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DOCTORAL THESIS

Product Development in Process Industry

– *Changes and consequences*

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“*Science is facts; just as houses are made of stones, so is science made of facts; but a pile of stones is not a house and a collection of facts is not necessarily science”*

Henri Poincare (1854 - 1912)

“The important thing is not to stop questioning. Curiosity has its own reason for existing. One cannot help but be in awe when he contemplates the mysteries of eternity, of life, of the marvelous structure of reality. It is enough if one tries merely to comprehend a little of this mystery every day. Never lose a holy curiosity”

Albert Einstein (1879 - 1955)

APPENDED PAPERS

Paper I [Chronéer, D.]
Have process industries shifted their center of gravity during the 90s?
International Journal of Innovation Management, vol.7, no.1, pp.95-12, 2003.

Paper II [Chronéer, D.]
Understanding changes in product development in Swedish process industries
Submitted for publication

Paper III [Chronéer, D.]
Are some process industries more product-focused than others?
- The role of innovation
Submitted for publication

Paper IV [Chronéer, D.]
The impact of supply chain information and networking on product development in Swedish process industry
International Journal of Logistic Systems and Management, vol.1, no.2/3, pp.127-148, 2005

Paper V [Chronéer, D.]
A change in supply chain information in Swedish process industries and its consequence on a changed development focus
Forthcoming in International Journal of Integrated Supply Management

Paper VI [Chronéer, D. & Laurell-Stenlund, K.]
Effective product development process: Towards a conceptual framework for process industry
Submitted for publication

Preface

This thesis is the main outcome of a doctoral process which I started for some years ago at the Division of Industrial Organization at Luleå University of Technology. During this process I have received great support and inspiration from a large network of colleagues.

First of all, I would like to thank my supervisor Professor Sven-Åke Hörte for his support during the process and who gave me the opportunity to become a PhD student. I am also grateful to Anders Nilsson and Hans Bylesjö for their valuable comments on the final manuscript of this thesis. I also would like to thank Kristina Laurell-Stenlund and Håkan Ylinenpää. They have assisted me with valuable comments and advice. Furthermore, I would like to send my gratitude to all the respondents at the companies that participated in the study. You made this research possible.

Finally, I would like to thank the ENDREA (Engineering Design Research and Education Agenda) and the research foundation of Handelsbanken (Jan Wallanders and Tom Hedelius stiftelse) for their financial support.

Abstract

This thesis addresses the issue of product development in Process Industry, and it is presented in the form of six appended papers together with an extended summary. Product development in Process Industry is not widely researched upon, and even less in the Swedish process Industry. For these reasons, the focus of this thesis is specifically on product development in Swedish Process Industry and on some of the consequences of a changed perspective in product development work in Process Industry. The selected research strategy has been a combination of exploratory interviews and a survey.

The main academic contribution of this research is the elaboration of several implications concerning a changed perspective in development work for Swedish process industries. An analysis of the entire supply chain for a process-based company and its actors will also contribute by facilitating this change towards a more product-focused development, i.e. this analysis can visualise vital and needed elements in the development work. The analysis also emphasises important actors who can become key actors in a formalised network involving the development team.

The main managerial implication of the research is the investigation of a changed perspective for Swedish process-based companies and the implications of such a change. Development managers can facilitate the change towards a more product-oriented focus in development projects by thoroughly view and analyse product development work as a process in the supply chain. Sources of innovation and key actors can be both suppliers (of machine equipment or raw material) and customers (customers and/or end-customers). However, an analysis of vital sources of innovation can require changes in both organization and means to cooperate.

Product development in the Process Industry is an unexplored area of research. This thesis shows that the theories of Management of Technology and Supply Chain Management can together emphasise some aspects to be highlighted to understand and create effective product development in Process Industry.

CONTENTS

1. INTRODUCTION

Product development organization and management have been researched for several decades now due to, among other things, a change of R&D Management practices during the 1980s and 90s. Gupta and Wilemon (1996) summarize these management changes for what they call the most technology-based firms:

- Increased emphasis on cross-functionality as opposed to being "technology driven" or "production driven".
- Increased focus on achieving business results, R&D is held accountable for directly contributing to business results not just in the long-term, but also in the short-term.
- Increased emphasis on development speed.
- Increasing constraints on R&D resources.
- Increased emphasis on R&D alliances.
- Senior management's perception of innovation.

The role of R&D has changed significantly since the 1970s. Innovation is not driven solely by technology, but by how technology is used (Miller & Morris, 1999). The wide range of activities expected from R&D departments and the demands being placed on them are ever more complex, i.e. emphasis is being placed on a company's linkages with other organizations (Trott, 1998). Some of these activities concern external knowledge acquisition and the development of systems and procedures to enhance the probability of success (Trott, 1998). Today's R&D management is not just about managing R&D resources. Uncertainty in the global business environment has developed an R&D perspective to include the management and integration of technology with other aspects, i.e. Management of Technology (Drejer, 1996).

However, what are the impacts of these changes in R&D management practises on Process Industry, with its fixed and costly production processes? Little research exists on the impact of changed R&D management practices on Process Industry, and specifically on product development. In one of very few exceptions, Hovgaard and Hansen (2004) discuss innovativeness in the forest product industry, and found no consistent, structured processes for product development. Hence, product development in Process Industry is not widely researched upon, and even less in the Swedish process Industry. For these reasons, the focus of this thesis is specifically on product development in Swedish Process Industry and on some of the consequences of a changed perspective in product development work in Process Industry.

1.1 Product development in Process Industry

Process industries like paper and steel have traditionally focused on developing their production processes, while product development received relatively limited attention until the end of the 1970s. Today, however, international competition has increased mainly due to market changes. Pulp and paper industries favoured more value-added paper grades during the 1980s, while the steel industry has also experienced a change in their markets with an increased demand for specific products with special material properties. This has led to more specialization in niche-products and an increased interest in product development (Chronéer, 1998).

The Swedish Process Industry comprises a large segment of the Swedish economy, though it has changed dramatically during the 1990s. After the recession in the early 1990's, a rapid and comprehensive restructuring of several industries occurred, leading to more skills-intensive industries. Rapid technological developments and tougher market requirements have also led to greater skills-intensity in other industries, forcing industrial companies to significantly change the way they work. Foreign competition has increased sharply with companies becoming more internationalised (The Federation of Swedish Industries, 1998), while product life cycles are becoming shorter due to ever rapidly developing technologies (Ita & Gross, 1995).

From production of commodity raw materials like steel, paper and glass to value-added materials such as advanced ceramics, process industries are uniquely built around production processes that manipulate material properties to produce raw materials for use in a variety of applications (Barnett & Clark, 1996). The characteristics of Process Industry are very different from assembly/fabrication industries and may require a different type of management emphasis (Utterback, 1996). Process development is an often difficult and constraining aspect of product development in the Process Industry and it is assumed that since product and process are symbiotically related in the production system, fundamental changes in the one must then incite parallel fundamental changes in the other (Etienne, 1981).

Why then is product development in Process Industry not researched upon more? A traditional focus by the industry on high volumes and the search for cost-effectiveness might be one reason. Research to date suggests a focus on various performance measurements (e.g. Kerssen-van Drongelen *et al*., 2000), production control (e.g. Fransoo & Rutten, 1994) and performance monitoring (e.g. Woll, 2003; Fiske, 2004). Part of this interest can be attributed to a belief in the economics of scale and an unwillingness to invest in emerging technologies. Product development in Process industry can be a major risk, due to the costliness and time involved. There has, however, been a recent reawakening with companies cutting

costs and repositioning themselves in the market place. The following sections will give a brief insight into product development in Swedish Process Industry.

The Swedish steel industry concentrates largely on special purpose products requiring very high quality. The industry's continuing competitiveness entails substantial investment in research and development, with "machinability" being a major aspect for steel producers. An often important cost factor in production as well as being complex, machinability is a measure of how easily a material may be worked in different cutting operations (e.g. measure of the tool life length) and depends on the interplay with other factors, especially machines, tools, skills and material. Good machinability means the ability of customers to increase their production efficiency and reduce the cost of the finished product, e.g. with reduced set-up times and increased production flexibility. Another aspect of importance for steel products is quality, i.e. that a company can guarantee quality is an absolute necessity considering the ongoing integration between producers and customers (Chronéer, 1998). Commercial steel has undergone radical change and development over the past ten years. Traditional steel types have been refined regarding both dimensional tolerances and uniformity of mechanical properties, while numerous steel grades have been developed for new applications, e.g. cold-forming steels and quenched-and-tempered structural and abrasion resistant steels (Chronéer & Laurell-Stenlund, 2001).

Another example of an issue in product development in Process Industry is when the product is often an intermediate industrial material used for further manufacture, i.e. transformed by customers. Concerning paper, pulping is a process stage preceding paper manufacturing where basic raw material is converted into a fibrous pulp. Few paper grades are produced from only one type of pulp. Different pulps, fillers and other chemicals are usually combined to achieve the desired paper properties. As an intermediate industrial material, paper does not exist in its own right, but is further converted into a variety of end products. Some product classes are as follows: printing and writing paper, packaging and printing paperboards, specialty papers like hygienic papers, wrapping papers and sack kraft. Some of the most important characteristics of a paper are low cost, high performance to weight and convenience of use (Chronéer & Hörte, 1998).

Today, environmental and economic pressures are forcing management to carefully scrutinise the operation of existing assets. Companies are cost cutting and targeting strategic dominance in selected markets by rationalising their product portfolios. Much of the industry has concluded that it cannot solve its problems by cost-cutting alone. Understanding the larger system requires knowledge of both 'hard' and 'soft' factors. In this context, 'soft' factors include systems management, marketing and sales functions (Anderson, 1997). How is it possible to understand this

larger system when product development concerns development of material properties and the product is manufactured in a continuous production process necessitating heavy investment? It is a complex matter because Process Industry generally has very inflexible and costly equipment. The production process is often unique for the purpose of manufacturing a specific product and the manufactured products are often interdependent. Changing the material properties of the raw material affect the entire product group (Lager, 2001).

