a necessity.

So the early drafts were then discussed primarily with Myresjöhus, who later created the blueprints. With deep knowledge of the terms of production in their factory, Myresjö suggested a number of changes. This led to discussions and minor conflicts, but solutions - sometimes compromises - were always reached in this iterative process. Myresjöhus had for example problems to accept the outline of the apartments. They were drawn to fit with a special sofa or bookshelf in mind, but they did not fit with the production module system developed in Myresjöhus' factory. Other conflicts with the module system occurred in other areas, e.g. the unusual room height.

Here we see an interesting contrast between customer-oriented production and the opposite, as an illustration of the fruitful work at this stage in the project.

Myresjöhus normally did not use external architects. The Bo Klok architect thinks that the use of external architechts is a major area of improvement for the small house producers in general, and that "the details in their (family house producers projects are not beautiful". The project architect was not

hesitant for compromising in some of the questions; "we always came to a good solution". But she says that the discussion was very important. Often in normal projects, the construction company changes details, by them seen as irrelevant, in the production phase. These changes might jeopardize the whole project, since the details are so important, she says.

The decorator and the architect decided three different external color combinations and six choices for the internal environment. The objective was that the project had to fit in most external environments in Sweden. The architect also wanted to create a more modern version, but at this stage this idea was not accepted.[274] The Bo Klok concept consists of a six-apartment building with a design related to Swedish countryside traditions, see *Figure 35.* A group of five to six of these houses is built in one project. The number of houses are held down in order not to give large scale impressions, which are considered to be bad.



Figure 35: An example of a Bo Klok house.

The project manager strived for a high level of preconstruction, and the ambition was to include pluming and electrical wires in elements as for example in external wall elements from Myresjöhus . The representatives from Myresjöhus initially tried to hold back these ideas, since they thought that it

[274] The idea was later realized as Skanska and Ikea were not admitted to participate with Bo Klok in H 99, the national housing exhibition in Helsingborg in the summer of 1999.

was not a good idea. They never went so far in their own concepts. The project manager persisted and decided that this kind of installations was to be partly assembled in the Myresjöhus factory, see *Figure 36*.

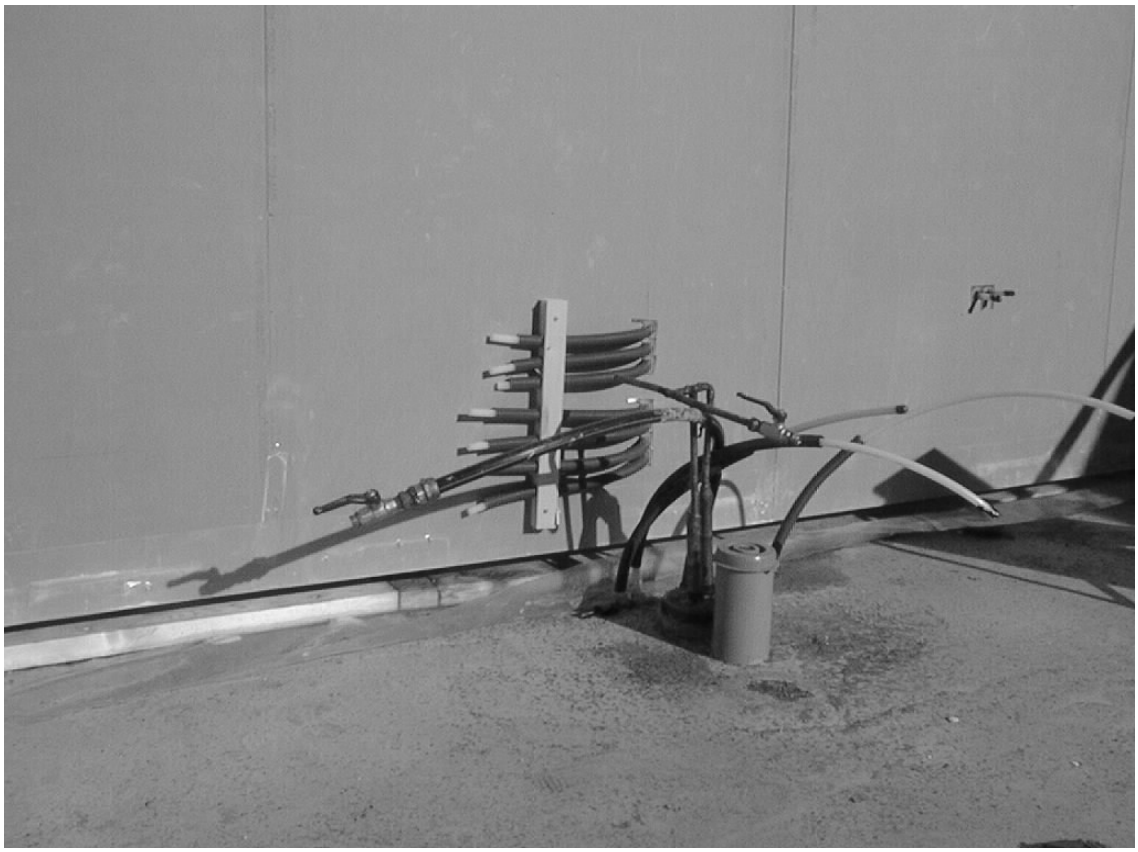


Figure 36: Installations in a wall element.

But in order to reduce costs significantly, it was not enough to highlight the production methods on site; soon Skanska's representatives directed their attention to the traditional purchasing patterns and the supply chains. The subcontractors' material flow soon also turned out to constitute a too large share of the overall costs to be left unstudied. On Skanska's purchasing department plans in this directions had been made up earlier and they now offered these plans to the project.

So what is seen is that when the project management conceptually had decided what to build, an intense chase for cost reduction started when investigating exactly how to build it. This work could be compared to the normal work in the stationary industry; every part of the production is analyzed. Notable is, from a conventional construction industry perspective, that all these activities and analyzing happened before the production of the houses had started.

IKEA also offered financial and decoration assistance to the customers in the Bo Klok projects. IKEA gave a check worth 3.000 SEK for new furniture, free delivery of furniture and two hours of free technical support to the Bo Klok customers. Information about local Bo Klok projects was given by local

advertising and marketing on the nearest IKEA shopping center. Customers who were interested could come to IKEA on a certain occasion to sign up.

4.2.5 A Minor Revolution

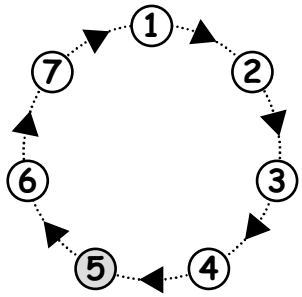


Figure 37: Stage 5; comparison between stage 4 and stage 1.

So how are the costs in Bo Klok reduced? This is achieved by such means as improved relations with suppliers, new delivery systems and a high degree of prefabricated elements distributed to the site in a well-structured way. Such behavior is not common in a conventional construction project.

*Every delivery to the construction site is carefully planned and a just-in-time performance is expected. This action calls for series of cautiously planned activities on the site. Only value adding activities can be done; there is no time for anything else! This includes and requires that suppliers and transportation companies also perform in a predicted and documented way. Construction elements and products, for example, have been packed in a specified way, marked with necessary data, and goods have been loaded in accordance with special specifications (*Figure 38*). Unloading is then managed in a carefully decided order, and most of the elements are built into the construction immediately when delivered. Participants in the projects refer to the delivery concept as IKEA-inspired. "Everything is delivered in flat packages". There seem to be no explicit concept, but the idea to change the normal behavior has succeeded.*



Figure 38: A Just-in-time delivery to a Bo Klok project.

By not unloading goods in a temporary stock all over the site, the unloading conditions on site are significantly improved. This is a notable improvement compared to previous research. All these integrating efforts in the supply chains are the results of the work of the actors, supervised by the contractor, striving for reduced costs.

The conditions in the Bo Klok concept are that the input of the construction process on site is the same in all projects. And so is the output. It is hence possible to map the transformation process, and this is experienced as meaningful since every project is not unique. This was done, and of course, as nearly always in process mapping, potential improvements were discovered. All activities were highlighted and time and costs were reduced.

Skanska had the ambition to control all the costs in the project, a remarkably holistic approach. The intention was to let no part of the project remain unquestioned. Traditionally the subcontractors' work is bought including the required construction material. The subcontractors have thus been responsible for the purchasing process of the material required for their own work. But in Bo Klok, as Skanska wanted to reduce the total cost also for the subcontractors' parts of the project, they decided to buy the material directly to the Bo Klok project via Skanska, and only use the subcontractors to do the actual construction work.

The transports to the sites were reduced in number. The logistics company ASG was chosen as the actor for nearly all of the transport services to the projects, see Figure 39.



Figure 39: ASG on site performance. Notably difficult site conditions.

*Myresjöhus AB was used as a terminal, and a lot of different construction material and products were loaded together on the same shipment, and the loading order was suited to fit the unloading on site (*Figure 38*). Many of the deliveries were planned to be unloaded directly into the construction work. The ambition was to reduce the number of products, that later would have to be handled and transported on site. For this purpose loading descriptions were written.*

To control the construction material in e.g. the loading, unloading and assembling on site, a product data system was introduced, building on an existing system developed and used by Myresjöhus.

The trucks used for deliveries of the prefabricated elements were all equipped with a crane to provide the site with the appropriate unloading handling aid. To enable the crane to unload the elements right into the assembling, the trucks had to approach the site in a specially decided driving pattern. This demanded that the site must be in exactly the right moment of production. The deliveries had to arrive in a defined construction stage, and the site personnel had to be aware of what was expected from them and the status of the construction site.



Figure 40: Construction element with attachments to facilitate unloading.

All elements had appropriate means of attachments in order to facilitate the unloading. (Figure 40) Products from widely different product groups were packed together to be unloaded in the apartment and the room they later were to be assembled in (Figure 41).



Figure 41: Construction materials unloaded at the place of assembling.

All Bo Klok construction material and products were to be included in central purchasing contracts negotiated by the central purchasing department at Skanska. Sometimes this meant that already existing contracts within Skanska were used, sometimes new contracts were written. As special project routines for sub-ordering were developed by the project managers, detailed information about how the deliveries were supposed to be arranged had to be exchanged between Skanska and the suppliers.

So the outline of the Bo Klok project was in many aspects unconventional and innovative. From a logistics perspective there were many unique solutions. The ambition to try to analyze and change the delivery patterns in order to improve efficiency and effectiveness meant structural changes in order to reduce costs. The careful planning of how different house designs would affect various stages in the supply chain, including transports, as well as the overall efficiency and effectiveness in the on site production is interesting. So the project differed from all other housing projects on the market, striving to reduce costs in all parts of the project.

From a supply chain management perspective, seeds to some of the supply chain management criteria could be found at this stage *(Table 6)*.

SCM principle	Case change actions
Compression	Challenging structures
Speeding up	Challenging structures
Collaboration/ Cooperation	Holistic approach
Integration	Holistic/Pro-active approach
Optimization	-
Differentiation/ Customization	Challenging structures
Modularization	-
Standardization	-

Table 6: Actions that led towards a supply chain management approach.

4.2.6 Market Introduction

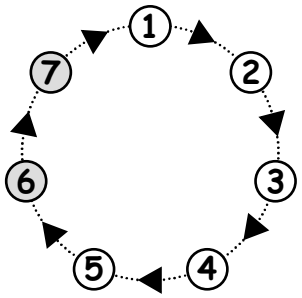


Figure 42: The final steps in the systems methodology; changes to improve the situation.

From here Skanska went on with the Bo Klok project, now with a large number of more or less unique solutions that had never previously been seen in the Swedish construction industry. Bo Klok was introduced to the market and production of the first projects began.

The purchasing department at Skanska probably knew that the desire to change the purchasing patterns for the installation materials would meet resistance among some of the actors in the system. The cultural difficulties in the system were underestimated and probably not considered to be taken into account. It also seems like some of the lack of doubts from Skanska also stems from a somewhat stubborn desire to demonstrate power. All the changes, compared to a normal Swedish construction project, that now came to be a part of the Bo Klok project were not discussed, explained or negotiated with the other parts of the system. Neither had these decisions support at this time in all parts of the own organization within Skanska. On site construction and on site casting are strong cultures within Skanska's own local organizations. There is reluctance towards pre-production and

pre-constructed elements, and these methods are often considered not to be "real" construction.

Myresjöhus had to produce the Bo Klok elements in a separate production line as they did not fit in the module system in the factory. In some areas a higher degree of preproduction than Myresjöhus was used to was used for the elements. Myresjöhus did not know at this stage how big volumes the Bo Klok project would generate, so they were a little reluctant towards special production investments.

4.3 Bo Klok on the Market

4.3.1 Reactions

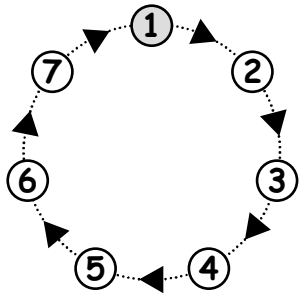


Figure 43: Once again the 1st step in the systems methodology; now the new situation, unstructured.

The Bo Klok project was introduced at the market, and the reaction from customers and media was extremely positive. Customers were lined up as the opportunities to sign up for Bo Klok apartments were given. These events took place at the nearest IKEA shopping center, and these happenings were given a lot of attention in Swedish media.

So in spite of tough conditions on the Swedish market for residential housing – mainly due to the harsh fact that the rest of the industry was unable to present a product that the vast majority of customers could afford to demand – the Bo Klok project was a great success. Product quality was regarded as high, costs substantially less than comparable products, and Bo Klok has repeatedly been described in terms of success in media and in consumer investigations. Skanska has, as a sign of the success, been asked to introduce the Bo Klok concept on the British market.

The project had reached its goal to offer housing at the decided cost levels. However it is not clear whether the project at this stage was profitable for all companies in the system, e.g. Skanska itself and Myresjöhus.

Now the plan was to start building Bo Klok projects in a lot of Swedish cities. Restrictions were from the start decided from inside the project in order to control the expansion of the market: Not too many dwellings on the same place (18-36 apartments, meaning maximum 6 houses), and not too many projects in the same city.