1.2 Concepts and definitions

To illustrate some concepts used in this thesis and the papers, a brief introduction of those most central is presented.

Concepts like "innovation" and "research and development" are commonly used to describe not only the creation of an idea, but also of the whole process of bringing an idea to a commercial application. Both concepts can be used synonymously (Lager, 2001); hence, various activities such as product development, process development, system development, service development and business development are often included in both concepts (Lager, 2001). But what is meant by innovation? Tidd *et al*. (2001) state that innovation is essentially about change, as in the product/services an organization offers or how they are created and delivered or both. Innovation can also be viewed as the core process within an organization associated with renewal, survival and growth (Tidd *et al*., 2001).

Innovation includes sub-activities such as product development (or product innovation) and process development (or process innovation). Product development has been described as an essential process for a firm's success (Brown & Eisenhardt, 1995). Process development, however, includes the technologies and improvements in making products (Tatikonda & Montoya-Weiss, 2001). In the forest product industry, for example, process development occurs through improvements of raw material utilization, computer-aided manufacturing and customized machinery (Hovgaard & Hansen, 2004). However, the management of the total spectrum of sub-activities encompassing the process of transforming a business concept into a commercialization is integrated into a technology management system, i.e. managing technology involves an integrated perspective of management, the entire system and its pieces, thereby requiring managers to take a systems approach involving the complete organization (Gaynor, 1996). Of note, the management of development in industry is nowadays often called "R&D Management", "Management of Technology" or "Management of Innovation and Technology", and the abbreviation MoT is commonly used (Lager, 2001).

For further reading of this thesis, it is important to understand that the concept of "development work" in Process Industry incorporates several aspects related to both the product (i.e. material properties) and the production processes (i.e. parameters connected to machinery). The concept of product development work will be mainly used in this thesis, but since development of a product in a Process Industry might consist of developing the product, the process or a mix thereof (e.g. section 2.3.2.), the concept of "development work" to emphasize the diversity in product development will also be used.

A common definition of product development was chosen, specifically as the process identifying a market opportunity and transforming it into a product available for sales (Krishnan & Ulrich, 2001). This is because product development is a complete system that might include various aspects depending on the industry and the company, i.e. the product development process is contextual. Cavone *et al.* (2000) identified the R&D organization and management as being heavily affected by the nature of the R&D process and the relative importance of the different activities within R&D.

I use another concept in relation to product development in my empirical investigation, namely *product-focus*. Since the content of product development for companies in Process Industry can either indicate a focus on the development of the product or on the development of the production process, I state that there is an increase of product-focused development if the respondent experiences that product development is more emphasised today than in the 1990s.

Because of numerous major changes in the operating environment of manufacturing firms since the 70s, many markets and industries have become increasingly international. Research from the 80s and 90s shows changed conditions in product development, such as pressure for tighter cost targets, reduced development cycle times, increasing speed of obsolescence of technologies, faster changing customer demands and the need for improved product quality (e.g. Cannon, 1978; Sands, 1983; Takeuchi & Nonaka, 1986; Barclay, 1992a, b; Cooper, 1994; Rothwell, 1994; Bower & Keogh, 1996). There has been an increasing emphasis on the importance of developing new products faster as a result of these changes. This has lead to a new way of organizing product development projects, in the literature known as the New Product Development (Doz, 1996; Hart & Baker, 1996; Jones, 1997).

Further, the concepts of product-oriented and customer-oriented development are utilised in this thesis and the papers to merely describe an active product development perspective compared to a production-oriented perspective, i.e. a defensive product development where the interest is solely in the technological solutions of

the production process, product development is a secondary result of changes to the production process (Utterback, 1996). Both meanings, i.e. product-oriented and customer-oriented development, are used synonymously in this thesis. However, concerning philosophies of customer-oriented and market-oriented development, I want to emphasise that some researchers state customer-oriented and market-oriented philosophies as representing different degrees to which businesses actively attempt to understand their markets. According to Slater and Narver (1998), a customer-led (customer-oriented) philosophy tends to be reactive and short-term in its orientation, and focuses on the expressed desires of the customer and the measures of customer satisfaction. This means that a business is market-oriented only when the entire organization embraces the values implicit therein and when all business processes are directed at creating superior customer value. But I would like to clarify that I do not investigate the market-orientation philosophy in this thesis.

Another main concept of this research is *Process Industry*, which is as the name indicates an industry that is process-based, i.e. it contains a number of process equipment items supported in structures, linked by pipework and controlled by instrumentation (Whittaker, 1995). However, Whittaker's definition does not consider one special characteristic of a process industry, i.e. the processing of material in a continuous flow. The definition of Process Industry in this thesis can be described as follows: "Process Industry is a part of Manufacturing Industry using (raw) materials to manufacture non-assembled products in a production process where the (raw) materials are processes in a production plant where different unit operations often take place in a fluid form and the different processes are connected in a continuous flow" (Lager, 2002, p.108). The concept of Process Industry is also used regarding the whole industry in general, though it should be noted that many different types of process industries dealing with different products/material properties exist in Process Industry, e.g. steel, paper, chemical, etc.

Paper 1 introduces the concept of *centre of gravity*, when an organization has a driving force or a centre of gravity (Galbraith, 1983). This centre of gravity arises from the firm's initial success in the industry where it grew. According to Galbraith, a company and its management are formed by the tradition and values of the industry it is belonging to, i.e. it depends on their position in the supply value chain. Further, Galbraith states that the values of the company, their management systems and their organization are all shaped by "the stage of initial success" and the anchor or centre of gravity established by the company by starting operations in a particular industry at a particular stage of that industry. This point is important because each stage of any industry has different success factors.

The supply chain can be divided into two halves, i.e. *upstream and downstream companies*, with each stage comprising different success factors (Galbraith & Ka-

zanijan, 1986). Every industry has a value-added supply chain, or a sequence of activities that transform raw materials into the end product or service. This chain in a manufacturing industry begins with a raw material extraction stage that supplies crude oil, iron ore or logs to the second stage of primary manufacturing, known as a variety-reducing stage to produce a standardized output like petrochemicals, steel and paper pulp. The third stage fabricates commodity products from primary material, when manufacturers produce, e.g. polyethylene, sheet steel or cardboard cartons. The fourth stage is the product producers, who add value usually through product development. The next stage includes the manufacturer and marketer of consumer products followed by the last stage involving the distributors and retailers, who sell to the final consumer. These companies add value by creating time and place utility (Galbraith & Kazanjian, 1986).

There are some fundamental differences that illustrate the contrast between upstream and downstream companies. As per Galbraith, downstream stages add value through producing a variety of products to meet the varying needs of customers. The downstream value is added through advertising, product positioning, marketing channels and R&D (Galbraith and Kazanjian, 1986).

1.3 Aims and scope of research

As stated at the introduction of the thesis, R&D Management practices have changed during the 80s and 90s, leading to new working methods of how companies in the manufacturing industry organize and manage product development. Therefore, the overall purpose of this thesis is to investigate how Swedish process industries conduct their product development and some of the changes from the 1990s. As already noted, only minor research attempts in the area of product development in Process Industry exist. This thesis will therefore contribute to our knowledge in this specific field by addressing the following main research questions and sub-questions:

1) *What are the consequences of a changed perspective in development work for process industries?*
   - Have process industries shifted their centre of gravity during the 90s?
   - Have upstream companies changed their development focus during the 90s or has R&D moved to more competitive countries? That is, have upstream companies come closer to their customers concerning product development, and if so, how is this achieved?
2) *Are there differences between process industries concerning a changed development perspective?*

- Are some process industries more product-focused than others? Are there differences between process industries concerning product-focused development?

3) How do process industries collaborate and use information in development work?

- What impact has a changed perspective in development for process industries on the use of information systematization and the view of networks in development projects?
- What has changed in the information flow concerning product development work for process industries? How is this change of information connected to the supply chain value for process industries? That is, is the needed information in product development linked to the entire supply chain?

4) What creates an effective product development process in Process Industry?

- What factors can be found in the literature that explains the efficiency and effectiveness of the product development process?

Research concerning product development in general is vast. For example, success factors of product development work, collaboration and networking have been some of the areas researched. Extensive research shows product development to no longer be considered an explicit task belonging to a sole manufacturer (Biemans, 1990; Sherman *et al.*, 2000). There are also several excellent review articles of product development available. They concern for example the identification of barriers to communication and cooperation (Griffin & Hauser, 1996), what factors speed up innovations and the effect on project outcomes (Kessler & Chakrabarti, 1996), and contextual variables for successful new product innovation (Balachandra & Friar, 1997).

Since the 1970s, there have been reports of a changing view towards innovation, i.e. the importance of new product development (e.g. Cannon, 1978) and attempts to improve the understanding of product development (e.g. Brown & Eisenhardt, 1995; Krishnan & Ulrich, 2001). Much research claims that internal cross-functional integration in product development (e.g. Kahn, 2001; Olson *et al.*, 2001) and external collaboration with suppliers and customers in product development projects enhance product development performance (Gupta & Wilemon, 1996). However, cooperation with external parties may pose numerous unexpected problems and requires much serious effort and commitment of the people involved to make it work.

Being flexible product developers while still maintain cost-effectiveness is a complex dilemma for many companies in Process Industry. Therefore, referring to the previously presented research areas on product development, a secondary pur-

pose with my research is to highlight the dilemma of product development in Process Industry as well as include this type of industry in the research of product development practices.

1.4 Disposition

This thesis has the following disposition, illustrated in Figure 1.

- Chapter 1, Introduction to the research area, product development in Process Industry. This chapter also explains the purpose and scope of the research and discusses some of the essential concepts.
- Chapter 2, Scientific considerations and research design. This chapter describes the methodologies used in the research; i.e. a case study and a survey. Also, how the interviews have been conducted and the techniques used in the analysis are also described.
- Chapter 3 presents a pre-study discussing product development in the steel and paper industries.
- Chapter 4 presents the context of Process Industry and the main theories of product development viewed as a general framework for my research. It also provides a brief overview of the main subject areas in the field of product development and some other areas, e.g. the management of technology that has been my focus throughout the entire research process.
- Chapter 5 summarises the appended papers and how they are interlinked. The six papers discuss the consequences of a changed perspective in development work, e.g. collaboration and a more extensive use of information. This chapter is divided into four sections: consequences, differences between process industries, collaboration and effective product development process.
- Chapter 6 contains the conclusions of the thesis and discusses the scientific contribution of the thesis and a presentation of some ideas for further research at the end.

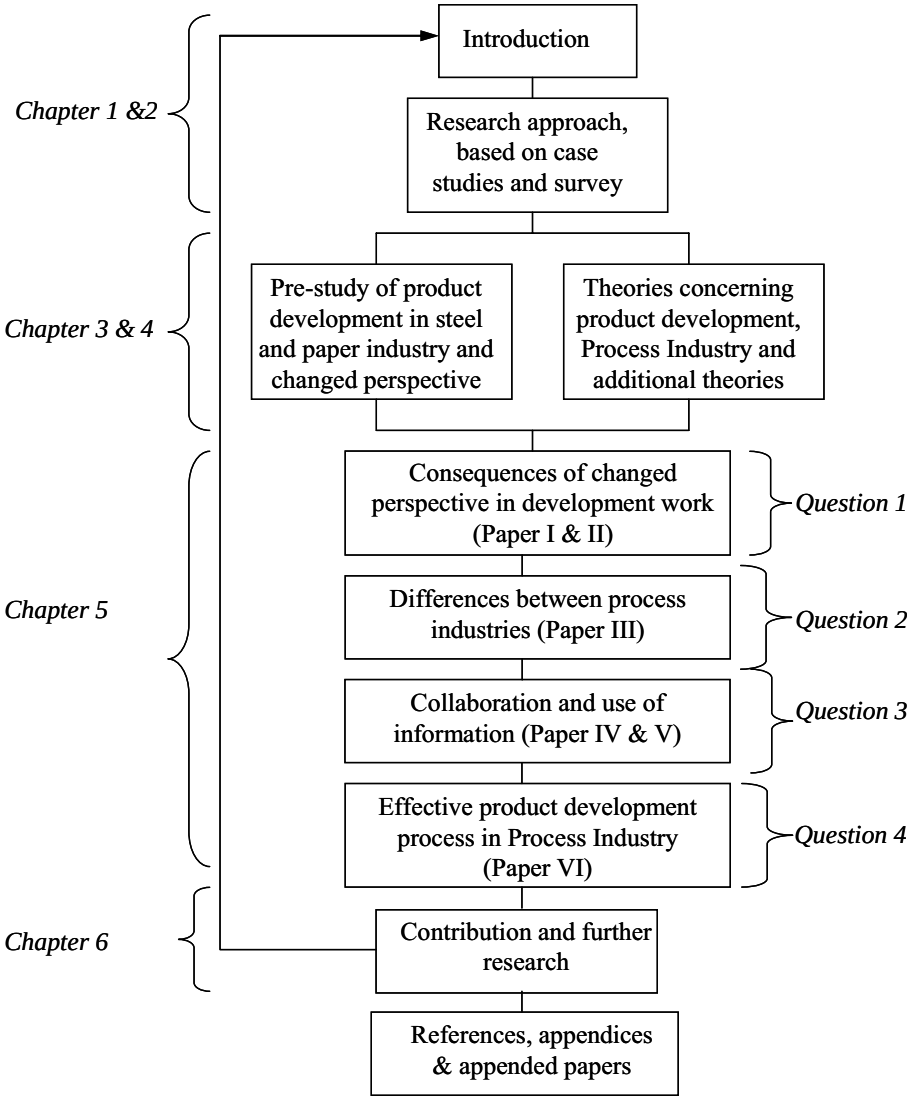

Figure 1. The disposition of the thesis.

2. SCIENTIFIC CONSIDERATIONS AND RESEARCH DESIGN

The aim of following chapter is to explain the background and the process of the research presented in this thesis. My scientific perspective is also discussed so that the reader can evaluate the trustworthiness of the results. The assumptions connected to the methodological approach are initially discussed. For this purpose, the relevant research disciplines for this study and their underlying methodology are investigated and the chosen abductive approach of the study is reviewed. The research design underlying the study follows, i.e. the methodological procedures. Finally, a description of the empirical data collection and a methodological reflection on the research process are presented.

2.1 Methodological approach

My investigation of product development in the Process Industry has focused on an understanding of various aspects, such as organization and management of product development work, network building, relationships between customers and suppliers, and the need for and use of information in product development projects. Therefore, the basis of the research approach is about achieving an understanding of how product development work is conducted in the Process Industry.

To describe the research process, I will first explain the "paradigm" in which I have conducted the research. The methodology itself does not create good research; it is the ontological and epistemological approach that creates the fundamentals of good research (Alvesson & Sköldberg, 1994). Ontologically, this study applies to a more analytical perspective (Arbnor & Bjerke, 1994), assuming that organization and management of product development as phenomena in process industries are a system that can be understood and explained through its actors, i.e. through information from those involved in product development. This thesis aims to create an understanding of how product development work is conducted in the Process Industry, e.g. the content of product development combined with process development, the product development team members, the issue of collaboration and future needs concerning product development. Therefore, an analysis of the empirical material plays a central role.

Epistemologically, origins from existing research on product development in the manufacturing industry are assumed (e.g. Smith & Reinertsen, 1991; Wheelwright & Clark, 1992a; Allen, 1993). Along with the research process, these assumptions are complemented by previous research of aspects specific to product development and highlighted during the 1980s and 1990s. Aspects like success factors (Balachandra & Friar, 1997; Cooper, 1994), customer collaboration (Neale &

Corindale, 1998; Magrath & Hardy, 1994), suppliers (Ragatz *et al*. 1997; Bruce *et al*., 1995) and networking (Håkansson, 1990) have been found to be crucial in product development work.

Product development in the manufacturing industry has been researched for several decades, though product development in the Process Industry is an area of limited knowledge and research. To understand product development in the Process Industry, a comparison between product development in the manufacturing industry (theoretical investigation) and steel and paper industry (empirical investigation) was conducted and indicated what aspects needed to be further investigated in the Process Industry. From these investigations, the special character of the Process Industry could be added to the theoretical field of organization and management of product development. This approach can be described as abductive. Abduction is generally a combination of induction and deduction, but adds the element of prior understanding (Alvesson & Sköldberg, 1994). To summarize, the research process has been an interaction of theories concerning product development and empirical work of a relative unexplored area, i.e. product development in the Process Industry. Theoretical areas concerning product development were then modified according to the characteristics of the Process Industry (*see Paper VI*).

2.2 Research design

Product development in the Process Industry is rather complex and, as previously noted, an area that needs to be further researched. However, research about product development in general is extensive. Therefore, the starting point of this research was to review existing theories about new product development. The result of the review was thereafter compared with case studies of how companies in the Swedish steel and paper industry organize and manage their product development work. This comparison lead to a general survey of some aspects related to product development for companies in the Swedish Process Industry and some of the changes that had occurred during the 90s, and a subsequent attempt to make additions to existing product development theory, i.e. include how Process Industry can adopt a more product-oriented view in its development work.

According to Yin (2003), the first and most important condition in differentiating among the various research strategies is to identify the type of research question being asked. This is one of the most important steps to be taken in a research study. The first research questions investigated here and presented in the pre-study (in Chapter 3) had an exploratory character, i.e. “how questions” are being asked about product development work. Yin (2003) states that a case study has a distinct advantage when “how” or “why” questions are being asked about contemporary set of

events, over which the investigator has little or no control. Since the first part of the research (the pre-study) was a kind of a "pioneer" study, focused on a "how" question about contemporary set of events, and addresses a little researched process, the case study was chosen as the most appropriate research strategy. Further, since I explored events like how information and communication flows in product development projects in the pre-study, I used a qualitative approach, i.e. any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification. Moreover, qualitative research is an analytic procedure that results in findings derived from data gathered by a variety of means, not only including observations and interviews but also secondary data such as documents, tapes, etc. (Miles & Huberman, 1994). The interview guide for the pre-study is presented in *Appendix A*.

The second part of the research process, the survey, was a mix of both quantitative and qualitative approaches, focusing more on the quantitative. The main purpose was to investigate the similarities and differences between process industries as well as view general trends and consequences of a changed focus in development work towards a more product-focused development. The character of the questions was still "how", but also "what". Some areas of interest were

- the content of development work,
- the organization of development work on both management and project levels,
- changes during the 90s concerning development work, and
- future needs concerning development work.

The interview guide for the survey is presented in *Appendix C*. The above areas of interest led to an understanding of product development in the Process Industry and how theories concerning product development can be adjusted to fit this industry. Figure 2 shows a summary of the research design with the different phases, i.e. literature reviews, cases and survey. They will be further discussed in the following sections.

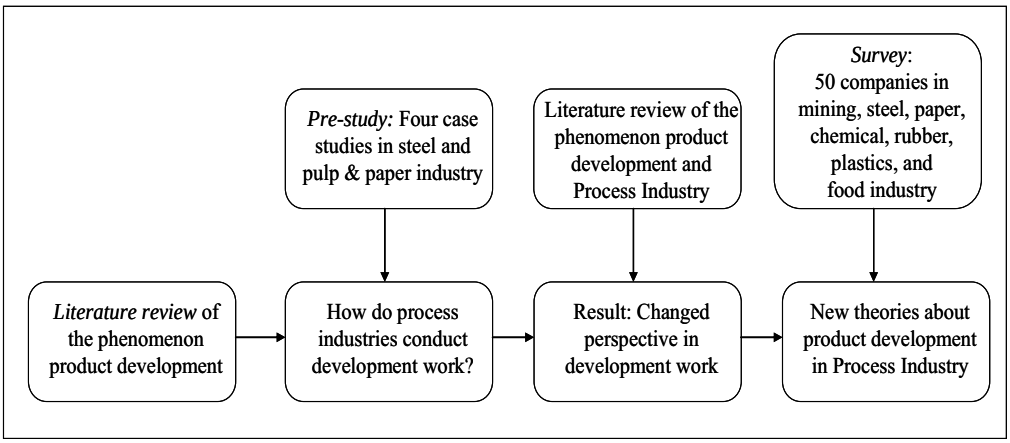

Figure 2. The research design.