But the plans from the purchasing departments had not really been possible to fully implement. Many of the material producers, normally selling to subcontractors, turned out to be unwilling to sell directly to Skanska. Negotiations led to that Skanska, after major difficulties, managed to persuade one of the national retailers for each group of installation materials to sell directly to the Bo Klok project. One restriction worth mentioning is that Skanska was only allowed to use these materials in the Bo Klok project. The project could, according to the reluctant retailers, be admitted to be an industrial project and hence it was possible to sell the material directly to Skanska. But Skanska was under no circumstances allowed to buy like this in the normal projects in the country. A substantial cost reduction was achieved for the materials in the project, and Skanska now wanted to use subcontractors to do the work on site. This meant that the subcontractors were expected to contribute with their competence and their services, while Skanska provided the required material. So this was a retreat compared to the initial ambitions from the purchasing department, where Skanska wanted to buy most of the material directly from the producers. Now material was bought from retailers with bad grace.

Before the purchasing negotiations were sorted out, the first project was in the production phase. For example the electricians were then used to, as in a normal project, that they would sell the service and material as a whole to Skanska. So the electricians bought the equipment they were used to, and the products their own local retailer offered. This meant trouble concerning e.g. the switches. The design of the prefabricated walls only allowed certain switches to be used, the ones that the local electricians brought turned out to misfit.

When the agreement was reached for the procurement of the subcontractors' materials, new problems occurred. The subcontractors claimed that they would not get enough compensation if they only were paid for their services; they also wanted to provide the material. Skanska refused since this was the very idea of changing the purchasing patterns. An angry debate started were representatives for the national subcontractors organizations accused Skanska for trying to destroy the structure of the business and ruin the subcontractors.

It turns out that this conflict hides a complex situation that has developed during the years. In an environment of increasing competition on the market for subcontractors, the hourly price for e.g. a pluming subcontractor had been reduced. As much of the work done in this business is bought as extra work, the hourly charged part of the total income for the subcontractors would have inclined if it had not been for another development. One compensation consisted of that the price for the installed material, also debited the customer (usually the general contractor), had risen dramatically. In order to create a total payment that covered the costs of the subcontractors, the total charges consisted of a part with a (too low) hourly charge for work services and a (too high) sum for the installed material.

The prices for the installed material are not easy to understand. And this is what made the purchasing department at Skanska irritated. The existing price lists showed gross prices in order to justify the invoices to the customers. But a complicated system of extensive discounts for the subcontractors made the gross prices rather uninteresting; no one hardly ever paid those amounts. From a purchasing perspective this has led to a situation where both the very few national retailers selling this kind of products and the subcontractors buying it might share the same interest: A gradually increasing price level (Appendix 4).

The national retailers, where the three major actors control about 85 % of the professional market, are striving for market control. The combination of gross prices and vast price discounts was used as a tool to control the usually quite small subcontracting companies. The situation had showed a similar development for materials for pluming, electrical work and other installations. And the producers, retailers and subcontractors are all gaining from the situation where the prices have been increasing and actors like Skanska, the clients and consumers have no alternative and no chance to analyze the costs.

So in the Bo Klok case, subcontractors who were willing to work for Skanska during the project circumstances had trouble. The retailers threatened to refuse to sell to them also in other projects, if they accepted to work for Skanska in a Bo Klok project. This means a great risk for a small subcontractor to accept the conditions, and thus Skanska experienced serious problem to find subcontractors in some of the Bo Klok projects.

In some of the early Bo Klok projects, the local organizations within Skanska had problems to accept the postulated working routines that came with the concept. The site managers were traditionally used to determine production methods and techniques themselves, and this caused some troubles. In one project the site manager insisted on changing the production order in the house production. This meant a whole lot of complications, e.g. that all elements had to be unloaded from the trucks and stored for days before they were used. At that time no appropriate lifting equipment were at the site, since the crane needed normally is on the delivering truck. All material stored on site had to be moved several times and this caused damages. This project was delayed, and it took twice as long time to complete some critical phases of the production compared to other projects.

It was also seen difficult to coordinate projects all over Sweden. An attempt to use the same working crew for repeated production of Bo Klok projects turned out to be a good idea, but it was difficult to keep the group ready since the projects' starts were hard to plan.

Taking control of the subcontractors' flows also turned out to be more complicated than Skanska had expected. Discussions and negotiations with the subcontractors and the wholesalers in these supply chains turned out to be frustrating activities. The different actors were unwilling to reveal their costs.

This would mean that Skanska had to give up the hunt for reductions in quite a big share of the total production costs, the ones related to the subcontractors' work. But Skanska was determined to purchase the material required for the electrical, ventilation and plumbing work. And the service that the subcontractors provided was bought separately. This caused a lot of turbulence among the subcontractors. For example, the subcontractors' organizations heavily criticized Skanska in the press, and many wholesalers even banned Skanska and subcontractors working for Skanska; the subcontractors were no longer welcome as customers in their stores! A lot of subcontractors refused to work for Skanska under these new circumstances.

So the outline of the Bo Klok concept was not introduced to the Swedish construction industry without problems. It was especially actors in the traditional supply chains of subcontractors' materials that protested. One explanation for this is that it was structural changes in the existing supply chains that was attempted, but acknowledged models for discussing the changes with the actors were missing.

Another reason is probably that a whole set of dramatic changes was tried to be carried out in an environment that had not experienced alternative, challenging supply chain structures for a very long time. The other actors that were affected by the changes did not accept the customer orientation as driver for structural changes.

As for the high ambitions of pre-construction, minor retreats had to be admitted by the project management. For example pre-produced inner walls and pre-assembled pluming products to be installed in the floors were found out to be too difficult to use in the project for various reasons.

It is hard to determine the exact reasons for these failures. It is likely a combination of that the material suppliers did not manage to deliver the products the way they were expected to, and that the site manager had too many new ideas to implement in one project.

In the first crucial projects a lot of things did not work out perfectly, but most of them led to feedback and development of the concept. It is also difficult to determine whether the suppliers that were reluctant to deliver in the Bo Klok-way always tried to perform their best when testing the new delivery systems to the early projects. A combination of that they were not used to the routines and that they basically did not want the routines to prove to work smoothly, might have affected the ambitious plan to create new routines for the supply of installation material.

4.3.2 Conflicts

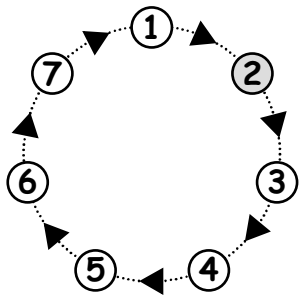


Figure 44: The 2nd step; the expressed new problem situation.

In spite of the troubles that occurred as a result of the unconventional behavior, Skanska succeeded in most efforts. But the central purchasing department within Skanska experienced the conflicts with the representatives of the subcontractors, the retailers and the material producers as very frustrating. In spite of Skanska's size as an actor, the subcontractors were fighting Skanska as the Lilliputs fought Gulliver. And Skanska was exposed to a lot of critique that influenced the rest of the market; in all of Skanska's normal projects this was discussed among the subcontractors despite that the Bo Klok market share of Skanska's total housing volume was negligible. It was at this stage a strategic question how to continue.

Was this the right thing to do? Should the Bo Klok projects proceed as planned, or should the purchasing pattern be modified? Should Skanska even develop this strategy to include all construction projects? Skanska had to decide whether to continue the new ideas for procurement, or to seriously consider the effects of the conflicts and perhaps withdraw the ambitions of change.

The main problem for the project, and also for Skanska at the time, was thus that the normal supply chains had been altered and that this had led to conflicts, influencing both the Bo Klok project and the rest of the construction market.

4.3.3 A New System

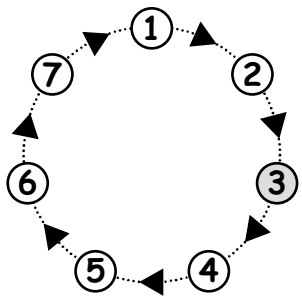


Figure 45: The 3rd step in the systems methodology; new root definition of system.

Could the modifying of the supply chains in the Bo Klok project be described as supply chain management? Skanska appeared as a strong channel leader, but was

it a question of managing the organizations in the chains to reach the common goal or was it simply a demonstration of power? And were the rest of the actors cooperating and contributing with their competence, or were they just trying to resist change?

The new defined root system is thus:

A supply chain, led by Skanska, with interested and competent organizations in the construction industry, willing to strive for reducing non value adding activities in the material supply in order to meet the expectations in the Bo Klok project to satisfy consumer demands.

The customers *are still the consumers, even though the restriction that it must be interested actors hopefully means that they will earn a lot of money. The* actors *are the organizations that are not only interested and competent, they are also willing to reduce non value adding activities. The* transformation *is the material supply, that is improving efficiency. The* meaning *is still to delight the consumers, but it is now also to do it by improvements. The* owner *of the system is Skanska and the* environmental constrains *is that it all has to meet the specific Bo Klok project expectations.*

4.3.4 Introducing Models

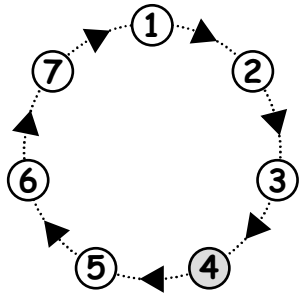


Figure 46: An introduction of conceptual models in the 4th step in the systems methodology.

Skanska had until now not really discussing supply chains or supply chain management. On the Skanska purchasing department, models for what called supply chains and value analysis existed, but they were not systematically used as a tool.

The managers in the Bo Klok project had a rather action oriented approach and a lot of the "strategies" appears to have been sound effects of common sense. A lot of the remarkable unconventional solutions for the Bo Klok project was explained by the project manager as natural actions that had to be taken to reach the decided cost level goal.

The purpose of step 3 in the systems methodology is to generate a debate of the system. The general idea to model the actors participating in the material supply of construction material as supply chains, have been presented a number of times to

actors in the construction industry in order to illustrate that what has happened in the case study is not especially notable from a logistics perspective.

When it comes to material supply for a construction project, there are – at least theoretically if the sometimes highlighted limited competence is neglected - many alternative combinations of organizations that might constitute the chain that uses its resources to satisfy the end customer needs. This could be modeled as a business network, seen in Figure 47.

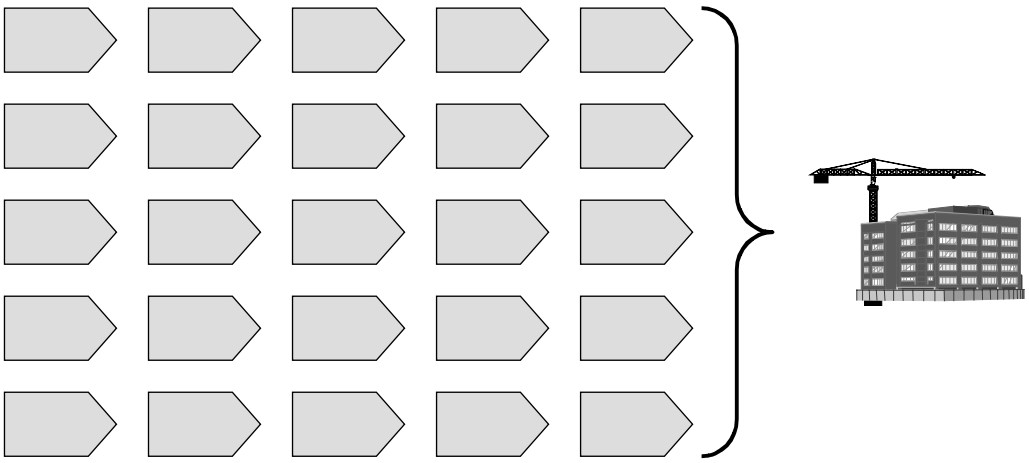


Figure 47: Multilateral structure in a business network supplying a construction site with materials.

But another modeling opportunity is the supply chain model. As soon as products are bought from the purchasing manager at the project site, a certain group of the actors in the network are excluded from the situation, and another group, the companies marked in Figure 48*, are together involved in the supply activities; they constitute a supply chain.*

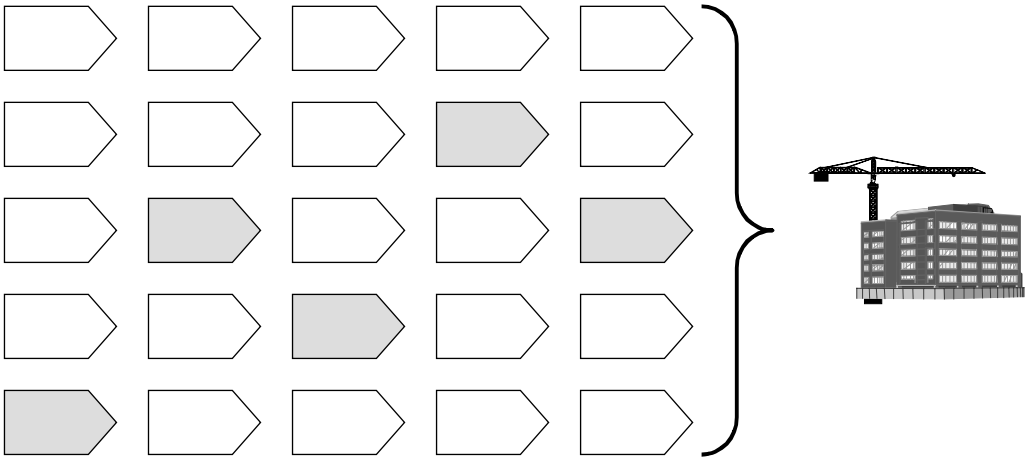


Figure 48: A general outline of actors that together constitute a supply chain system.

*In the supply chain model, the actors that are not involved in this procurement are left out (*Figure 49*). Now the companies that are interacting and together using the sum of their skills to fulfill customer satisfaction are the parts of the supply chain. Interesting questions emerge from a supply chain management perspective:*

Are all the actors adding value to the system? Are they competing with other actors at the same position, or are they competing in their own chain against other chains? How much are the total costs in the chain for warehousing? What information is shared to which actors in the chain? Have they all agreed on the objectives of the chain? Do the actors in the chains see themselves as parts of a chain?

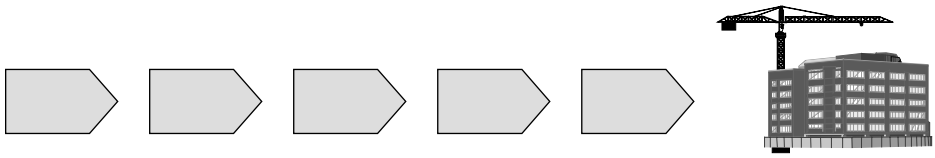


Figure 49: A partial supply chain in the construction industry.

It could be seen as an attempt for compression in order to reduce non value adding activities for reducing costs in the supply chains. Trying to exclude links in the chain not adding value for the end customer is efforts for compression.

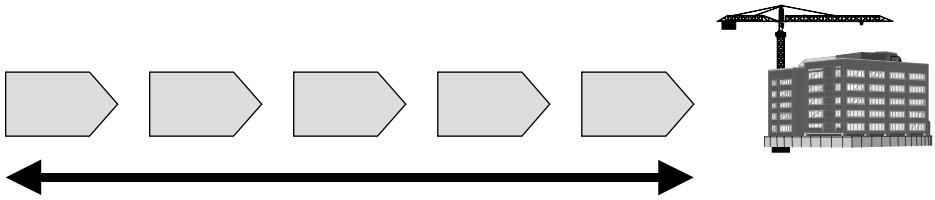


Figure 50: Integration between the links in a supply chain.

In supply chain models the efforts for integration can also be showed. Integration can be applied to reduce time or decrease cost to move sequentially (fig 42) *or vertically* (fig 43).

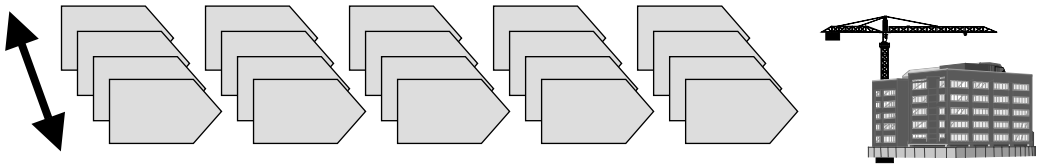


Figure 51: Integration between different supply chains.

But the supply chain perspective was rejected by many of the actors represented in the models. As action research, a lot of presentations on variations of the theme "logistics in construction" were held initially on assignment of the Swedish Building Costs Committee. As the word was spread, several presentations were held on request for various internal company meetings and industry gatherings.

The very idea to reflect on whether all actors contribute to customer value seemed to be offensive to some. In the construction culture, with "unique" products, the chain was regarded as a meaningless model since the next buy would constitute a new constellation of actors anyway.

Another obstacle when introducing the models was the confusion about the construction process. -Where is the client? -Where is the architect? -Where are the designers?

The construction industry and the actors have not been used to supply chain models, and this is obstructing when it comes to discussions of structural changes in the supply activities. The normal focus is on the production phase on the construction site, maybe also trying to incorporate the designing phases into the picture.

4.3.5 A Key to Success

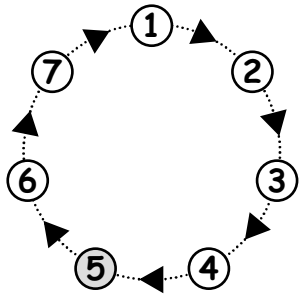


Figure 52: Step 5 in the systems methodology; a new comparison between 4 & 2.

From a supply chain perspective, what is seen is that Skanska more or less successfully has tried to redesign some of the supply chains in order to meet the demands of the Bo Klok project and in the end, the consumer. It could be seen as at least the embryo of supply chain management.

Starting with the needs of the consumers, demands were raised on the production on site and later the related supply of materials. In order to reduce the cost, a schematic analysis of costs was done, leading to a questioning of the value adding of some of the actors in the Bo Klok supply chains, especially the ones that did not want to discuss what their share of the total cost consisted of. As the locally contracted subcontractors did not want to contribute to Skanska's efforts to lower the costs, Skanska's representatives soon wanted to solve this problem themselves.

*By removing the subcontractors from the supply of material as a sign of supply chain compression, and providing them with material on site, Skanska could reduce the costs (*Figure 53*).*

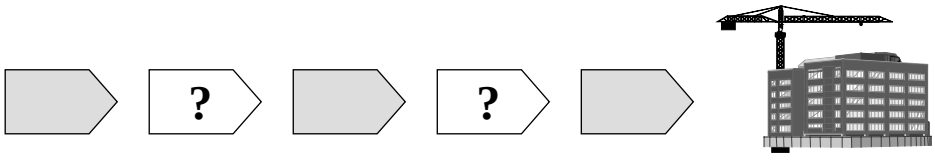


Figure 53: Questioning the value adding of some of the actors in a supply chain.

Similarly Skanska turned to the retailers to discuss costs with them, but they initially resisted discussing any other supply of materials than the normal: via the

*subcontractors. Hence Skanska tried to exclude them too, from the redesigned supply chain (*Figure 54*). This could be seen as differentiation. The supply chain is redesigned from its original in order to meet the demands of an identified consumer group.*

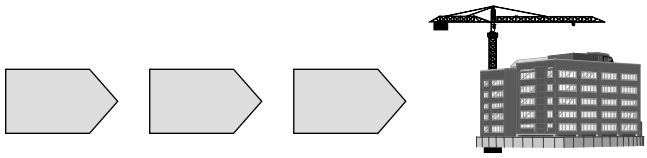


Figure 54: A redesigned supply chain, in order to reach customer satisfaction.

But the logistic service, in terms of getting the material to the site, is traditionally taken care of by the national retailers. So when Skanska tried to buy the material directly from the producers, they too were unwilling to sell. The prices are depending on the purchased quantities. So in order to get the desired price reductions, Skanska had to buy larger quantities than they needed at the moment. This calls for a new kind of logistical solution, and Skanska therefore started to create a sort of logistics center. In order not to be dependent of actors in the supply chain not willing to participate in alternative supply structures, Skanska had to manage the products themselves. However this so called logistics center have so far been of marginal importance.

Observing Skanska's work side-face, one might see it as if Skanska is trying to redesign the supply chains in order to lower the costs, while the other actors are unwilling to participate, and they are even trying to stop Skanska. It is a difference here between the view upon who is the customer. Skanska has in this project identified the ultimate customer, the consumer. But the actors involved in for example the supply of installation materials see the subcontractor as the customer. The reason for this might be that this structure leads to the fact that the customers, the subcontractors, for years do not protest when the material prices rise dramatically. Instead they welcome such a development as it enables them to increase their total incomes. But from a consumer perspective, of course this is unfortunate.

Maybe we should have seen a more developed discussion here that took advantage of the competence of the actors in the supply chains in order to create the optimal supply chain for the consumer. Unfortunately the actors have not been contributing to such a discussion. This partly depends on the culture in the business and the affection for demonstrating power. Another reason is that the actors are not used to the situation when an actor in the system challenges the structure. A third reason might be the absence of accepted models that the actors themselves find useful, and that recognized alternatives have not existed.

A comparison between the new way of distributing the materials to the site and the traditional supply chain shows that the new way has reduced costs. And thus the efforts contributed to the project objective of Bo Klok, lowering the cost to the fixed total cost. So from a logistical view, it is the right thing to do, trying to use more or

less deliberate supply chain management in order to lower costs of supply. And the actions that have been taken are just a beginning. Now it opens up possibilities to create partnerships, develop the relations between the actors in the chains, integrate the actors in the chains, integrating the supplies in the various chains, implementing performance measurement systems in order to identify and develop areas of improvements.

4.3.6 Changes for the Future

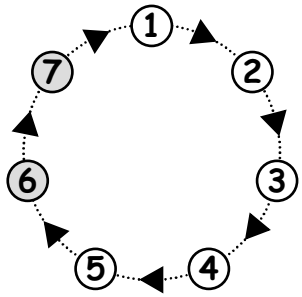


Figure 55: The last steps in the systems methodology; changes to improve the situation.

Skanska can now use the learning from Bo Klok and to take the general knowledge to other projects. By studying the purposeful work to reduce costs and time for the production of the Bo Klok houses, everyone can see that this shows results. A lot of the lessons that can be learnt from Bo Klok is also applicable in other construction projects.

Notable in the flow orientation perspective is the articulated interest in the customer, the repeated production that, with small-predicted diversities in order to satisfy the customers' wishes, gives us the fixed output. This means that it is also worthwhile to try to change the conditions of the inbound logistics, instead of accepting poor conditions as a result of an unstructured flow beyond the contractor's control. So the input is also being carefully and deliberately fixed. Site production activities are mapped, and the mapping provides us with a useful tool to further optimize the use of resources in order to reduce project costs even further.

So one experience from the case study is to increase the flows of information, and control them in order to strive for taking advantage of situations when Skanska has the prerequisites for controlling most of the activities, as in the Bo Klok concept. So this learning must be communicated in the organization.

It is a risk that internal resistances for various reasons slow down the expansion of the Bo Klok project. The top management must decide whether the new Bo Klok concept is allowed to grow or if it is to be stopped. Some may be tempted to stop the project since it might be considered as an internal competitor to conventional housing projects.

Other types of changes for the future of the project are more specific. Still some potential must be emphasized from a logistical standpoint:

- *The follow-ups that are provided by the feedback system in the Bo klok projects are used, constituting a good base for continuos improvements. Develop the feed back system!*
- *The structural floor in the buildings is mentioned by many actors in the case to be an area of improvement. Demands could be raised to the supplier for an improved product, and also for an urgent improved delivery performance.*
- *In a supply chain perspective, prognoses must be used more and better to help the suppliers to plan their production and optimize production capacity in order to keep low costs. Production volume should increase and then the volumes should tried to be kept on a more constant level if possible. If the production volume not varies too much it will be easier to benefit from the developed supply chain learning from the stationary industry. A performance measurement system is also needed to inform the actors in the supply chain how they are contributing to the total effectiveness and efficiency in the Bo Klok project.*
- *Materials handling on site can be further improved. Sometimes obvious and unnecessary influences from the ordinary construction site-culture have been observed in the case study.*
- *The work with the foundation structures has not been really included in the Bo Klok concept so far. Include it in the holistic approach!*
- *Skanska also has to develop the relations to the other actors in the system, e.g. the actors involved in the supply of installation material. It is a pedagogical challenge not (even to try) to overrun the others, but to explain and persuade the actors to cooperate. And in order to do this, a continuos company strategy, embracing all kinds of projects must be developed.*

In systems terms we need systems changes in:

- *Structure. The efforts for compression in the supply chain are structural system changes. And by redefining the original, traditional system and hence be able to communicate in early stages, not only between actors in the supply chain or actors in the traditional project value chain but between all the actors in both the mentioned systems, the system borders are now changed. Aspects that were impossible to influence, parts of the systems environment, become internal factors with relations to the other actors in the system and hence possible to communicate with and affect.*
- *Procedures. By e.g. controlling the traditional desire to change what creates the unique projects, yet other procedures become possible and high quality is possible to secure. By having only a limited number of choices and alternatives allowed in the projects, the use of carefully planned procedures is obvious.*

- *Attitude. Industrialized construction is considered to be possible and the benefits are accepted by the constructors and appreciated by the consumers involved in the Bo Klok project. It is possible to change supply chain structures. The structures can and must be questioned in order to meet consumer demands.*

The case study has to certain extent been a question of action research. And the Bo Klok project is still considered as a novelty on the market, what will happen next is to a large extent up to Skanska.

5. Case Study Synthesis

In order to condense what can be learnt from the case study, a short case study synthesis is added preceding the analysis in the thesis.

5.1 Success

5.1.1 Solid Demand

Bo Klok could be described as a success, and there has been a tremendous demand for Bo Klok apartments. A number of projects has been started all over Sweden, and even if the total number of houses still is limited, some new projects are planned.

The reports in media have given a picture of pleased customers, and the quality in the projects has been praised.

5.1.2 New Markets

Even at places where no demand existed for normal residential housing before the introduction of a local Bo Klok project, the project has been a success. Bo Klok houses have been built in districts where no housing projects have been started for years. Customers, who would never have been able to afford normal priced housing, have paid interest in the Bo Klok project.

On this new market, Bo Klok can so far benefit from what appears to be an absence of competition.

5.1.3 Just a Beginning

Many of the participating actors have learnt a lot in the projects so far. Some of them are though of the opinion that too much time and efforts have been spent in the project, if it is seen in relation to the quite small volumes produced so far; they had expected that many more projects would have been started.

The success in the Bo Klok project is showing the way for new logistical efforts, questioning the existing systems structures and mental models among the actors in the project as well as other actors in the industry.

The market reactions, demonstrated as consumer delightment, should be a source of inspiration for Skanska's competitors. So far we have not seen any reactions. But when we see a number of projects like Bo Klok, where systematical efforts to reduce costs are demonstrated, then we will most likely see that the results in the Bo Klok project, that attracted much attention, where just the beginning. Now it is possible to build on the new experience gained by Bo Klok.

In the project a set of different areas of improvement could be identified among the interesting findings in the case study, and logistical efforts could most likely contribute to further improvements.

5.2 Systematical Efforts

5.2.1 Systematical Efforts Show Results

I order to reach results, as in the Bo Klok project, persistency and purposefulness is needed. And it gives results to work persistently for a long time. Cost reduction was needed in all parts of the projects. By e.g. carefully planning and replanning the design of the houses, appropriate solutions were found. In the same way the existing material supply structures had to be redesigned in order to reduce costs.

But actors who challenge the existing structures will meet resistance. Thus there must be a clear goal for the actors. An extraordinary clear customer focus could serve as a pedagogical tool in order to persuade other actors to participate in the efforts to reach such a goal.

5.2.2 A Potential for the Industry

There is a repertoire of unused logistical possibilities for normal construction projects. All technical or other types of solutions demonstrated in the Bo Klok project are maybe not applicable in all kind of construction projects. But when the Bo Klok management team were hunting costs, the systematical efforts included a lot of such unconventional ideas concerning the flows of material and information that are normally not is seen in the Swedish construction industry. And a lot of the activities are logistical solutions, e.g. trying to manage the supply chains. Thus the construction costs and the housing costs in other types of projects could also be reduced by the use of systematical logistics efforts, e.g. by a supply chain management approach.