2.3 The unit of analysis and data collection

As stated by Galtung (1968, p.9), "social science data are obtained when a social scientist records facts about some section of social reality, or has facts recorded for him". But what is data in social science? Galtung means that the structure of data has three parts - a unit of analysis, the dimensions or variables and the value of the units on the variables studied (i.e. the responses or outcome). The following sections will discuss the chosen units of analysis, the variables and the data collection methods in both parts of the research.

2.3.1 The Cases

The focus of the pre-study, the first part, concerned the members of product development teams in companies in the steel and paper industries and more specifically, how information is exchanged and how communication is handled concerning product development activities. The main purpose here was to investigate the frequent studied phenomenon "product development" in a context other than products with high value-added, i.e. products like steel bars and printing paper. A secondary purpose was to investigate if product development played a major role for companies manufacturing these products, while the problem in focus concerned an orientation change in product development projects in the steel and paper industries. These industries have traditionally had a production-oriented view on product development, i.e. product development has mainly been the result of process development. However, this thesis argues that in product development projects this production-oriented view is changing towards a more customer-oriented view.

The pre-study, with a focus on product development projects in the steel and paper industries in Sweden, was based on four cases. The main unit of analysis was product development projects and their team members, while the main data collection was from project members who were actively involved in the product development process. The decision to compare the steel and paper industries and other manufacturing industries was solely based on "product development" research literature.

The research design was mainly exploratory with a case study approach consisting of four companies. The selection criterion for these companies was that they should represent the desired type of industry, i.e. Process Industry. Two pulp and paper companies and two steel products companies agreed to participate. The cases were completely retrospective because another selection criterion of the companies was that the product development projects studied at each company had to all be completed. The final outcomes of the product development projects were known and to minimize bias, several actors involved in the same project were interviewed. The interviews at each company were based on discussions of a specific product development project involving certain issues.

Preliminary discussions to prepare the empirical research were initiated mid-1997. Interviews were then carried out with representatives of each company. All interviews were conducted between September 1997 and December 1997, with a total of 21 respondents being interviewed, including managers and project members with varied backgrounds (marketing, technical, production and engineering). The main professions were marketing managers, product managers, production managers, technical managers and production engineers. The interviews were semi-structured with a guide as a checklist focusing on specific issues, e.g. cooperation, integration, information and communication *(see Appendix A)*. The purpose of this checklist was to ensure the inclusion of the issues related to the research questions. Each interview lasted approximately two hours and the data were gathered from different levels and functions within the companies. Table 1 shows some descriptive data of the four companies.

Table 1. Data about the companies.

Cases	Number of employees	Product/material properties	Raw material	Dispersed PD-members	Number of interviews
Company A	390	Building material/ mechanical strength	Steel plates	Yes	7
Company B	380	Rail bars/ mechanical strength	Raw steel	Yes	4
Company C	300	Pulp & paper/ mechanical and tensile strength	Wood fibers/pulp	No	5
Company D	350	Pulp & paper/ mechanical and tensile strength	Wood fibers/pulp	No	5

To gain a wider perspective, the steel and paper industries were analyzed utilizing secondary data as well. Annual reports and industry-specific magazines provided the underlying industry-specific information needed for the research, e.g. the characteristics of the steel and paper industries.

All interviews were subscribed and incorporated into the software technique 'Non-numerical Unstructured Data Indexing Searching and Theorizing' (version N4), a computer package designed to aid users in handling non-numerical and unstructured data in qualitative analysis. The texts were then coded with nodes and organized into a “tree” structure, thereby enabling a thorough analysis of the material *(see Appendix B).* The coding of the material was based on areas of interest emerging from existing theories of product development, i.e. issues discussed in the selected literature.

The written material was coded by subjects in following three steps. The material was divided into two main groups, namely paper and steel industries, followed by a coarse coding with five main subject groups, and finally decomposing the coarse codes into more detailed codes. The coarse coding concerned these subgroups:

- general information about the company
- the product development project; the PD-process, cooperation
- communication; problems, means of communication
- information; sources, means of information retrieval
- time allocated for education and learning of other functional areas

These five coding areas exist to distinguish the main information concerning how product development projects are managed and organized in the steel and paper industries. One part of the material was independently analyzed by another researcher, enabling a comparison of the coding. The two independent codings

showed no major deviation, and the main material was coded in accordance with each other.

The cases were limited to the steel and paper industries and to one product development project at each company. Further, all interviews took place on one occasion, i.e. the respondents were interviewed only once without any follow-up interviews. A third limitation is the lack of any industry-specific generalization of the cases. The conclusions of the material did not include the entire steel and paper industries, but just the four companies. However, the empirical material indicated a possible trend in the steel and paper industries, i.e. the industry is headed towards a more customer-oriented perspective in their product development project. However, a more extensive research to permit industry-specific conclusions of the material was needed. This led to step two of the research, a survey of how companies in the Process Industry view their development work.

2.3.2 The Survey

The second study, the survey, focused on "development projects" in various process industries, since product development often combines both product and process development. As in part one, the companies were selected on the criteria that they should be part of the "traditional" Process Industry, i.e. produce a product with the possibly to be further value-added in the next stage of the value-chain (e.g. by customers in their production process), and they conduct some type of development work, i.e. they have a development department operating in product development, process development, or a combination of both. Since development work in the Process Industry can combine both product and process development and the balance between product and process development may differ, the author wished to investigate the content of development work, the organization and management of development projects, changes concerning development work during the 1990s and any future needs in development work, e.g. referring to collaboration with suppliers/customers, required knowledge/competences in development work, etc.

The cases in the pre-study indicated a trend towards a more customer-oriented perspective in product development work, but to verify *what* has changed and *how*, the research was complemented with a survey. The purpose was to gain more general empirical knowledge about the implications of a changed development focus (towards a more product focus) in the Process Industry with the aim to include as many existing Swedish process industries as possible. The following section presents the general characteristics of the industries included in the research, i.e. mining, steel & metal, pulp & paper, chemicals, rubber, plastics, and food & dairy industry.

Mining companies can be engaged in the mining, processing and selling of metals and minerals, like zinc, copper and gold. Process development is important in this type of industry because of their products with low functional content.

The Swedish steel industry focuses largely on special purpose products requiring very high quality, while its continuing competitiveness entails substantial investment in research and development. Stainless tool and high speed steels represent important types of Swedish specialty steels. Besides manufacturing steel in the form of sheet, strip, wire, etc., specialty steel mills carry out extensive production of fabricated goods.

Today's paper industry products can be complex, e.g. a package consisting of more than just paperboard; its construction is glued together, where information is printed, and perhaps containing a plastic or metal foil barrier. The paperboard must possibly be able to let some amount of air through the package or it must be airtight, requiring a specific know-how. Knowing how different parts of the package influence each other and eventually how consumers perceive the contents of the packaging is vital.

The chemical industry includes products such as liquid and powder coatings for industrial application, paints and adhesives, surfactants, chemicals and systems for environment compatible pulp bleaching processes and chemicals and systems for papermaking. Within the rubber industry, industrial know-how and state-of-the art polymer technology is of importance, where one are of development might be compression-moulded products in polymer material. Customers can be within the automotive, engineering, chemicals, building and construction industries. Development areas in plastics might concern injection-moulded items such as customer-specific tasks involving thermosetting plastics and thermoplastics - from idea stage to finished product.

The trend in the food and dairy industry is towards more sophisticated products. Today's development work requires other competences, e.g. behavioural science about how a customer thinks and acts, providing a better understanding of why a customer chooses a specific product. A product today can comprise aspects other than just the physical content, i.e. a product can involve aspects such as packaging, convenience, etc.

However, due to the scarcity of available companies in selected industries, the total number of companies was quite low. The sample of companies was taken from industry lists identifying those companies active in the industries mentioned above. Representatives of Swedish branch organizations also suggested existing companies. The purpose of this part was to investigate more deeply if a trend towards a more customer-oriented perspective in product development work existed

and what implications a changed development focus (towards a more product focus) had for companies in the Swedish Process Industry. This change will have implications on how to organize and manage development work. A total of 50 companies from various industries participated in the research, i.e. mining (ore), steel, pulp & paper, chemical, rubber, plastics, and food & dairy.

Because one interest of the research was to investigate if the focus within product or process development had changed during the 1990s, the main selection criterion of the companies in the study was that they must have a development department where they either conducted product development, process development or a combination of both. Companies were initially contacted by telephone to ensure that they had development departments involved in development projects, to identify the key respondents and to solicit cooperation. Of 55 companies, 50 agreed to participate in the research, with one respondent at each company. To ensure reasonable data reliability, the respondents received after the interviews a copy of their answers to the questions where they could make alterations, etc. Since the purpose of the study was to investigate current development work, changes during the 90s, and any future needs to development projects, the respondents were required to have deep insights in development work. Therefore, most respondents were R&D managers, while in smaller companies some were project leaders or members of product development projects. Table 2 gives the distribution of the companies in each branch sector and their size. The companies are divided into three groups, i.e. small, medium and large, depending on the number of employees; *see Table 2*.

Table 2. Number of companies in sample by Type of Industry, Size, and Product

Type of Industry	**Size of the company**			**Type of product**		
	Small (25 ≤ no. employees < 100)	**Medium** (100 ≤ no. employees < 500)	**Large** (no. employees ≥ 500)	**High-volume**	**Niche**	**Mixed**
Ore	0	0	2	2	0	0
Steel	0	1	8	1	4	4
Paper	0	0	7	2	2	3
Chemicals	6	6	3	5	5	5
Rubber	1	2	3	0	5	1
Plastics	2	2	0	0	4	0
Food/Dairy	0	1	6	0	1	6
Total	**9**	**12**	**29**	**10**	**21**	**19**

The survey also compared the strategies of the 50 companies (i.e. the Groups' strategies) from the 7 process-based industries over a 15-year period (based on an

analysis of annual reports from 1985 and 2000), i.e. the analysis was based on if the companies had changed their strategic development work statement (i.e. what was regarded as important in each year and what was the main focus). Key terms like product development, higher margins, value-added products, and customer need were searched for in the strategy statements. A changed strategy was indicated if the company emphasized some of these key terms in 2000, but not in 1985. Annual reports are one source of documentary data for longitudinal studies that many companies produce at the same time of the year, and are readily available. They have been used in past research to assess and explain corporate strategies, to identify key areas of competition and to explore causal reasoning within firms (Huff & Huff, 2000). Further, annual reports are a company's most important strategic communication document and lay out the positioning groundwork to explain where the organization is going over the next few years (Goldstein, 2001). However, financial statements do have their limitations, the most serious is that they are based on forecasts, estimates and assumptions (Bandler, 1994).

Data was gathered from structured telephone interviews with open-ended questions (*see Appendix C)*. Each interview lasted between 30 and 90 minutes and took place from October 2000 to December 2000. There was one interview per company in the survey. The interviews enabled a rich understanding of each company's current development work that could be used to explain certain phenomenon. The majority of the interviews were recorded and typed and all interview materials were coded with the software technique called 'Non-numerical Unstructured Data Indexing Searching and Theorizing' (version N5). The texts were first coded with nodes and organized in a "tree" structure (*see Appendix D*), enabling thorough qualitative analyses of the material concerning, e.g. future development needs. Here, the interview material was initially categorised into different nodes consisting of specific subjects by using Text Search on specific words/concepts. All documents and coded texts containing a specific discussion on a specific theme were scanned. One main node consists of the following sub-nodes: general information about the industries and the companies in each industry, development work for specific companies, how they organize it, how they view changes to it, and what type of information is needed for it. Another main node consists of the company's position in the value chain and its collaboration with suppliers and customers, and the need of information from the value chain. Some sub-nodes have been created due to some interesting themes from the respondents (e.g. the label "Facilitator", emanating from the company's development work being viewed as facilitating customers' product development work). This analysis was then used to explain what has changed in the companies and how.

After the software technique coded the material, the material was tested in SPSS 11.0 (Statistical Package for the Social Sciences) to gain a more general picture of some development work aspects, such as the product type, development focus (product, process focus or a mix), change of focus during the 90s, etc., *see Paper 2-5*. Some of the techniques used in SPSS were cross-tabulation, chi-square tests, cluster analysis and factor analysis. These analyses were used to obtain a more general view of what aspects concerning development work have changed for Swedish process industries and to determine a specific pattern.

2.4 Reflections on the research process

When analyzing the quality of a research, it is commonly discussed in relation to the concepts of generalisability, validity and reliability (Galtung, 1969). Hence, can the research be generalised and rendered trustworthy? Yin (2003, p.98-99) underlines the importance of data triangulation and discusses four types of triangulation in doing evaluations of the data. They are

1. data triangulation (the use of a variety of data sources),
2. investigator triangulation (the use of several different researchers or evaluators),
3. theory triangulation (the use of multiple perspectives),
4. methodological triangulation (the use of several methods).

Information was collected from multiple sources with the aim to investigate development work in the Process Industry (with a focus on product development). These sources were respondents with experience from product and process development work as well as written reports of various types (company material and annual reports). Theories with different perspectives on the same phenomenon have also been integrated, i.e. literature review concerning Management of Technology (MoT), product development from mainly the Manufacturing Industry and Process Industry, and literature related to Supply Chain Management (SCM). The use of two different data collection methods (both cases and a survey) made it possible to enrich the empirical results and explore the research problem more comprehensively. In the pre-study, how process industries (steel and paper) conduct their development work using four cases was first explored, i.e. with a qualitative approach. A survey to incorporate other industries was then conducted with the purpose to investigate any similarities and differences in organizing and managing development projects today as well as future needs in some areas concerning development work, i.e. a more quantitative approach.

Theories concerning product development in manufacturing industries comprised the underlying basis of the research area. Further, the use of interviews in

both the cases and the survey (altogether 71 interviews) gave in-depth knowledge of how development work in process industries is conducted; this was considered important since not much research is done regarding organizing product development work in process industries. Table 3 shows the composition of the two research studies. Of note, the survey has both a qualitative and a quantitative approach, but since the purpose was to obtain a more general view of how process industries conduct development work the focus is on the quantitative analyses.

Table 3. The composition of the two studies.

Study characteristics	**Case**	**Survey**
Time of study	1997	2000
Character of study	Qualitative	Quantitative
No. of companies participating	4	50
Type of industry	Steel, pulp & paper	Mining, steel, paper, rubber, plastic, chemical, dairy
Number of respondents	21	50
No. of employees in average	300-400	50-1000
Unit of analysis	Product development team	Development project

The main data collection was achieved by personal or telephone interviews. Personal interviews can be more difficult than telephone interviews to discuss more detailed product development. However, since the purpose of the survey was to discuss how each company conducts product development in general and not to elaborate on specific product development projects, telephone interviews were judged to be appropriate.

3. PRODUCT DEVELOPMENT IN THE STEEL AND PAPER INDUSTRY – A PRE-STUDY

The research presented in this thesis is based on a pre-study and a survey. The pre-study is documented in a licentiate thesis (Chronéer, 1999), but to understand the underlying basis of the following investigation, this chapter briefly summarises the theoretical base and the main findings of the pre-study. The major question in the pre-study was to investigate how steel and paper industries organize and manage their product development projects while focusing on information and communication flows during the product development process. The pre-study was based on four cases (two companies in each of the steel and paper industries) and the main data collection was conducted from project members actively involved in the product development process; the following research questions were addressed.

> 1) How are product development projects managed and organized in the steel and pulp & paper industries (compared to companies within the manufacturing industry)?
>
> 2) Is there a trend towards a more customer-oriented view within the steel and pulp & paper industries?
>
> 3) How can integration mechanisms be adjusted to fit a customer-oriented perspective in product development for the steel and pulp & paper industries?

3.1 The theoretical base of the pre-study

The pre-study focused mainly on theories about organizing and managing product development projects, and the methods and techniques used to communicate and inform into product development projects.

The literature review showed that many markets and industries have become increasingly international. Product development has felt pressure in the areas of tighter cost targets, reduced development cycle times, increasing speed of technological obsolescence, faster changes in customer demands and the need for improved product quality. As a result of these changes there has been an increasing emphasis on the importance of developing new products faster. This has lead to a new way of organizing product development projects, i.e. New Product Development (NPD) (Hart & Baker, 1996; Doz, 1996; Jones, 1997), meaning that the rules of the game in new product development are changing due to the emphasis on speed and flexibility when developing new products today (Takeuchi & Nonaka, 1986).

The review also demonstrated the product development process to be one of the most widely studied activities in a company. Most studies focus on a particular aspect of the product development process, e.g. collaboration (Bruce *et al.,* 1995; Song *et al.*, 1997), improved communication (Allen, 1986), design of manufacture (Miles & Swift, 1998), or time to market (Brooks & Scofield, 1995). Further, to reduce the time between conceiving and launching new products, an internal collaboration should exist between functional areas like R&D, product design, manufacturing and marketing throughout the new product development process (Song *et al.*, 1996). This will improve their cross-functional communication and understanding of customers needs so that they can design, produce and market products that provide value for the customers efficiently, while indirectly lead to more successful outcomes of new product development projects.

The pre-study showed that numerous normative models of the product development process exist (Wheelwright & Clark 1992a; Hart & Baker, 1996; Rochford & Rudelius, 1997). But a common weakness of normative models is that as general representations, they do not consider industry-specific conditions. New Product Development (NPD) is often stated as a requirement in today's manufacturing industry, while being context dependent. Trott (1998) points out that the process management depends on the type of product being developed. A way of looking at this is to divide the wide range of activities involved in the development of a new product into technical and marketing activities.

As argued above, the organization of product development involves the interaction of members from various areas ranging from internal functions within an organization to external members such as customers. Communication and information exchange will, therefore, play a major role in product development projects. Communication is identified as a critical integrative facilitator in a product development project (Seregelyi & Kohut, 1992). However, the frequency of communication is not as important as its quality (Griffin & Hauser, 1992). Project members need the right integration mechanisms to collaborate, both internally between functional areas and externally to suppliers and customers. However, unless mechanisms are put in place to modify the information flow and thereby allowing it to be transferred and available when downstream teams start their work, nothing changes operationally, i.e. the downstream activity cannot commence (Griffin & Hauser, 1996). An effective product development organization needs information from a complex web of sources, including customers, suppliers, sales, marketing and company management. Within the product development organization, information must flow into and among numerous teams.

Integration is a key word when discussing information and communication in product development projects. Both internal and external integration are needed to

facilitate the exchange of information and communication between functions and to lead product users. The integration of various functions in product development projects implies the inclusion of new information sources, e.g. literature, vendors, customers, technical staff, company research, personal experience, experimentation (Allen, 1985). The information flow in a product development process is like a network with different actors, i.e. it includes all information from the market to the sales. For this flow to work in various projects (small/big), different integrating mechanisms need to be chosen. Galbraith and Kazanjian (1986) discuss some integration mechanisms that may be used to facilitate internal integration, ranging from common goals and procedures to lateral linkages (e.g. direct contact, liaison roles and integrator roles). A formalized system of procedural interaction has been shown to positively impact information exchange (Song *et al.*, 1996).

Another interesting aspect in the pre-study concerned the various methods and techniques available today that enable the creation of communicative links in product development projects, e.g. facilitating the collection, selection, evaluation, and storage of information concerning product development. Distributed engineering is one field where information and communication tools have been developed and are of great use. Using the right communicative links in product development projects can enhance the integrative environment for project members and thus facilitate the information exchange (Travica, 1995). Today, various aids to facilitate and enhance the quality of communication are available, e.g. Computer-Aided Design (CAD) and information technologies (IT). Much communication among project members concerns information exchange, with information conversion usually being a very complicated process. The solution to various problems requires information of different types, contents and ranges. The choice of information system should be based on the type of network it is suppose to create.