5.2.3 Effort – A Prerequisite for Success

But the dramatically reduced costs in the Bo Klok project is no coincidence. It is the predictable result of deliberate systematic efforts in order to reach a stated objective. So the normal cost levels, for normal Swedish construction projects are consequently also the result of a lack of such efforts to reduce costs. In order to success in reducing construction costs, one must try.

In order to benefit from a more or less industrialized production, efforts to use a holistic approach to a project as demonstrated in the Bo Klok project are needed. If not, the different sub systems will disturb each other and cause reduced overall efficiency and effectiveness.

5.2.4 Low Price Housing Possible

It is possible to create low cost housing with high quality in Sweden today. It is not a utopia. It is possible to be successful and create a product that the majority of the consumers can afford to demand. In spite of high tax pressure and all other reasons that are given in the debate of today in order to justify and explain the absence of low price housing on the Swedish construction market, it is not impossible.

But in order to be successful, there must be a clear vision with a corresponding strategy. And in order to explain to the actors participating in such an effort, it is a pedagogical advantage to have a clear customer focus, as in the case study.

5.3 New Ideas Encounter Resistance

Skanska has played a key role in the project to initiate and support changes. From Skanska's perspective the resistance that the change efforts have met, could be divided into external and internal resistance.

5.3.1 External Resistance

The actions that have been taken to obstruct the change efforts in the project are not hard to explain if the systems culture is considered. Changes in procedures or structures are unlikely to be successful if they are not accepted by the existing culture. As the actors in the existing supply chain for a long time have experienced no questioning of the systems structure, such challenges meet direct resistance.

And since the systems actors are not familiar to supply chain models either, structural changes in the chains are hard to communicate or debate among the actors.

The initial unwillingness among e.g. wholesalers of pluming systems to contribute to new, efficient, consumer oriented solutions for the distribution of their products caused a suspiciousness among Skanska's staff that initial deliberate bad supplier performance occurred in order to "prove" that the new ideas did not work out.

5.3.2 Internal Resistance

If the case study system is studied on a more detailed system level, we see that the unconventional ideas in the project also have met internal resistance within organizations in the supply chains. The existing corporate culture in Skanska has difficulties in seeing the advantages in a production like the approach used in Bo Klok; high degrees of preproduction is not seen as "real construction". The tradition that the site manager himself to a large extent decides what methods, techniques and procedures should be used is not accepted within the Bo Klok concept. Some site mangers have persistently tried to use ideas of their own to plan the work on site. Such phenomena,

causing problems for the Bo Klok concept, could probably be related to a "not invented here" syndrome.

Also regional differences in systems cultures could be observed, if an appropriate system level is chosen for the analysis. In some regions in Sweden, the use of pre-produced elements in construction is more accepted and used that in others. In such regions were there is a reluctance towards such production methods no Bo Klok projects have so far been started. If the local organization is not interested in starting up projects, a Bo Klok project startup is unlikely.

Another potential resistance is the internal competition from existing traditional concepts within e.g. Skanska. In spite of the top management commitment, it should not be taken for granted that a new low cost housing concept is entirely seen as a positive novelty.

5.3.3 Change Management

Questioning the existing structures is necessary and thus the right thing to do in order to reduce costs, and this is proven by the case. And a continuous work to try to create the best possible conditions for the flows of material and information is basically what logistics is all about.

But nevertheless, a deep understanding of the systems that one would like to change is needed. And Skanska underestimated the resistance that the unconventional behavior in the project would mean. The real system studied in the case showed that the corporate culture had profound values that were not favorable for the redesigning of the system. This makes changes extremely difficult.[275] The ability and the interest for changes among the actors in the system are crucial.

Instead we could see that Skanska's staff became tired from the unwillingness to participate demonstrated by the representatives for material suppliers, e.g. sub-contractors and wholesalers. Instead of persuading them, Skanska's representatives changed strategy and tried to overrun them by creating a new supply chain structure without their participation. Seen as a dynamic system, Skanska's resolute actions created an as resolute reaction of resistance from the wholesalers and the subcontractors.

[275] Arbnor, I & Bjerke, B (1994), "*Företagsekonomisk metodlära*", Studentlitteratur

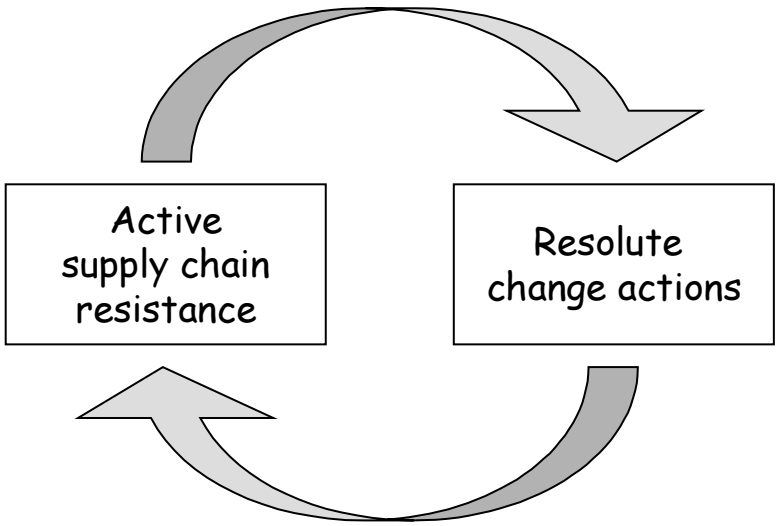


Figure 56: Dynamic systems effects of the change efforts in the case study.

But in order to overcome the difficulties and resistance that occurred, the vision in the project, the clear customer focus, has helped. If the strategy for the project had changed every time an obstacle occurred, then the chances to be successful in change efforts would have been dramatically reduced.

Skanska might be in a hesitant situation right now, regarding the future of the Bo Klok project; it has been remarkably quiet from the Bo Klok project for the last 12 months. The external resistance in the system on the case level is mirrored also on a higher systems level. This means a risk for Skanska if the resistance from actors as national wholesalers affect Skanska's abilities to purchase certain construction materials and services also on other housing markets where a conventional supply chain structure is used.

5.4 A Systematic Approach?

Whether the approach used in the Bo Klok project could be described as supply chain management is further discussed in the analysis. Clear is, however, that it has not been a question of a deliberate and systematic supply chain management approach in any deeper sense. The project management has not discussed issues in terms of such theoretical concepts, and they were neither aware of nor familiar with the terminology.

It is almost only Skanska that have been active in the change process, and Skanska could maybe therefore be described as "channel leader", initiating and coordinating supply chain management efforts. The work has been managed with a fruitful and quite systematic combination of common sense, derived from a deep knowledge of the traditional construction industry environment, and pragmatism.

However, the general approach is to a large extent colored by a – maybe not clarified - flow orientation, and can be understood in the light of supply chain management. What could be seen is that the Bo Klok project with its supply

of construction materials has, by the all the changes that differ the project from traditional housing projects in Sweden at this time, been moved significantly from traditional supply towards theoretical supply chain concepts, see *Figure 57.*

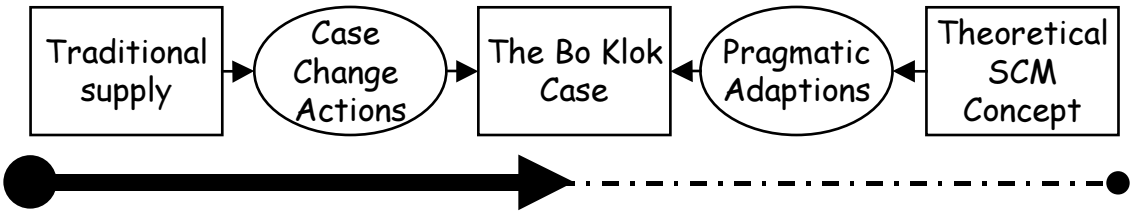


Figure 57: A movement from traditional supply towards a supply chain approach.

6. Analysis

In this chapter the case study is analyzed in general, and the change actions in the case project are discussed. A model developed from the case study and the literature review is introduced.

6.1 Case Study Analysis

6.1.1 Managing Supply Chains

Without doubts, the case study clearly reveals unconventional and interesting efforts to manage supply chains. The main driving force for this work was the desire to reduce costs in order to reach the firm overall cost level objective.

With a questioning attitude, worth special attention, the project management investigated the possibilities to reduce costs. The industrial approach also called for integrative initiatives, moving value-adding activities to earlier links in the supply chains.

Some of the supply chains in the case study are more or less controlled by Skanska by direct or indirect ownership. And suppliers that already had a quite developed business relation to Skanska produced some construction materials. Skanska started up discussions with all suppliers in order to find out how the cost could be reduced for Bo Klok. An overall holistic approach to the costs in a project like Bo Klok was missing. The efforts to involve other organizations in the supply chain in order to work together to reduce total costs for the consumer show a clear movement towards supply chain based supply.

When trying to understand what subcosts the total cost consisted of, the frequent lack of cost transparency was highlighted. Especially for construction materials, traditionally bought by subcontractors, as installation materials, this was striking. The costs for installation materials and installation work made up a substantial part of the total costs. The cost level objective called for action, and Skanska was determined to reduce the costs also for the installation materials. By not accepting these costs, Skanska took a principally important step towards supply chain management.

Inspired by the considerable difference between the prices for installation materials provided by the conventional supply chains that Skanska could see and the prices for the same materials if they could be bought directly by Skanska from manufacturers, Skanska started to challenge the existing purchasing patterns. This could be described as a very unconventional managing of the supply chains.

6.1.2 Supply Chain Management?

In the fourth step of the thesis approach model, the case findings will be understood in the light of the theoretical models. Also, reflections of the pragmatically adaptations in order to practically benefit from a supply chain management approach are presented *(Figure 58).*

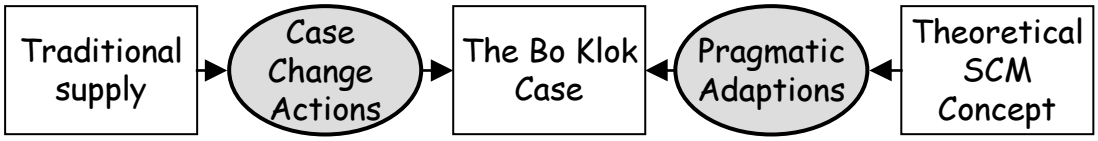


Figure 58: An analysis of the case actions.

In the case study, a set of actions in order to change the conditions for the material supply has been noticed *(Table 7).* Examples of the notable holistic approach used are the investigations of total costs by striving for cost transparency, the inclusion of e.g. the installation materials and the integration of distribution aspects in all project stages. The extraordinary pro-active approach in the case could be exemplified by the iterative investigations of up- and downstream consequences from design alternatives, and the determination to limit the alternatives and choices of the product. Also the actions that have challenged the existing structures in the case study are uncommon, such as the desire to create cost transparency, the market orientation brought into the manufacturer and the discussion in terms of value adding.

Case change actions		
Holistic approach	***Pro-active approach***	***Challenging structures***
Investigate total costs	Investigating possible alternatives upstream	Striving for cost transparency
Not ignoring installations materials	Discussing design alternatives in terms of consumer costs	Confronting production orientation with market orientation
Incorporating distribution issues	Limiting product alternatives	Discussing in terms of value adding activities

Table 7: Examples of change actions in the case study.

The case change actions in *Table 7* are not specifically addressed to the defined supply chain management criteria. However, the change efforts are colored by a flow oriented approach and clearly causes a project movement from traditional supply towards supply based on flows. The word *flow* was also, as mentioned in the case introduction, used frequently by the Bo Klok project manager, and the pro-active actions that have been taken indicate awareness of an extraordinary holism in the project. This is not enough to describe the project as being a supply chain management project. However, the actions taken also indicate movements from the traditional supply of materials in the construction industry in the direction of theoretical supply chain management

approaches. The change efforts could be interpreted and understood in the light of logistics and supply chain management.

The Coyle model states a set of factors comparing traditional supply to supply chain-based supply. In traditional forms of material supply companies are trying to optimize their own functions, e.g. stock levels. The flow is interrupted as organizations are minimizing their own company costs and keeping information within the organization. Risk calculations are done with focus on the own company, and planning is also oriented to the own company functions. The inter-organizational relations are thus also focused on keeping low company costs.

In the supply chain management-based company the flow of goods is visualized and not interrupted, and the cost are considered with the consumer in mind. Information and risks are shared among the companies in the supply chain, and planning as well as relations are colored by partnership.

In the light of this model we can see that the case change actions have caused an interesting and not random movement, from the traditional movement towards the supply based concept. Notable are efforts to move focal points from internal matters among the participating separate companies to – if not clearly to the supply chain – the consumer. The pro active approach and the questioning of structures in the case study must be admitted to be very focused on the end product, but it facilitates the movement of the company focus from internal matters to supply chain challenges. The general movement from traditional forms of material supply, where every company in the supply chain is trying to optimize their own functions, is seen in *Figure 59.*

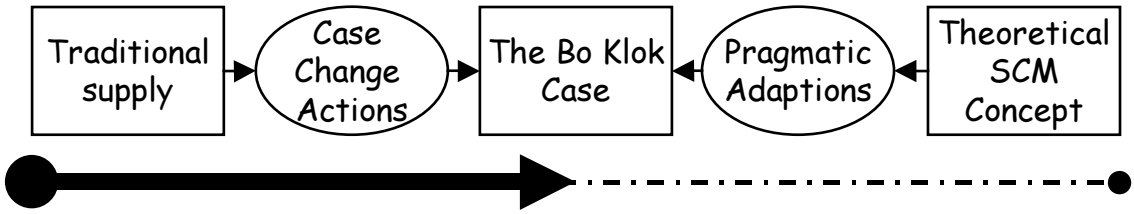


Figure 59: Approaching a theoretical supply chain management approach.

A totally supply chain based business environment, as described in the Coyle model, is by Paulsson et al[276] viewed as a utopia; it is more to be seen as a vision. By working in that direction, however, we can influence the development of our companies and our supply chains. Hence one might reflect over the underlying pragmatical adaptations that exist in the case study *(Table 8)*. Such adaptations of pragmatism must always exist since the total theoretical supply chain is not realistic.

[276] Paulsson, Nilsson & Tryggestad (2000), "*Flödesekonomi – Supply Chain Management*", Studentlitteratur

Pragmatic adaptations in the case study
Partial supply chains
Consumer not included
Focusing on costs
Adaptations to forceful resistance

Table 8: Examples of adaptations in the case study seen from a theoretical supply chain management approach perspective.

6.2 Introducing a Model

In order to communicate the possibilities of systematically using logistics and supply chain ideas in the construction industry, a model is presented. The purpose is to show how the concepts can relate to existing knowledge among the actors in the business.

6.2.1 Challenges with Model Development

If we try to connect the supply chain models to the existing debate and models among the actors in the construction industry, we will meet the type of objections and resistance described in the case. The actors have for a long time been involved in a quite imprecise debate, where various models and questioning of the actors and their roles have been discussed. The flow orientation and the logistics perspective are seen as something strange and supply chain models are rejected or misunderstood.

One major reason for this is probably that the actors do not understand how the supply chain models connect to their present frame of reference. In an attempt to pedagogically guide the actors in the construction industry into a higher level of logistics awareness, a new model is needed.

The ambition when developing such a model was to relate to the production phase at the production site, an activity and environment seen as familiar and (maybe too) important by the actors in the system.

6.2.2 Material Flow

Supply chains are a set of organizations that together act to satisfy an end customer, a consumer. In a business environment where relations to customers and relations to suppliers are regarded as more and more important, more or less stable constellations of the organization form supply chains. This trend towards a reduced number of deeper relations between companies in the

construction industry is seen in the industry today.[277] If the desire to look upon every project as absolutely unique is kept under control[278], possibilities to model supply chains occur.

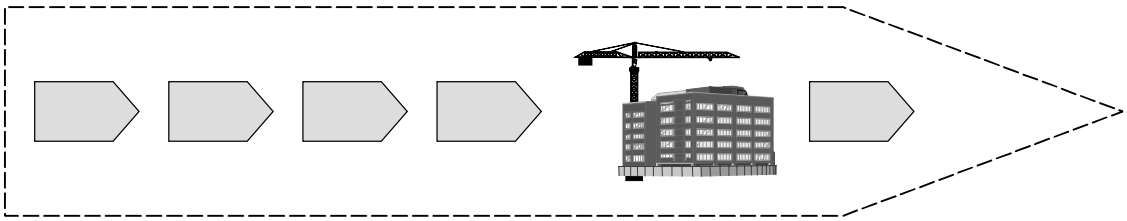


Figure 60: A construction material supply chain.

The actors in such a chain can be the material producers, the transport and logistics service providers, the wholesalers, the subcontractors, the contractors; those handling materials and information in the material flow. Often the transport and logistic third party service providers, taking care of the physical distribution, are left out from supply chain models. On the construction site, marked as a house under construction in *Figure 60,* the material flow comes to the contractor, who handles it on the site in order to create customer value. If waste products are left, they are taken care of by yet other actors.

6.2.3 Project Value Chain

From the idea stage in the project, investigations and analyses are brought the project to conceptual design and then design of the product. The production – also in *Figure 61* marked as a house under construction - is finally succeeded by the production phase. Perhaps the building is sold, and such a sale could of course also be included in the model.

[277] Dubois, A & Gadde, L-E (2000), "*Supply Strategy and Network Effects – Purchasing behaviour in the construction industry*", IMPSERA Workshop, Jönköping 2000-03-31

[278] Larsson, B (1992), "*Adoption av ny teknik på byggarbetsplatsen*", Institutionen för byggnadsekonomi och byggnadsorganisation", CTH

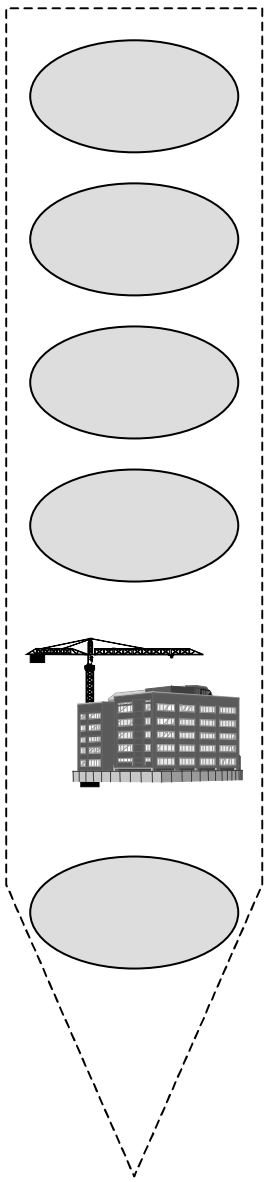


Figure 61: The construction value chain described in the literature.

In this model that some of the companies refer to as the construction value chain, and in the literature often is called the "building process", we find clients, architects, designers, subcontractors and contractors in respective phases, handling information. The owner might take care of the maintenance phase or perhaps later sell the building.

These kinds of models, sometimes described as the "value chains" exist in various forms internally in some of the Swedish construction companies, and these model are accepted among the actors. The need for integration in the chain has been debated in recent years.

6.2.4 Bridging the Gap

Bröchner discusses the existence of two processes.[279] One process handling only information regulated by contracts between companies. Architects and consultants are found here. The other is "the material value chain" where material producers and contractors act. He claims that construction consists of an intertwined mix of the two. The idea is also mentioned by Agapiou et al, where the primary focus of the "logistics concept" is said to be "to improve the coordination and communication between project participants during the design and construction phases, particularly in the material flow process."[280] This might sound strange to logistic ears, but the meaning is quite interesting. The title of the paper, "The role of logistics in the material flow control process*",* implies that the article is hardly written by logisticians. Naim discusses the effects of an uncoordinated flow of requirements from the construction phase to the manufacturing phase.[281] But a model trying to illustrate these ideas has not been found in the literature.

Both the supply chain and the earlier value chain can include an illustration of the construction site. Contractors and subcontractors can be found on the site, and that is also the place where many of the detectable problems occur when there are discrepancies between the performance of the supply chain and the site demands of the value chain. By modeling the two processes together the known actors can be identified, and the relations to the supply chain have been found to be recognized easier by the actors themselves *(Figure 62).*

[279] Bröchner, J (1995), "*Byggmarknad och samhälle*", Avdelningen för Byggadministration, KTH

[280] Agapidou, Clausen, Flanagen, Norman and Notman (1998), "*The role of logistics in the material flow control process*", Construction management and economics (1998), 16

[281] Naim, M M (1997), "*Lessons for construction from manufacturing systems engineering*" Logistics Technology International 1997

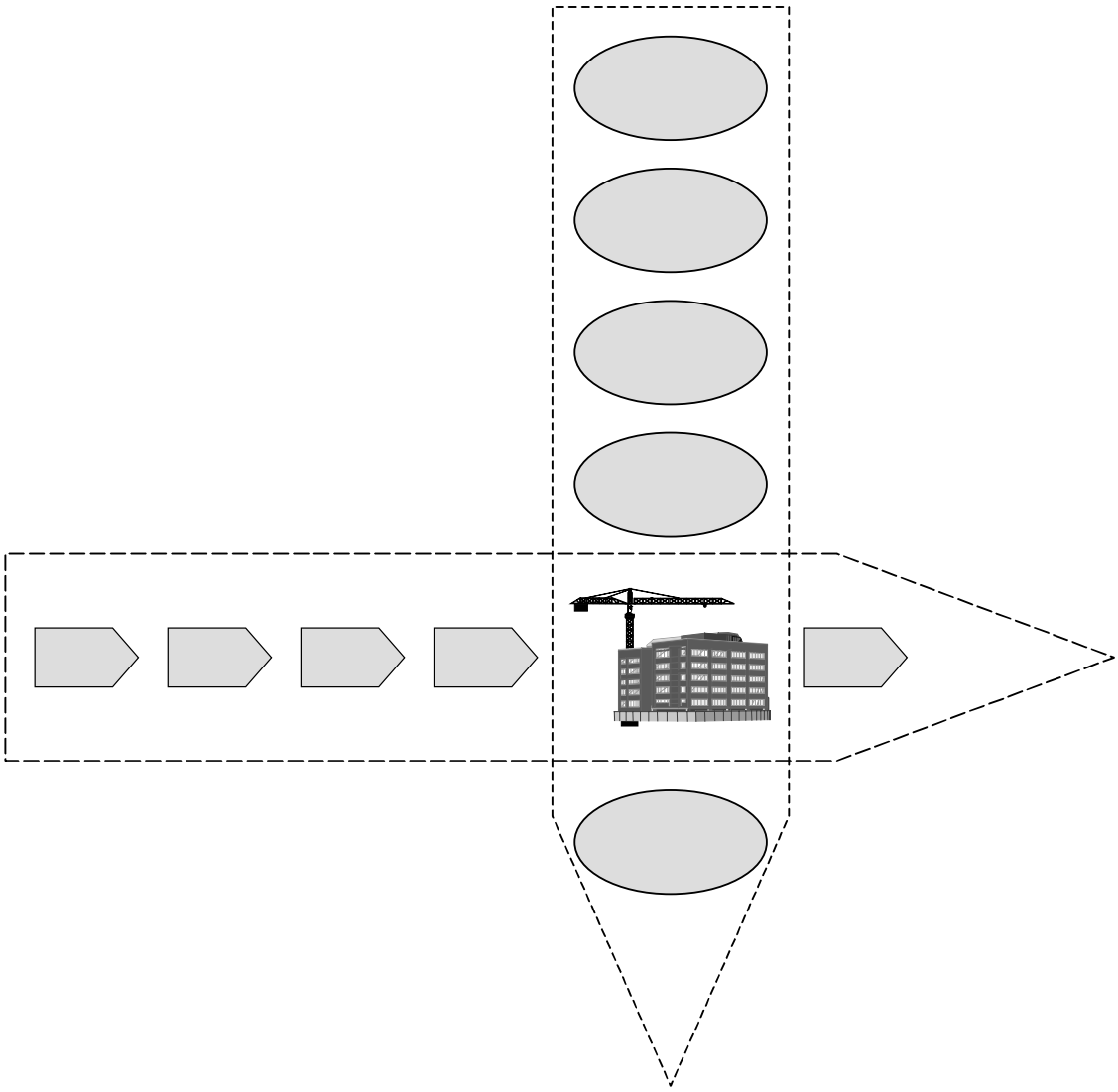


Figure 62: The interaction of the supply chain and the traditionally modeled construction activities.

In order to optimize the activities in the supply chains, or trying to reduce non value adding activities, the actors in the supply chain must know what they together are expected to do. In a project-based, decentralized business as the construction industry this is normally not the case. Often the expectations are neither expressed nor communicated. The contractors on site have maybe not even defined what they need, and how they need it. It is often just the last links in the chain that have a short notice information about what is more or less expressed and expected. So it is not surprising that products are not developed by the actors upstream in order to meet the specific project needs of the actors on the construction site; the material producers often have limited contact with the project environment and are succinctly not familiar with the project needs.

On the other hand, the need for integration between the designers, the contractors and the client has been debated for years. This is apparently

difficult, so it is maybe not surprising that the designers next to never even have tried to find out relevant characteristics of the actors engaged in the material supply.

By sharing information from all stages in the two processes, new possibilities for using supply chain management knowledge opens up *(Figure 63).* If early stages communicate – as they had to do in the Bo Klok system because of the extremely low cost level – an enormous cost saving potential appears.

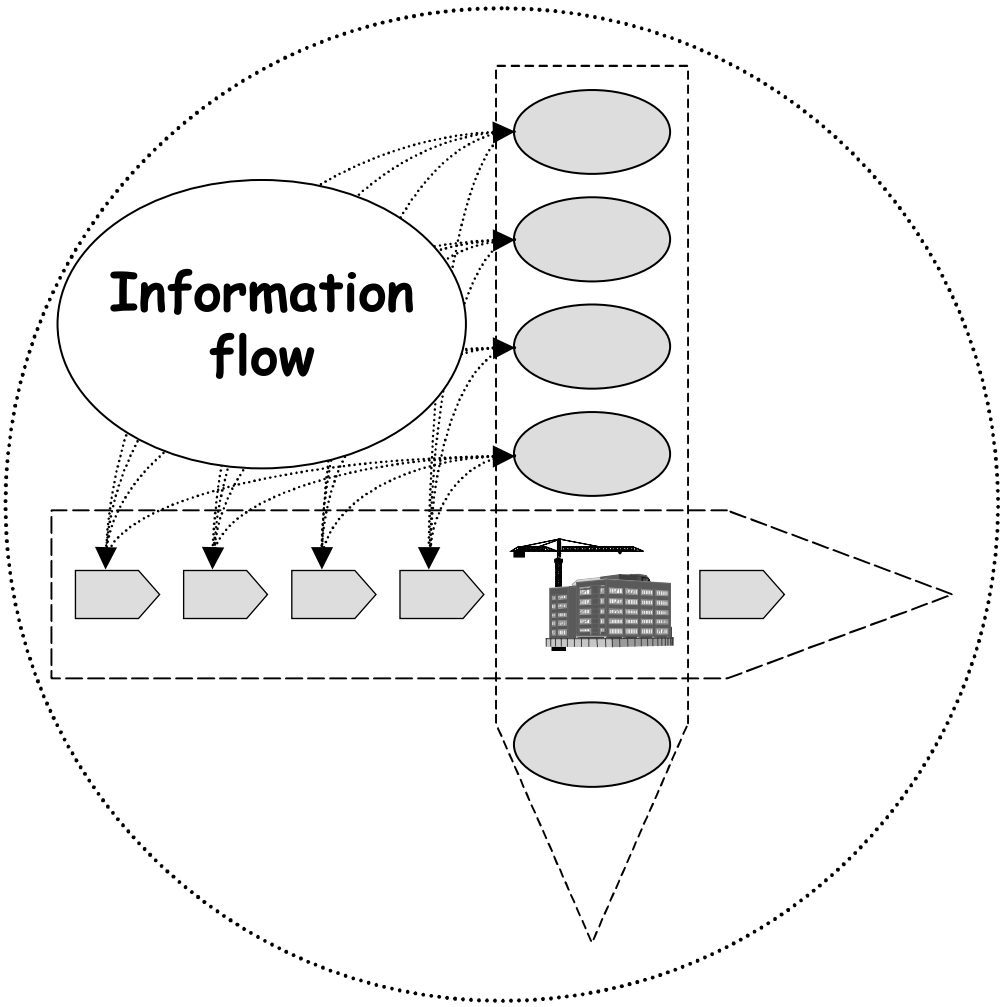


Figure 63: Flow of information in order to coordinate the two processes.