The introduction of different technologies has made it possible to collect, analyze, store and supply information faster and more efficiently. According to Pahl and Beitz (1988), research evidence shows technical developments to greatly depend on the efficiency and range of its information system. Today, there exist a number of methods and techniques to facilitate cooperation between project members, functions, and to the customers. Structured methodologies such as quality function deployment [1](QFD) and design for manufacturability (DFM) have been

[1] QFD (Quality Function Deployment) is a technique to enhance communication between functions. QFD was developed in 1972 at Mitsubishi's shipyard and is today used in some companies to encourage more communication with members of the organization external to the development team. Its relationship matrix translates customer needs, the language of marketing into more technical terms.

developed to deal with the challenge of solving detailed problems that cut across traditional disciplines, departments and functions. The computer has the potential to change the performance of product development. CAD (Computer-Aided Design) and other problem-solving techniques can aid in solving detailed problems. Systems that facilitate communication and store information in large-scale databases are often provided for product development. However, they are not fully utilised by product development teams. QFD is found to increase team communication on all non-administrative aspects of new product development (i.e. information type as planning, design, customer needs and market information). However, QFD can decrease communication outside the team (Griffin and Hauser, 1992).

Finally, the pre-study also discussed a company's decision to choose a certain strategy or perspective in product development issues. According to Galbraith and Kazanjian (1986), a company and its management are formed by the tradition and values of the industry they belong to. It all depends on their position in the supply value chain; *see Figure 3*. The companies' values, their management systems, and their organization are all shaped by "the stage of initial success" (Galbraith and Kazanjian, 1986). The company has established an anchor, or a centre of gravity, by starting operations in a particular industry at a particular stage of that industry, considered important because each stage of any industry has different success factors. Strategic changes will then take place through moves in and around this centre of gravity.

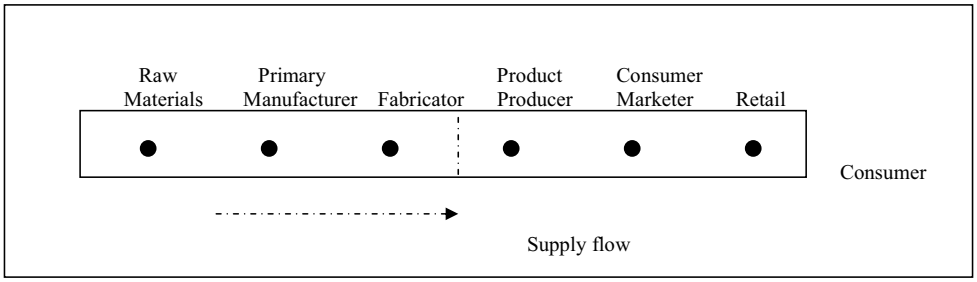

Figure 3. A value-added supply chain in a manufacturing industry *(source: Gailbraith & Kazanjian, 1986).* The dashed line splitting the chain into two segments divides the industry into upstream and downstream.

Companies in the steel and paper industries are typical primary manufacturers or fabricators. Their gravity of centre will therefore be located between stages two and three. They are also typical upstream companies with a focus on their technological know-how.

3.2 Results of the pre-study

The literature review revealed few researches attempting to describe the product development process for the steel and paper industry. However, in the steel and paper industries, the pre-study shows how the product development process can be visualized as a three-phase model, where each phase is a sum of a set of several more specific activity stages, i.e. conceptualization, investment and start-up, *see Figure 4*.

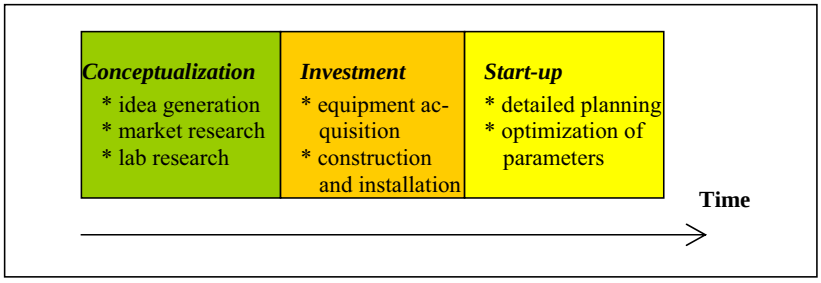

Figure 4. Product development process in steel and paper industries *(source: Chronéer, 1999)*.

The process begins with a *conceptualization* phase, where paper or steel companies initiate the exploration and idea formation with a particular new product in mind. The product ideas often come from product development (i.e. technical service) and rarely from marketing. This phase contains idea generation, market research (analyses of customers, markets, technical issues) and pre-planning. Laboratory research of material properties is also conducted in this phase. Before the next phase begins, decisions at several managerial levels have to be carried out, though this phase is not well structured and there is normally no formal project plan.

If management approves the conceptualization phase and if there is a need for investments in process technology, the second phase named *investment* starts. This phase comprises the implementation decision, equipment acquisition, construction and installation, test runs, test marketing and feasibility demonstration, and initial quality development. It is more structured than the previous phase with time schedules, resource allocations etc. In the steel and paper industries, it is formally named an investment project. Product development projects become more formalized and more structured upon entering the investment phase. The project becomes well structured when it includes a decision to invest in the production process.

The third phase is called *start-up*, i.e. initiation of the production tests. This phase contains a more detailed planning of product development, optimization of several parameters in the process and market introduction. The product's material

properties are established and the product can be tested at the customer's own workshop.

For steel products, the product development process differs slightly from the description above, and if the development concerns new metallurgical properties or the appearance of the product, e.g. plates, rounds bars, bulb flats or rails. Development of new metallurgical properties in material involves a much more time-consuming process with metallurgical departments (it can take 20 years). After the establishment of the metallurgical property, the project focus will swift from researching the new steel property to marketing it.

The first question to investigate in the pre-study was how product development projects are managed and organized in the steel and paper industries. Traditional development projects in the steel and paper industries mainly focus on the production process, and a close cooperation with equipment suppliers. This means that product development relied more on using the company's resources and skills to develop and manufacture improved and competitively priced versions of the product in large volumes. Process engineers mainly performed development projects. The role of R&D in these projects was therefore as a support function that performed basic research on technological issues and material properties. However, the constellation of teams was about to change. The study showed teams starting to consist of members from different functions, i.e. development, marketing and production. They were also formally named cross-functional teams in the companies. However, different functions were active in various phases of the product development process. The main responsibility related to the development department, operating with both process and product development.

As per the first question, the results showed emerging product development teams in steel and paper companies to be formally organized as cross-functional teams, where all aspects were supposed to be integrated in the product development process. No major difference was perceived when compared to how the Manufacturing Industry organized its product development projects. Members from marketing, production and technique/development met regularly to check certain issues about the products (development, introduction, etc.). However, the core of the product development team consisted mainly of technicians, such as process engineers, technical support or members from the technical department (could be named development), who participated in all phases of the product development process. Further, the function of marketing was most active at the end of the product development process. However, if management emphasised the need for major market research, then marketing was also active at the beginning of the product development process.

The second question involved a more customer-oriented view within the steel and paper industries, where customers had begun to demand more value-added products. This change of demand had led to an increased interest for product development work in the studied companies. An indicator of the increased interest was the formation of special product development teams with informal links to their customers. But how did product development members collect and spread information considered useful to their project? Although not systematically spread through formalized integration mechanisms, much information was stored in various reports.

The third question concerned how integration mechanisms could be adjusted to fit a customer-oriented perspective in product development for the steel and paper industries. Product development members were aware of the importance of creating links to their customers. Collecting information from them and using it in product development projects was desired. They were also required to visit customers at their own workshops so as to to demonstrate the benefits of the product, the product's material properties. These visits were documented in reports. However, in general, the information exchange between the product development team and their customers was mainly informal. In reality, product development members were "mentally" working with a customer-oriented view in projects, though the product development team's environment was still very traditional. Missing were the integration mechanisms to a more customer-oriented view in product development projects, i.e. mechanisms that could facilitate a more formal and systematic method to exchange information with customers. They had not been adjusted to fit the new perspective, i.e. the main traditional working procedures had not been changed. No formal guidelines on working procedures consider the customer-oriented perspective in product development projects, and a forum for information sharing was missing. It was suggested to process industries, like steel and paper, to find suitable ways of structuring their information gathering and sharing and facilitate their future product development work. The result also indicated that market information processing was equally important in these studied industries and that the use of information could eventually play a significant role for product development. Therefore, to facilitate the communication and interaction between R&D and marketing, extra efforts were needed to review and renew the current organizational structure. The input and feedback from customers were obviously not satisfactory documented and spread within company groups and professional groups. Moreover, there was no systematic way to gather all the information about the views and problems of customers, and create ideas about future products.

The empirical findings of the pre-study strongly suggested that managers from the steel and paper industries should not only be concerned with the hard, technical topics underlying product development projects, but also devote more attention to the soft, market and market-related issues. This should be formally stated in the company's product development strategy. A means to facilitate cooperation and communication should be available and supported by management. However, the technical issues are not unimportant, though the findings indicate that more attention should be given to market-related activities.

To sum up, the pre-study indicated the companies in Process Industry to be heading towards a more customer-oriented view in product development projects. The role of customers and suppliers in product development projects has changed, influencing both the role of a product developer as well as the competence requirement in projects. Since paper and steel products are often raw materials for other products further down the chain and will eventually impact the properties of the end product, product developers must study the whole distribution chain. Successful product development requires a continuous and frequent use of customer concepts, i.e. to be familiarized with the market aspects, the customers' way of perceiving and understanding the products and its problems, etc. Hence, the first step is to identify who are the customers, especially those considered external. End users and the choices they make matter the most, i.e. an awareness of the buying customer's process and who the end users are. Various models for development cooperation can be used to increase awareness. If customers are important to a product development project, gathering, structuralizing and distributing their information is essential. Therefore, both sales personnel and various network partners are sources of valuable information to be formally used by product development members.