Normally in a construction project, the architects and the designers have no detailed knowledge of neither technical aspects of materials or construction nor costs control. And the design is fixed long ago, when the material producers and the other actors in the supply chains receive information about what they are supposed to accomplish together. Most likely the design is not suited to fit the subsystems within the supply chain. Hence the increasing costs levels are repeatedly found to be high and also hard to reduce. But since the project at this stage is short of time, as the production phase on site has probably already started, the actors in the chain have no choice but to accept the situation. By acting in such an environment for a long time this is

considered to be the normal conditions, and considering this it is not surprising that supply chain management concepts are rejected.

The only way for the project managers who often are concerned about the prices – and hopefully the total cost levels – is to negotiate with a lot of different suppliers in a bidding procedure. These actions unfortunately undermine the long term cost reduction, on the expense of price hunting. The project orientation reduces the incentives for reducing these problems by creating solutions for the next time.

A structural change is needed in order to create opportunities for the actors in the system to use their skills together. Redesigning the system provides this. The systems borders are moved from either including the actors in the supply chain or including the actors in the traditionally modeled value chain with architects, designers and so forth, to now include both types of actors *(Figure 64)*.

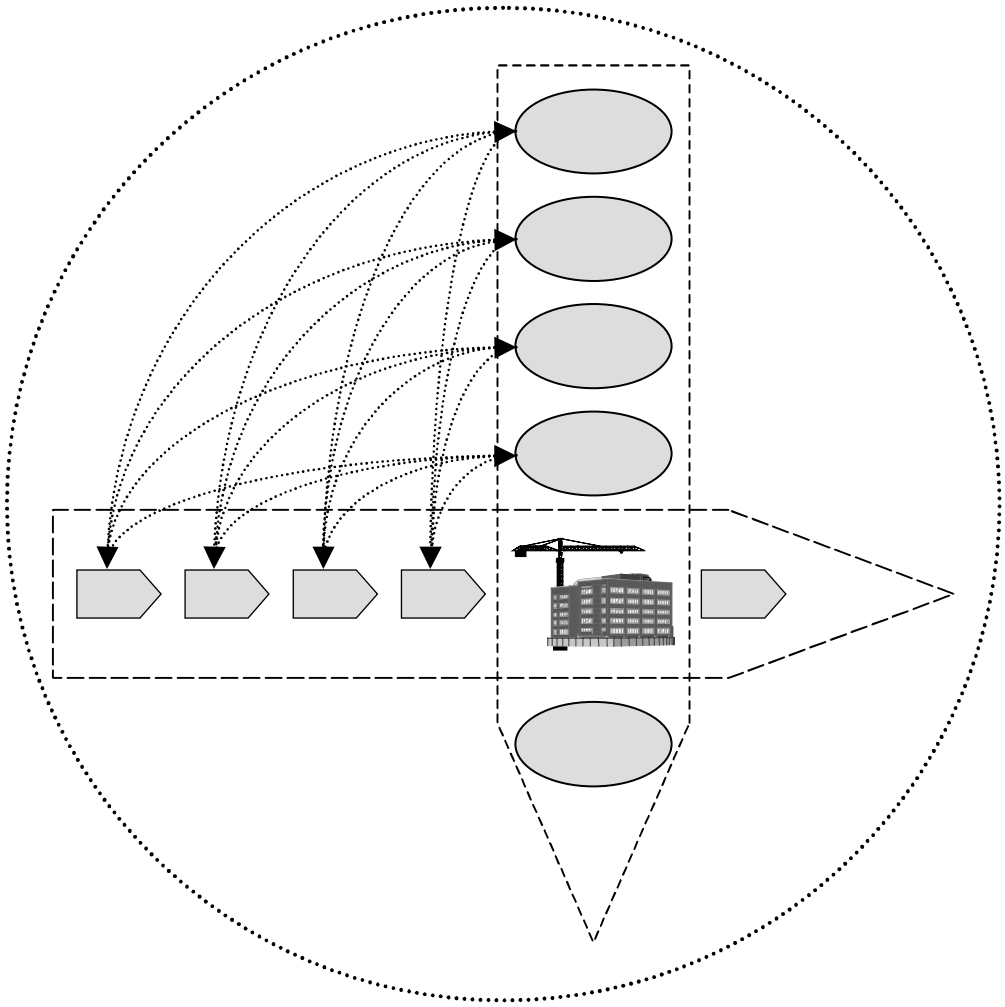


Figure 64: The new defined system, with expanded system borders enabling information flows between early stages and actors in the previous two different systems.

The conditions for the supply chain is now not set outside the system, as an environmental restrain. It is now a part of the system, and conditions can thus

be affected by relations and flows of information from the actors in the supply chain and e.g. the designers, a phenomenon forced to occur in the Bo Klok study. But a more systematic and deliberate use of this model, where the model is used as a generic set of ideas in order to improve effectiveness and efficiency in all types of construction projects, will open up new possibilities to control and manage supply chains in the construction industry in order to meet the site demands in a cost efficient way.

The supply chain management principles in this thesis will all, with a systematic use of this model's ideas, be more or less applicable, depending on the exact characteristics of the project at hand. By systematically creating routines and project procedures about how to manage these flows of information, supply chain management concepts will appear to be meaningful for the companies in the supply chain.

6.2.5 Limitations of the Model

The model is not aiming for being the ultimate model outline of a construction process. It is trying to bridge an existing gap between the contemporary models and logistics modeling and logistics theories that already exist.

By introducing supply chain models among the actors in the construction industry, the chances to discuss urgent structural changes in the material supply increase. The difficulties the actors have to face today – evidently showed in the case study – can partly be explained by the lack of recognized and spread models.

Natural from a logistical point of view, the model is widening the focus from a myopic view of the construction site. The flows of material and information that create customer value are included and integrated, trying to explain how the working site is an important part of the whole, but definitely not the only one.

The most important part of the model is not included.[282] But it is the customer that is the guiding star of the model *(Figure 65)*. The customer orientation means that the creation of customer value is central, and that it is more important for each and every one of the actors in the system, than to manage the effectiveness and efficiency of the internal administration of the separate organization.

[282] This thesis has thus weak similarities with Wittgenstein's Ph.D. thesis *Tractatus Logico-Philosophicus!*

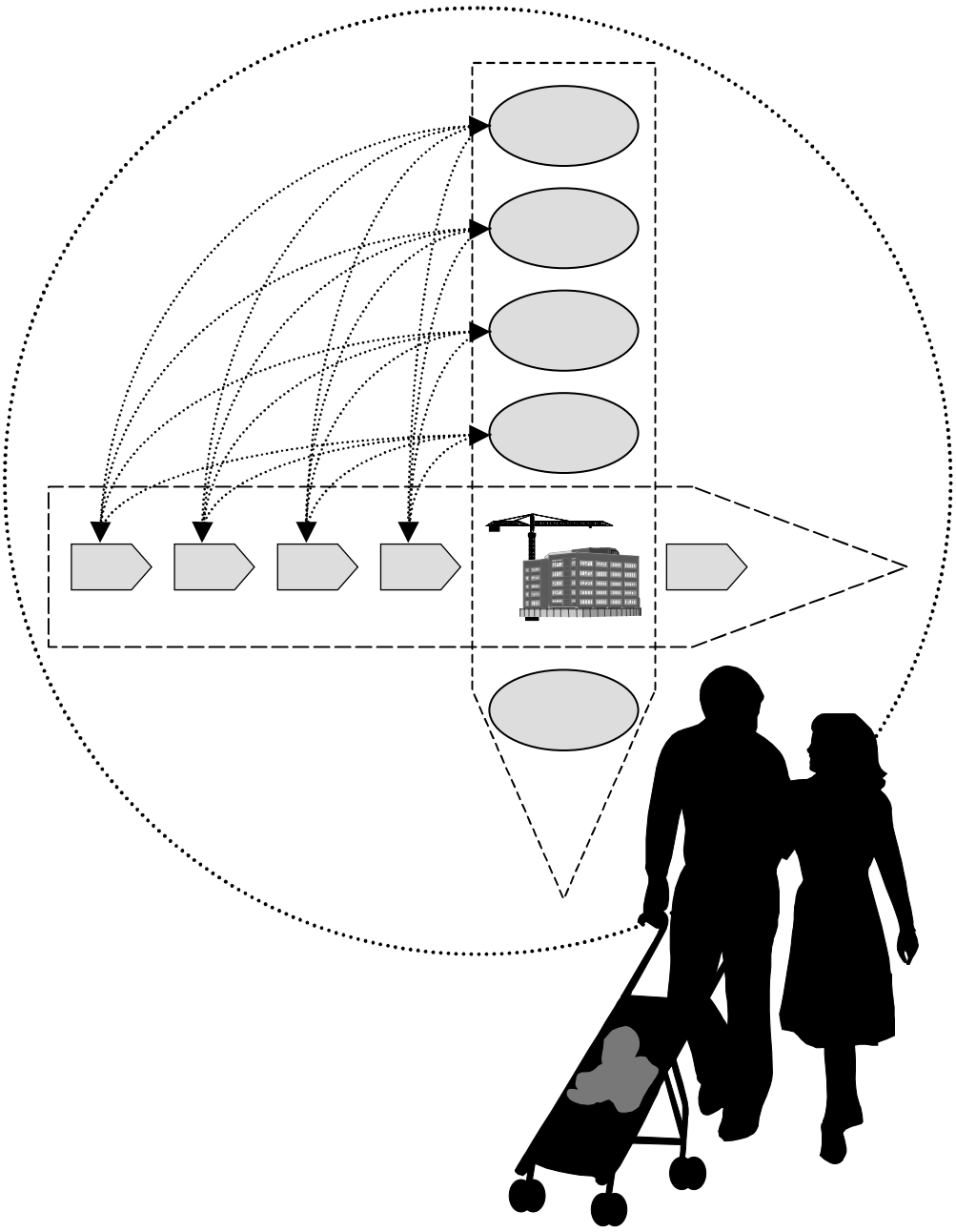


Figure 65: Coordinating the actors' efforts in order to create consumer value is the very purpose of the model.

The model is not claiming to be a robust business process model. Even though the model share the logistic roots with some of the existing process models, this one is not to be taken for a process model. The vertical and horizontal orientation of the two groups of actors within the models has no symbolic meaning in any deeper sense. Supply chain models are usually found to be oriented horizontally from left to right, while the "construction process", or the construction project's value chain in the literature has been found in all kinds of orientations and variations.

One thought through process model is not elaborated here. Main processes have to be carefully identified, and mapped. It is hence not as uncomplicated

as in the draft presented below *(Figure 66)*. The design phase is often unfortunately not completed when the construction activities on site start. And, of course, the supply of material is – or rather should be – an integrated part of the construction. However, the two processes *supply chain design* and *construction design* can be mapped as being parallel. When they are analyzed on a deeper level and broken down to activities we could map outputs and inputs that could be integrated, and the desired information flows between the two could be described.

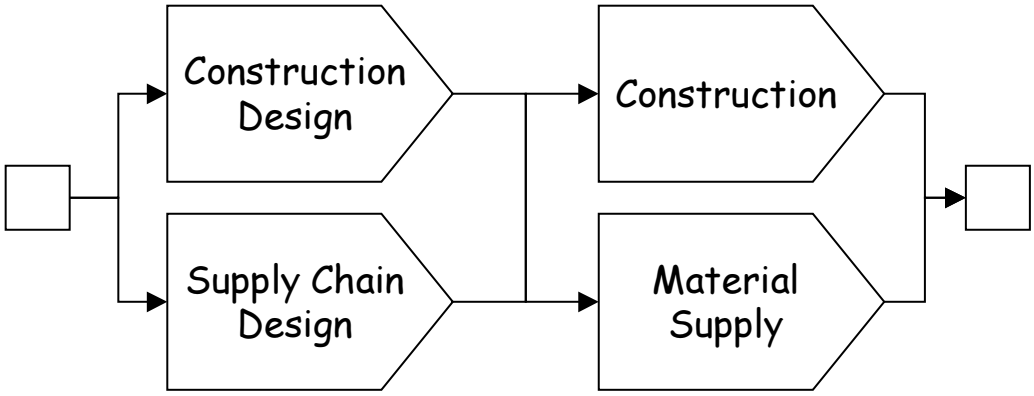


Figure 66: Draft of a process model.

7. Conclusions

Conclusions from the study are drawn and the five-step thesis approach is summarized in a table. Then conclusions of the potential of supply chain management as well as driving forces and obstacles for supply chain management are stated.

After practical, theoretical and methodological contributions, a discussion of applicability, methodology and paradigm is followed by suggestions for further research.

7.1 Supply Chain Management in the Construction Industry

7.1.1 Conclusions from the Literature Review and the Case Study

Logistics knowledge in general is found to be poor in the construction industry. Competition and consequently customer orientation has for a long time been weak and thus also cost consciousness. This partly explains the lack of developed applied logistical concepts. The companies in the construction industry are hence not used to flow models or supply chain models.

The absence of logisticians reduces the possibilities to handle logistical problem. By normally not seeing the possibilities to pro-actively manage material flows, flow-related problems are frequent, yet often not considered to be problems; it is a part of the normal production conditions on site so. So far, flow-oriented companies do not seem to exist in the construction industry yet, and flow approaches are rare both among practitioners and researchers. Pro-active logistics can improve effectiveness and efficiency and thus reduce costs, and this insight has caused a clear trend in the stationary industry towards pro-active approaches as supply chain management. A responding movement in the construction industry is not yet seen.

The material flow to the construction site consists of many different flows that are not coordinated. The consumer is only interested in the total efficiency and the overall effectiveness. So if an attempt is to be made to reduce the total costs in a construction project, a holistic approach is needed. If the material flows are not considered in a holistic view, uncontrolled flows threaten to disturb and destroy the conditions for controlling the other flows. Some of the companies are trying to reduce costs from time to time in pilot projects. But all companies are not putting enough energy into these efforts all the time.