4. THE THEORETICAL CONTEXT OF PRODUCT DEVELOPMENT IN PROCESS INDUSTRY

This chapter presents the main literature review from where the research is based upon, beginning with an extensive review concerning product development in the Manufacturing Industry. Specifically, the areas of organization and management of product development along with communication and information flows between project team members were of interest, as briefly presented in chapter 3. Other theoretical areas concerning product development, e.g. collaboration and integration of customer and suppliers, have been of interest as my understanding of product development work in Process Industry increased. To understand product development in process industries, the theoretical framework was complemented with theories concerning Process Industry and Management of Technology.

4.1 Innovation and product development

Innovation is essential to an organization's survival, and the product development process considered as one of the most important ways to make the innovation task operational. Roberts (1988) emphasizes that innovation is composed of two parts: (1) the generation of an idea or invention, and (2) the conversion of that invention into a business or application. Innovation concerns products, services and production processes, but cannot be defined as a product or process innovation in absolute terms, i.e. the definition of an innovation as a process or product innovation is dependent on the specific company (Chiesa, 2001). Chiesa *et al.* (1996) view innovation as a set of processes, and identify four core processes:

- New product concept generation - the process bringing together technology and market needs to develop new product concepts;
- Technology acquisition - the development and management of technology per se, i.e. the process of acquiring the necessary technology for product and process innovation through internal R&D or other means or both;
- Product development - the process of bringing a new product concept through development and manufacturing to the market;
- Production process innovation - the process of innovating and developing new production processes.

Innovation uses knowledge to offer a new product or service that the customer wants, i.e. the process of invention to commercialization. This process cannot be separated from a company's strategic and competitive context (Afuah, 2003). The type of innovation, i.e. what is changed (product, process or service) and the per-

ceived extent of change (incremental, radical or transformation), will influence the management of the innovation process (Tidd *et al.*, 2001).

One process in innovation that has received much attention during the last three decades is how to conduct product development. Numerous studies and articles dedicated to this subject exist. Håkansson (1990) points out two interrelated factors to possibly explain this high level of interest for product development, viz. new products have been seen as the means to secure the future of the company, and the belief that everything is developing more quickly today, thereby shortening a product's life cycle. Hence, there is an increased need for the continual development of new products.

Sources of product development are often seen in the literature from three perspectives, i.e. initiated by the producer, the user, and product development as an interaction of them both (Håkansson, 1990). In the production perspective, the product concept has its origin in the production process and principally involves members of engineering and production. In the user perspective, marketing and users become more active in the process. Products are often complex when dealing with producer goods in particular, meaning that many different specialists from both production and users are involved in the business procedure. The purchasing and marketing of such products often therefore develop into an interaction process involving both parties (Håkansson, 1990). Further, product development can be used as a means of showing mutuality in the relationship with an important customer, i.e. used to secure the selling of established products, as well as finding new markets and strengthening established relationships, e.g. suppliers.

As previously noted in chapter 3, there has been an increasing emphasis on the importance of developing new products faster due to changes concerning product development, i.e. tighter cost targets, reduced development cycle times, faster changing customer demands and the need for improved product quality. This led to a new way of organizing product development projects, called New Product Development (Doz, 1996; Hart & Baker, 1996; Jones, 1997), and new rules of the game in new product development (Takeuchi & Nonaka, 1986; Cooper, 2001). Cooper (2001) uses the term "new product development process" in reference to a conceptual and operational model for moving new projects from idea to launch and beyond, implicating the processing of new products using a parallel approach (Takeuchi & Nonaka, 1986) instead of the traditional linear approach. In the alternative approach, the activities of the new product development process overlap rather than being performed sequentially. Therefore, the concept of New Product Development (NPD) is a new way to organize product development through cross-functional integration (Wheelwright & Clark, 1992b), including effective problem solving

(Brown, & Eisenhardt, 1995), and, e.g., product technology transference (Tatikonda & Stock, 2003).

What then is product development? As often stated in the literature, the main purpose of product development is the creation of new products (Smith & Reinertsen, 1991; Allen, 1993; Cooper, 2001). But what is a new product? Does it mean new to the customer, new to the company or a new area of application? Cooper (2001) identifies six different types or classes of new products:

- **New-to-the-world products** (the first of their kind, create new markets)
- **New product lines** (new products to the company, not new for the marketplace)
- **Additions to existing product lines** (fit into a company's existing product lines)
- **Improvements and revisions to existing products** (replacements of existing products in a company's product line)
- **Repositionings** (new applications for existing products)
- **Cost reductions** (new products designed to replace existing products at a lower cost)

These classes illustrate numerous ways to describe a product development process. Almost every company has its own description of the product development process. However, Cooper (2001) states that the best firms are more likely to include the following activities in their process: product-line planning, strategy development, concept generation and concept screening. Traditional models for product development have been mostly derived from observation in industries such as the automotive or appliance industries. The literature often describes product development in the manufacturing industry as a process that includes all activities to transform a product concept into a physical prototype (Wheelwright & Clark, 1992a).

What activities does product development include? An early model developed by Olsson (1976) describes a systematic approach of the integrated product development process (later modified by Andreasen & Hein, 1987). According to this model, *product development* is a creative and multifunctional process where there is an interaction between the phases within the product development process, i.e. the phases overlap each other. This is also visualized by, e.g., Wheelwright and Clark (1992a). The phases can be described as: Concept Development, Product Planning, Product/Process Engineering and Pilot Production/Ramp-Up. Further, in the product development process, R&D as a function is responsible to keep abreast

of the latest research within their industry, including both basic and applied research.

There are numerous ways to describe the product development process. Other researchers describe product development as the entire process from identification of a market opportunity to transformation into an available product for sale (Krishnan & Ulrich, 2001). Different views of product development may depend on the R&D strategy. Jones (1997) points out that an R&D strategy primarily addresses technological issues, while for manufacturers following either an offensive or defensive approach to product development the role of research and development is critical. According to Jones (1997), offensive product development is characterized by significant R&D activity in the development of new technology and new processes, thereby enabling manufacturers to be first to market with innovative new products. Defensive product development, however, relies less on developing an original idea of a product, and more on using the company's resources and skills to develop and manufacture improved and competitively priced versions of their product in large volumes.

As already shown, the process of new product development can be broken down into a number of stages and given different labels. The initial stage may be known as exploration or screening. The actual process of new product development contains a number of different stages with processes that are probably very similar in content; rather, it is how they have been named that appears somewhat arbitrary (Rudder *et al*., 2001). The activities in the product development process (PDP) and their efficient execution are important factors for new product success (Fairlie-Clark & Muller, 2003). To manage the process, it is important to identify which activities are present in a particular PDP and which should be present. How to manage the product development process is frequently discussed in academia and industry. Rudder *et al*. (2001) identify different theories and recognize very little consensus as to the correct way to manage the process of product development, since there is little consensus as to what actually constitutes a "new product". Many product manufacturing companies have developed their own models, with some being very comprehensive (Fairlie-Clark and Muller, 2003).

In NPD, new products should be processed using a parallel approach (Takeuchi & Nonaka, 1986) instead of the traditional linear approach. In the parallel approach, the activities of a new product development process overlap rather than being performed sequentially. Another difference is that there should be internal collaboration between functional areas such as R&D, product design, manufacturing and marketing throughout the new product development process to reduce the time between conceiving and launching new products (Song *et al.*, 1996). This is because cross-functional communication and the understanding of customer needs

will be improved so that manufacturing and marketing can provide value to customers in a timely manner. Indirectly, it can lead to more successful outcomes of new product development projects. Further, the parallel and integrated approach to product development not only includes internal functions such as R&D, marketing and production, but possibly also suppliers and customers in the product development process. External collaboration can yield many advantages, such as reducing time to market, gaining access to new technologies and markets, attaining economies of scale and scope, and sharing the financial risks of investments in product development. Many companies already organise their activities to improve the cooperation and communication across their borders and enable them to interact with suppliers, customers and competitors in all phases of the new development process.

The literature also uses various concepts such as Simultaneous Engineering (SE), Concurrent Engineering (CE) and Integrated Product Development (IPD) to describe different approaches of product development (Andreasen & Hein, 1987; Ulrich & Eppinger, 1995). CE principles have been widely adopted to replace the sequential ”over-the-wall” processes and shrink lead-times in hardware design. However, no well-accepted definition of this concept exists (Gerwin & Susman, 1996). The intention of CE tools is to increase the concurrency of multidisciplinary design by integrating various enabling technologies, such as computer-aided design, computer-aided manufacturing, communication networks, etc. However, because product development activities might be complexly coupled, overlapping interrelated activities can present many difficulties. Without careful management of the overlapping product development process, the development effort and cost may increase and the product quality may worsen. Krishnan *et al*. (1997) present a framework to help determine how to disaggregate design information and overlap consecutive stages of a development process based on the properties of the information exchanged between the industrial design and engineering design stages.

The internal and external cooperation and integration of a company is another aspect that is widely discussed in product development literature. Research shows that building bridges between functions and to suppliers and customers increases the likelihood of success for the company. These bridges can take the form of cross-functional teams with R&D, manufacturing and marketing integration (Fischer *et al*., 1997; Song *et al*., 1997; Song *et al*., 1998; Kahn, 2001; Olson *et al*., 2001) and R&D and marketing integration (Gupta, 1990; Griffin & Hauser, 1996; Song *et al*., 1996; Ottum & Moore, 1997). Other forms of collaboration are strategic partnerships (Magrath & Hardy, 1994; Littler & Levrick, 1995; Comer & Zirger, 1997) with suppliers (Hartley *et al*., 1997; Swink & Mabert, 2000; Petersen *et al*., 2003) and customers (Campbell & Cooper, 1999; Butscher & Larker, 2000; Gruner & Homburg, 2000; Kärkkäinen *et al*, 2001; Mello, 2001).

However, problems of organizing for effective new product development do exist (Sands, 1983). Sands (1983) focuses on the question of the "right" organization for new-product activities. What is best for one firm might not be best for the other. In actual practice, a range of new-product organizations can be found. Other researchers such as Cavone *et al*. (2000) explore how a certain managerial/organizational style relates to the type of R&D process (varies from industry to industry) and to the different nature of R&D activities. They also identify the key characteristics of the R&D organization and the strategic management of technology associated with each style. R&D organization and management are heavily affected by the nature of the R&D process and the relative importance of the different R&D activities. Differences depend on the efforts required to generate an innovation, the related risk, the role of R&D in a firm's strategy and how R&D can contribute to generate competitive advantages. To conclude, it can be argued that there is not one best way to organize an R&D activity and that practices cannot be transferred from other industries blindly.