Stressing the possibilities for supply chain management is necessary, since the literature review confirm the somewhat bewildering fact; it is clear that the industry suffers from problems. These problems could to a certain extent be traced to an insufficient material flow control. Yet very little effort among the actors is put into developing logistical skills.

Systematic efforts to reduce costs show results, and this is clearly seen in the case study. Many of the efforts in the case study are of logistic nature, and the efforts to manage the supply chain could perhaps not really be described as true supply chain management, but the approach used could be developed to a deliberate supply chain management approach. The supply chain management concept is hence possible to apply in the construction industry. And it is not only a possibility; the use of supply chain management is a necessity in order to be able to offer products that the vast majority of the market can afford to demand.

If we would have seen more of these efforts in the rest of the construction industry costs could be generally reduced. This offers both the possibilities for customers to reduce their housing costs and the companies in the construction industry to increase their revenues. So by using logistical approaches as supply chain management costs can be reduced. But not only can the cost for directly logistical activities as distribution be reduced, the general conditions for the construction work can also be changed to the better by structural changes in the material flows. This is demonstrated in the case study.

But actors in the construction industry trying to change the flow structure, as seen in the case study, will meet resistance. In order not to be stopped, a determined strategy is needed.

A model to relate supply chain models to existing models is presented in order to bridge an existing gap. The model can be used to coordinate the efforts of the actors in the construction industry in order to improve supply chain performance and overall effectiveness and efficiency.

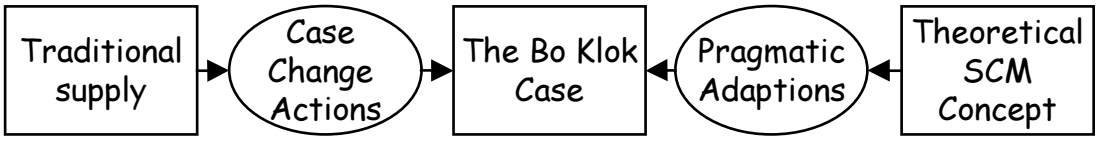


Figure 67: Conclusions from the study are presented as summation.

As the last step in the five-step thesis approach, the case findings will be summarized and condensed in a structure based on the theoretical models[283] *(Figure 67).*

[283] Since a deliberate supply chain approach has been used and only fragments of the supply chain management criteria defined by Otto and Kotzab could be identified in the case study, the Coyle model is used in the concluding summary of the case findings.

Factor	Traditional supply	Case Change Actions	The Bo Klok Case	Pragmatic Adaptions	Theoretical SCM Concept
Warehousing	Company based		Partly supply chain coordinated		Supply chain coordinated
Flow of goods	Interrupted	Challenging structures	Terminology highlightening flows	Partial supply chains	Continuos/ visible
Costs	Company minimized		To large extent consumer oriented		Total cost for end customer
Information	Company controlled	Holistic approach	Quite company controlled	Cost focus	Shared
Risks	Company focused		Unclear		Shared
Planning	Company oriented	Pro-active approach	Quite company oriented	Forceful resistance	Supply chain team oriented
Inter-organizational relations	Company focus on low cost		Varying In some of the chains partnerships		Partnerships focusing on the total costs for the end customer

Table 9: An overview of the thesis approach.

By systematical efforts it is possible to move from traditional supply towards supply chain-based supply. The case shows that it is possible. And this is a successful way to reduce costs. A general movement on the scale for the Swedish construction industry as a whole would be desirable. *(Figure 68)*

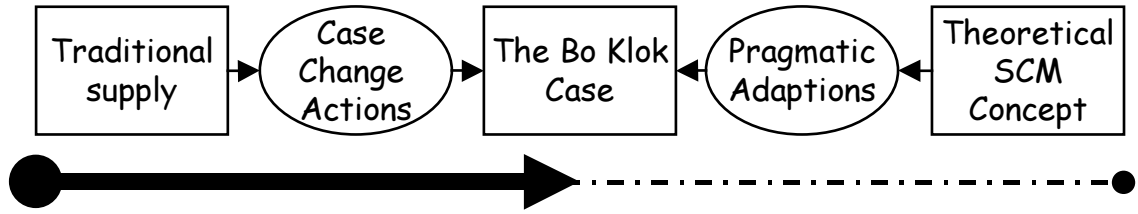


Figure 68: Moving on the scale for the construction industry as a whole.

Still it is not possible to go all the way to the point of supply chain-based supply. The way is more important than the goal, and supply chain-based supply can work as a vision for organizations in the supply chain. By working in the direction of the vision, lots of synergy effects become visible and possible to benefit from. Such insights have been successfully used in the case study, but a deliberate and systematical supply chain approach would show likely even better results than the ones in the case study.

7.1.2 An Opportunity with Potential

The case shows that improved logistics, changing material flow structures and the use of a supply chain management approach is both possible and successful. And the Bo Klok case is only a fumbling start.

Trying to reduce costs shows results if actors are trying. But hardly anyone seems to be willing to try. Highlighting the case study might contribute to a paradigm shift for the construction industry. It is possible to make money on volumes instead of margins. There is a possibility with great potential to create and develop new housing markets.

Synergy. The holistic nature of logistics will cause competence synergies if supply chain approaches are adopted. When logisticians start working from within the companies the development will speed up.

By showing the consumers – and by showing the industry's own actors - that low construction costs also mean low consumer prices for housing, as in the Bo Klok project, the possibility and the right for the consumer to raise cost demands are made evident.

Reducing costs. Optimizing resources in the logistics activities of course means that costs can be reduced. But it also means that there is a possibility for changing the conditions of the production, as in the case study. Industrial approaches to construction are enabled by the holistic grip of all activities created in the implementation of e.g. supply chain management.

New markets. There is a latent demand for low price housing on the Swedish market proven by the success of the Bo Klok project. Actors persistently trying to be successful on this market, learning to handle the demands, have an opportunity to earn money. As it is now on the Swedish market, all of the companies are trying to compete on the same dream market: The markets in city centers where it seems like any levels of prices and costs are accepted.

7.1.3 Drivers

A number of driving forces for an increasing supply chain management approach in the construction industry has been found in the study. The drivers are listed below and then discussed one by one.

- Costs
- Time
- Market development
- New technologies
- Increasing competence
- Increasing competition
- Product development
- Marketing

Costs. The first and foremost reason for the construction industry to reach for supply chain management is the possibilities to reduce costs. Reducing costs is not only possible, it is necessary. The cost reduction was also the main driving force in the case study.

By improving the overall efficiency and effectiveness of the material flows, not only the end product can be more worth its price, also the revenues for the actors participating in the work can increase. And the basic idea behind the sharing of the revenues must be that only the ones adding customer value, and thereby justify their participating in the chain, should have a share of the common profit.

Time. A fast on-site production with high quality is made possible by supply chain management. As in the case study shortened lead-time is important as e.g. the cost for tied up capital is reduced.

Market development. In order to benefit from economies of scale, a large number of projects is needed. And by weakening the latent demand for low price housing, a new, so far mainly undeveloped share of the Swedish housing market, is opened. The temporary low number of started housing projects is biased, in the sense that it is only the existing market that is considered.

There is a large group of customers that so far has not had the possibility to afford the new production housing offered at the market. If they realize that it is possible and reasonable to raise demand for low price housing, the new market is a fact. By earning money from the volume of the products instead of the margins, this new market can be profitable for e.g. construction companies that accept the challenge to develop the needed skills. The creation and development of the own market is a characteristic of a modern company.

New technologies. In order to manage and control the information flows technical solutions must be implemented. But as the construction industry is on the lagging edge, when it comes to this kind of issues, software and hardware to a large extent already have been developed for customers in the stationary industry. Thus technologies exists.

Information technology means great opportunities for the management of supply chains. Until recently, the fact that the production was moving on from site to site caused difficulties for building flexible computer networks, but nowadays these kind of problems belongs to history.

Increasing Competence. Slowly, we see change efforts among the Swedish construction companies trying to create organizations focusing on separate markets. For the housing projects, where the construction company not only have a design and construct contract but also strive for controlling the early phases as well as the later maintenance phase, in these projects the benefits from logistical skills might be more obvious. A model as the one presented in *chapter 6*, is easily recognized in such a project.

At the central purchasing departments, supply chain models will be developed leading to a need for supply chain management concepts.

There are potential benefits to be seen in the construction industry, as the logistical competence increases. By thinking in the terms of flows, hopefully a fast replay of the scenarios seen in the stationary industry will be seen regarding the logistical development.

Competition. Hopefully the subsidies that have been withdrawn from the Swedish construction industry will stay gone. A stable business environment with predictable competition conditions is beneficial for the development of logistical concepts and supply chain management approaches. Systematic efforts to keep the cost levels low, unavoidably lead to a need for logistical approaches. This development will be supported by the fact that most of the potential consumers demand low price products in harmony with continuously increasing customer orientation.

Customer orientation means that the supply chains must keep changing in order to try to add value. Not that the customer must be changed in order to fit the existing supply chains.

In normal housing production there is no overall control of flows of construction material. But the only thing interesting to the consumer is the total effectiveness and efficiency; it will not be appreciated if one or some of the actors in the construction projects work well. So by trying to see the material flow as a whole is necessary in order to create customer value in an effective and efficient way on a competitive market. And this is exactly what was forced in the case study.

New companies enter the Swedish market, partly as a consequence of the European common market. Market control and price control is obstructed, and competition will increase. New distribution channels are created as consequences of the possibilities from E-solutions and B2B applications. The market control among wholesalers and manufacturers is threatened.

Product development. Analyzing the potentially strategic role of purchasing, the construction companies realize that they have problems to develop the possibilities for product development. In order to coordinate the actions in the supply chains to add maximum value for final customers, products adapted to the characteristics of the supply chain, as well as the need of the construction company, must be developed. And this development is well suited for outsourcing, but the existing purchasing patterns obstruct such possibilities, since the material producer rarely has any relation to the actors down stream. Product development was used in some of the supply chains in the case study, while it was more difficult in others. This potential for outsourcing development is a strong driving force.

Marketing. Material manufacturers find difficulties to direct and coordinate their marketing efforts. Since the information flows between the actors are not controlled or managed, the manufacturers have to direct their marketing efforts towards many links in the supply chain. But they also have to direct efforts towards designers and contractors. In a holistic approach this would not be necessary, and this is a driving force for the manufacturers to adopt supply chain management thoughts.

7.1.4 Obstacles

Also a number of obstacles for supply chain management approaches in the construction industry have been discovered, and they are listed below and then discussed one by one.

- Organization
- Low competence
- Limited competition
- Attitude
- Traditions
- Technique

Organization. The project focus is obstructing all holistic efforts such as supply chain management and contributes to fragmentation. The decentralization also makes supply chain initiatives difficult, as central initiatives meets resistance in the contractors' organizations.

The absence of logisticians and the generally sparse central planning functions makes implementation of logistical concepts difficult, as well as seeing the benefits from such concepts. The managing of flows was enabled in the case study by the resources for planning.

Supply chain initiatives aiming for low cost housing risk to meet internal threats in the contractors' organizations. New products are competing with the own traditional products.

Low competence. The fact that there is no formal logistical competence in the constructors' organizations also means that the construction industry partly is left outside the logistics world in terms of conferences, research and so forth.

Interesting solutions in order to improve effectiveness and efficiency seen in the literature review remind of the initiatives in the case study. Ideas have been tested before, but seem to be forgotten now.

The absence of relevant terminology makes logistics problem almost impossible to solve. This also reduces the possibilities for successful outsourcing. If competence is lacking at the buyer's side it is an obstacle for buying appropriate logistics services.

Limited Competition. The driver for continuously putting efforts into reducing costs in the construction industry has for a long time not been strong enough. Still it seems too weak, at least now when it is possible, and easier, to build for the customers who do not demand reduced prices. The efforts that could be seen in the Bo Klok project are really hard work compared to picking the low hanging fruits.

Attitude. The desire to see the differences instead of the similarities, treating the projects as unique obstructs supply chain approaches. The normal desire to change details, controlled and stopped in the case study, supports these problems

The strange strong own opinion among the actors in the construction industry that they are conservative, obstructs new ideas as supply chain management. Also mental models by the site manager as a problem solver do not support pro-active approaches. Solving a problem is more appreciated than preventing it.

The attitude towards research and development enables the *no time* or *no money* models that seem to be the altering models to handle research and development depending on the cyclic nature of the business.

Traditions. Pricing systems with extensive price reductions, and a lack of cost transparency cause difficulties to approach a supply chain based supply. Purchasing patterns that make analysis of transport services and product impossible.

The customer orientation is traditionally weak, and it does not facilitate supply chain-based supply.

Time is always short, and it is seen as a part of the culture. By starting up the production nearly always without completing the design and planning phases, the prerequisites for tailoring a supply chain that can contribute to a fast and correct construction phase are missing.

Technique. Lack of standards obstructs rational actions in a smooth flow. There is a very large number of products and handling equipment for products in the construction industry. Integrative efforts in a supply chain based environment calls for a holistic approach.

But the lack of standards must not be accepted. It is not only cause for the lack of flow management, it is also an effect of a longterm absence of actors, actively trying to create standards in order to facilitate effectiveness and efficiency in the material flow. National standards are common among construction materials, and in order to benefit from e.g. the common European market, these standards must disappear.

Appropriate software for controlling and managing material flows in the construction industry supply chain does not exist yet, because there has been no demand for such products, so far.

7.2 Contributions

7.2.1 Practice

The research work has been structuring and explaining the actions that were carried out in the studied case, the Bo Klok project, that have attracted a lot of attention. But the attention in for example media that has been directed to the project has not addressed the unconventional and interesting changes in e.g. the material flows. By highlighting the notable logistic aspects of the projects and discussing them in terms of e.g. supply chain management, awareness and a language for such phenomena have repeatedly been demonstrated. In many interesting debates with actors representing various parts of the construction industry, these discussions have led to conflicts and arguments. Maybe this will not show immediate results, but most probably have new thinking started among actors never previously confronted to logistical models and language.

An appropriate language to discuss logistical problems is necessary in order to reach common solutions affecting many actors. Without supply chain models, structural changes in the supply of material are difficult to communicate and hard to understand.

The questioning of the existing supply chain structures, that led to a silent battle between the actors, has been encouraged and explained in terms of supply chain management. The introduction of supply chain management approaches, seen as natural and obvious development in the stationary industry for a long time, has caused strong reaction from the actors in the construction industry. In the research work, efforts have been put into trying to defuse the issue.

Thus a logistics interest in the construction industry has been stimulated and encouraged as a result of action research in the project.

7.2.2 Theory

An existing theory has been tested in a new context. Supply chain management has been found to be applicable in the construction industry, even if the case study provides no example of a systematic use of supply chain management. But the effects of the efforts to manage and control the supply chains are described and analyzed.

A model connecting existing knowledge and accepted models to new knowledge as supply chain models has been developed, trying to bridge the gap that obstructs fruitful discussions *(Figure 69).* The model can hopefully make it easier for researchers focusing on the activities on the construction site to understand the role of the material flows.

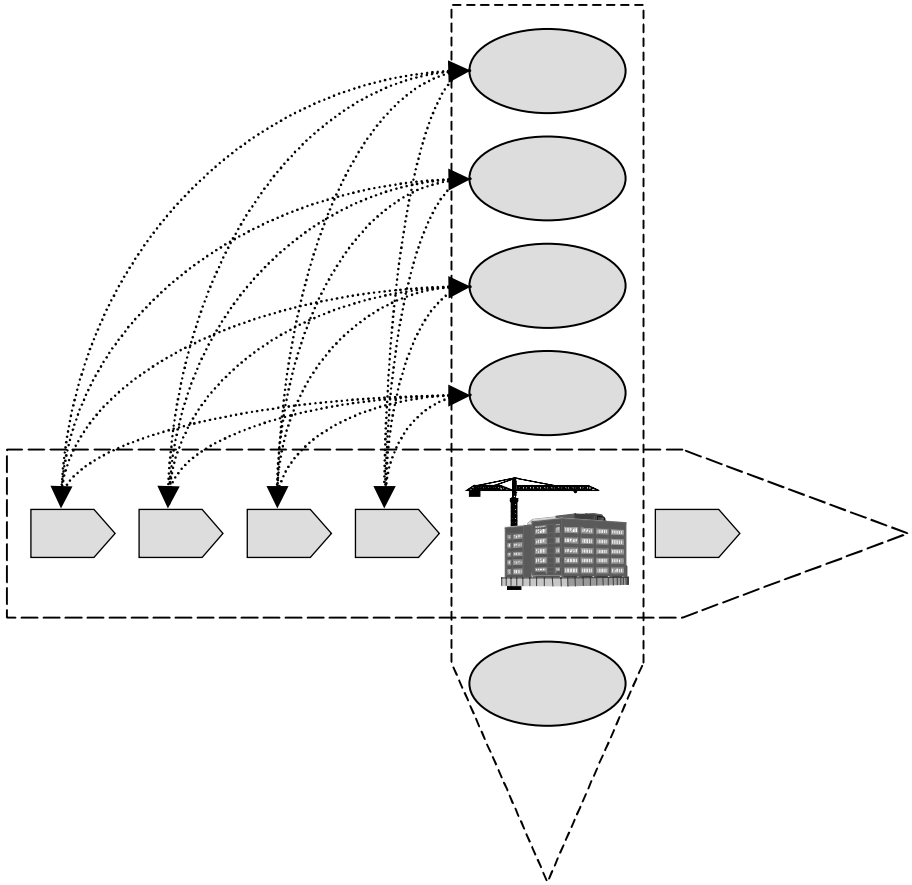


Figure 69: The model connecting the supply of construction material to existing models.

A minor finding from earlier research and confirmed in this study, interesting from a theoretical modeling perspective, is that the material flow to a construction site consists of a multitude of different material flows *(Figure 70).* The flows have very different characteristics and are not integrated. The insight is important because all flows have to be managed in a holistic approach in order to avoid disturbances and sub-optimizations. Yet it has not been described in the literature, nor has the consequences.

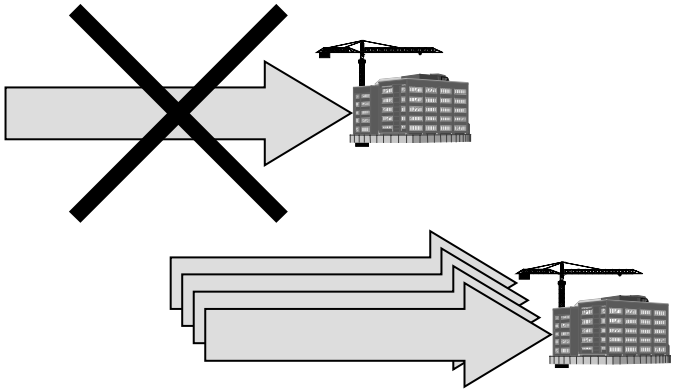


Figure 70: The multiple flows to the site.

7.2.3 Methodology

A systems model has been developed and used as a structure in the thesis.

A critical discussion has been conducted in order to contribute to a methodological development of management research in the construction field as well as the field of logistics.

7.3 Discussion

7.3.1 Applicability

Even if it is not a deliberate or aware supply chain management approach that has been investigated, it is clear that a supply chain management approach is usable and that the concept is applicable in the construction industry. And the use of supply chain management is not only a possibility; it is a necessity in order to be able to offer products that the vast majority of the consumers on the market can afford to demand.

The model presented the analysis can help all actors in the construction industry to understand how supply chain management can contribute to the development of the industry. However, it is clients or large contracting companies that have the best possibilities to manage and control the important information flows showed in the model.

7.3.2 Methodology

The quality of research work can be discussed in terms of validity and reliability.

Validity means that it is the right things that have been measured or studied in order to address the research question. The decision to study the Bo Klok project was made since it provided a unique and interesting case. From a retrospective perspective it seems to have been a good choice. By structuring and explaining the actions in the case study that had been taken in order to reduce costs, a more or less clear picture of a supply chain management approach emerged. This picture was then appropriate for discussions of to what extent this could be described as supply chain management.

When one refers to the reliability of a study, it is whether the study is carried out in a appropriate manner or not. Do the interviews and the observations in the case study serve a true picture of the development in the case? By using a methodological triangulation, where observations, interviews and document studies have been complementing each other and comparisons have been possible, the reliability has been improved. Also by asking the same questions to different persons, a more interesting and probably more true picture has evolved. By being critical up front to all data, reflecting over sources and

possible bias, validity and reliability have been strived for throughout the study.

The methodological systems approach used in the study can also be discussed for evaluation and reflection. The overall systems thinking is useful in a logistics context, but it is more problematic to handle when it comes to practical work in a thesis.

A clear methodological guidance for the logistic systems field seems to be missing. Maybe it is an advantage to elaborate your own systems model, in spite of the risks that comes with own elaboration. Unfortunately many researchers in the field have focused on results and perhaps are they not so interested in methodology. Some logisticians find the systems thinking attractive, but the implications for the results are often unclear. The ambition in this work was to use systems thinking as a tool for structuring, presenting and analyzing the case study. As for the structuring in the cyclical model, it helped the author to arrange the case study presentation. However, the systems thinking was maybe not fully used in the analysis. Explanations of the studied systems in explicit systems language have been sparse.

The advantages of a qualitative approach justify the disadvantage to present figures and economical measurements for the use of e.g. supply chain management. A deeper understanding has been necessary in order to interpret the studied phenomena. And the resistance of logistical models and the lack of a logistical language in the studied environment mean that surveys would most likely be failures.

By spending time in the studied environment of the case study, a broad picture of the case from top management to carpenters on the site, from the architect to the suppliers has evolved. By for example only interviewing top management, as often seen in management research, the picture would have been less rich, and a lot of contradicting findings would never have got any attention.

As a result of the action research approach, the work has got a lot of attention so far. And things are now hopefully starting to happen, as discussions of further research have started with a number of organizations. This is to a large extent the result of our work. And this is the benefit from action research; that the researchers are deliberately trying to change the studied environment, not only describing it.

7.3.3 Paradigms

What about the paradigm demonstrated in the thesis? Is it special? Is it worth discussing? Yes, it most probably is. From a logistical point of view the construction industry stand out as fascinating and to a large extent incomprehensible.

The results from the research are not too complicated, and the main message is simple: Be aware of flows; see flows; think flows and start act flow-oriented. Let us for example use a supply chain management approach that has proven to be successful in other types of industries! Maybe it is too simple; the message is maybe too easy to be understood. Yet hardly no one in the industry seem to take the consequences of an understanding and try to initiate a change. And the few people, suddenly understanding the message in its simplicity immediately rush on: OK, show me exactly what to do! But this is not the question that has been addressed so far in the research work, and a disappointment could be seen in the face of the redeemed, as the insight starts fading away.

The problems are easy to discuss with my logistician peers, but the challenge remains to gospel the logistical message loud and clear to the construction industry. But as a pedagogical reflection, the problem is basically not to teach. It is to create learning…

The research in this thesis has showed that it is possible to use a supply chain management approach. By facilitating understanding, action becomes possible for the actors as the mental model changes. And this could mean a beginning of a paradigmatic change in the construction industry.

7.4 Future research

7.4.1 Testing and Developing Supply Chain Models

The model introduced in the thesis *(Figure 71)*, showing how the supply chains connect to the traditional models of the construction project value chain, should be tested. In cooperation with an interesting client the information flows in the model should be planned in advance and then managed in the project. An interesting client could for example be a contractor controlling all the steps in the value chain.

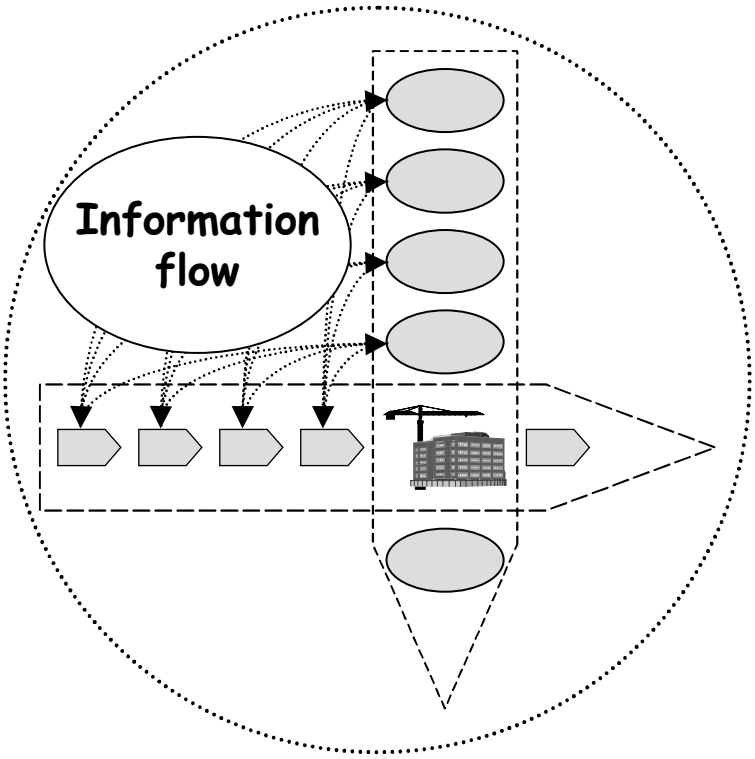


Figure 71: A model that needs to be tested and developed.

By using the model in a project as a pedagogical tool to explain what is aimed at, the actors could be encouraged to participate. The ideas represented in the model could be tested and further developed, resulting in new models.

7.4.2 Problems Caused in and by Construction Material Flows

One important area of future research is the more practical aspects of how to reduce the problems caused in and by the material flows to and from construction sites. Severe problems are caused by traffic disturbances, environmental impacts from transports, high cost levels for the distribution services and invalid delivery performance.

An higher level of understanding about how the actors in the construction industry can act to prevent and reduce these kinds of problems is needed. Models and tools to manage potential problem situations would be useful, and a changed behavior among the actors could be encouraged.

7.4.3 The Role of the Client

In order to find out how a client can continuously contribute to an improvement of the effectiveness and efficiency of the construction activities enabling also the production of unsubsidized low price housing, another research project is needed. By participating in a number of projects, researchers can understand and develop the possibilities for the client.

A model is developed for evaluation, securing that only actors continuously trying to reduce costs in order to give the client the most value are allowed to

participate in construction projects. In order to get a chance to participate, contractors, subcontractors and other actors must show recent performance improvement as well as plans for future improvements of how they will work to reduce costs.

7.4.4 International Comparisons

To widen the focus from national to global investigations could also be very interesting. Even if a comparison for a lot of reasons is difficult, new insights could be gained. A majority of the construction research is done and publicized nationally, and there is a need for internationalization.

A comparison of the conditions for efficient and effective material flows for the construction industry between Sweden, the USA and Japan would most likely provide interesting results.

7.4.5 Construction Environment Software

The profound problem in logistics in construction so far seems to be the fact that this environment shows a general absence of desire for flow control. By not having control of the material flows on site, controlling the material flows outside the site - in order to create the best possible conditions on site - seems far too ambitious.

Developments of software to manage and control material flows in the stationary industry have taken place for many years now. But a corresponding development of software, adapted for the demands in the construction industry, cannot be seen. This quite strange reality is explained by the fact that the potential customers, the construction companies, not are willing to pay for such software, since they so far have not seen the use of it.

But the development of such software would dramatically change the conditions and the need for logistics and supply chain management.

7.4.6 Quantitative Results

So far a lot of the efforts from logistics research in the construction industry has been qualitative research. In order to create understanding of why logistics thinking not seem to be adopted, to what extent logistics approaches are applicable and so forth, quantitative approaches have often been chosen. This, however is not enough.

Quantitative results are needed in order to persuade the actors that insufficient logistics is an important explanation of an extensive part of the redundant construction costs. In order to show in financial terms how much there is to win from bold venture on improving logistics performance quantitative data would also be useful.

But caution must be considered so that answers are not made up to questions that are unknown. Also figures showing the exact amount of something that is not defined or understood must be avoided.

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Appendixes

Appendix 1: **Field Study Observation Protocol**
Appendix 2: **List of Interviews**
Appendix 3: **Financial Consumer Investigation, Bo Klok**
Appendix 4: **Price Development, Installation Materials**