To achieve cooperation and integration in the product development process, another aspect is essential, namely the use of techniques and tools. For instance, applying information technology to sales and marketing has meant tighter coordination between sub functions (Bondra & Davis, 1996). Further, understanding customers' wants and needs is closely connected with the disciplines of marketing and R&D. Information gathering and sharing and well-functioning communication links are often stated in the literature as success factors of product development projects (Griffin & Hauser, 1992, 1996; Moenaert *et al*., 1994; Fischer *et al*., 1997). Tidd and Bodley (2002) review the range of formal tools and techniques available to support the new product development process. The study identifies the potential mediating effect of project novelty on the process of new product development, and some of the dangers in adopting so-called 'best practice' methodologies without considering context or contingencies.

4.2 Product development in Process Industry

One major difference between Process and other Manufacturing Industries is that Process Industry has generally very inflexible and costly equipment. As well, the production process is often unique for the purpose of manufacturing a specific product and the manufactured products are often interdependent. Changes in the properties of the raw material affect the entire product group. Product development is mainly context-dependent and the management of its process depends on the type of product being developed (Trott, 1998). The following sections will there-

fore give some examples of product development in the mining, steel, paper & pulp, chemical and dairy industry.

The mining industry

Product development in the mining industry can consist of mineral extraction and producing high-quality metals in a cost-effective and environmentally friendly way. For example, the mining company can extract base and precious metals from concentrates of copper and lead as well as recycled materials. Achieving high quality is essential, since the smelter is an integrated metallurgical complex that extracts high-purity metals at low cost and with minimal environmental impact. Continuous process development also has to deal with new raw materials of complex compositions and to meet the market's needs for top-quality products (http://www.boliden.com).

Another example of product development in the mining industry is the development of pellet products with properties that can be mixed with sinter in blast furnaces. An example of a mining company is LKAB, who founded the experimental blast furnace considered an invaluable tool in the efforts of product development (Tottie & Lager, 1995). LKAB develops pellets for direct reduction mills with lower concentrations of impurities, higher metallization and good sticking properties, i.e. properties that provide better total economy for the customer and a smooth and stable process in a direct reduction furnace. Full-scale trials are conducted at the customers' plants (http://www.lkab.com). Here is the production process, i.e. the blast furnace the main customer, and the customer's demands on the product are difficult to interpret. It is important to develop large-scale, quality-assured mining and processing, automation and advanced process control.

The steel industry

Steel is one of the world's most widely used structural materials, able to meet many varying demands. Much development work focuses on products with a special market interest, such as polished, brushed and decorated surfaces, and work hardened high-strength stainless steels and grades with a special corrosion resistance (http://www.outokumpu.com). Both material properties and production techniques are of interest in the steel industry. The most important demands come from today's consumers. When buying products containing steel, they may have specific demands in areas such as cost, life expectancy, appearance, strength, weight or environment-friendly properties. Lighter products are one category of product development, since high-strength steels are stronger than ordinary steels, allowing the

customer to need less steel for a given task. Reduced material cost is another aspect in the development of high-strength steels. Even if high strength steel is slightly more expensive per kilogram, a lower material cost is still the aim. High-strength steels can also improve the reliability of production due to their more consistent material properties. Another aspect of developing high-strength steel is the extended useful life and improved durability of a product. As an example, products will be stronger and more shock resistant. Another part of product development is the offer of technical assistance and advice in the areas of process and production development (http://www.ssabtunnplat.com).

The paper industry

As an example, pine and birch can be the primary raw materials in packaging papers. However, depending on the type of tree and its pace of growth, the developed fibres will be different. For example, the harsh Scandinavian climate means coniferous trees that grow slowly and develop long fibres - the perfect raw material for strong paper (http://www.billerud.com). These fibres are then processed into pulp that is converted into packaging paper at a mill. The product development process consists of combining the raw material, technology and production processes and creating paper of high quality, e.g. advanced kraft paper, sack paper and raw material (liner and fluting) for containerboard. Further, packaging paper can be supplied to different types of converters who convert the paper into packaging for the industrial, agricultural, pharmaceutical and food sectors. Conversion often takes place in different stages, e.g. the paper is first printed, then coated with plastic or aluminium and finally folded and glued into a finished packaging. During conversion the paper must meet many requirements. It must be strong, clean, and hygienic and have an even surface that suits production in fast, modern machinery. Customers are manufacturers of, for example, carrier bags, cement sacks, sterile packaging for medicines, food packaging and containerboard boxes. The finished packaging is delivered to the company that fills it with a product (e.g. flour, sugar, bread or different kinds of chemicals). More comprehensive product development can be sack paper with excellent porosity (allowing air to pass through) with retained high strength. This provides better filling economy through a faster and cleaner filling process, and smaller, more compact sacks, which means lower paper consumption for the customer (http://www.billerud.com).

The chemical industry

The chemical industry is built on both product and process development, where a company's fortunes can still rise and fall with news of its latest research advances

and setbacks. But with customers increasingly demanding better products, lower process and more tailored services, the industry is changing its approach to innovation. Chemical companies have always been market focused, but that focus has not always played a leading role in product innovation. Now, industry leaders are committed to building market awareness into every stage of the product development process (Chronéer, 2001). Products consist of chemical solutions to customers needs, e.g. it can be based on the state-of-the-art know-how in nitrile technology. The chemical company can then supply the standard fatty amines used as the basic building blocks for derivation in the production of ethoxylates, amides, paint, ink, paper chemicals, adhesive polymer dispersants and cationic wax emulsions. Product development is a complex process of how to mix the raw material and know the outcome of the chemical process.

The dairy industry

Dairy industry can be characterized as one of the most market-driven industries of the process industries. Knowledge of consumer behaviour and preferences and product development in this industry is essential to be one step ahead of the customer's need for new products. Dairy products are all kinds like ice cream, yogurts and chilled deserts. Product development can be about microbiology and concern taste preferences. In this industry, product development consists of various techniques, including high-pressure treatment suitable for the production and chemical composition of a set of processed foods. The challenge is to maintain and develop a position as an innovative global supplier of added value, e.g. milk-based ingredients for leading food producers (Chronéer, 2001).

In the Process Industry, products are processed with minimal interruptions in any one production run or between production runs of products exhibiting process characteristics, such as liquids, fibres, powders and gases (Gunasekaran, 1998). The general characteristics of this industry add value to materials by mixing, separating, forming or chemical reactions. The Process Industry obtains their raw materials from mining, forest or agricultural industries. These raw materials vary naturally in quality with many products being produced from a few kinds of raw materials, compared to the usual schedule in discrete manufacturing where end items contains many different components (Gunasekaran, 1998). However, there has recently been a reawakening involving companies in the Process Industry cutting costs and repositioning themselves in the market place. Since technological developments are moving at an ever more rapid pace, product life cycles are becoming shorter (Ita & Gross, 1995).

4.3 A summary of my framework and complementary theories

This section will briefly summarise the main theoretical areas and some specific aspects considered essential for my research. Two main areas of the literature review, Product Development and Process Industry, are presented in the previous sections. Here, the theoretical framework is complemented with aspects concerning Management of Technology.

When I started my research of product development in the Process Industry, theories concerning product development were vital, *see previous section 4.1*. However, product development can also be viewed as belonging to the discipline known as Management of Technology (MoT) (or Technology Management), since product development incorporates product and production technologies. As my understanding of product development in the Process Industry increased, I realized the complexity of handling the inter-linked processes of product and process development. Further, product development may also be market-orientated or production-orientated. A production-oriented perspective on product development primarily involves an interest in the technological solutions of the production process. Developing this process and equipment is often a link in an optimization of the production process, i.e. finding a more cost-effective process. Product development will then be a secondary result of changes to the production process, i.e. product development is defensive (Utterback, 1996). According to Utterback (1996), a project team will then consist mainly of internal personnel, such as process engineers and laboratory personnel. External cooperation will mainly occur with equipment suppliers. R&D is a support function that can serve the development team with research on specific topics, such as metallurgical properties.

Understanding product development in the Process Industry implied a need for a wider view of the process of developing new products and understanding the innovation process. Hence, my frame of reference has then been complemented with theories concerning MoT, i.e. to view product development in a larger context and system and to understand the development of the discipline MoT, thereby enabling a deep understanding of product development in the Process Industry and its complexity. To understand product development in a larger context, I found it essential to understand the discipline Management of Technology and the development of the discipline over the years. Chanaron *et al*. (2002), meaning that MoT can be clustered into two main research tracks, namely managing technology as an activity and managing technology as a resource. This is based on the assumption that technology and managerial functions are closely related, impacting on each other. Management of Technology is a concept that has expanded to incorporate issues other than just R&D management. Drejer (1996) shows us, from a historical perspective, the different approaches to Management of Technology, where the strategic MoT

seems to be the latest trend in the development of MoT. To illustrate this, he divides the field of MoT into four schools of thought: the R&D management school (with a start during the 1960s), the innovation management school, the technology planning school and, finally, the strategic MoT school (emerging during the 1980s). Since product development is one aspect in the entire innovation process and in MoT, understanding how the view of the innovation process has changed during the last five decades is essential. Rothwell (1994) also gives a historical perspective of the innovation process and introduces a fifth-generation innovation process. The 'fifth generation' innovation process is regarded as a 'system and integration networking model', as a multi-institutional networking process (strong linkages with leading-edge customers, strategic integration of primary suppliers). This perspective of the innovation process, with product development being one activity, implies a need for a wider view of the process of developing new products.

Various aspects on product development were found essential during my research process. Some of the aspects concerning product development were investigated in the pre-study or were indicated in the pre-study that required further research. These aspects were mainly new product development, success factors, information technology, concurrent engineering, functional integration, cross-functional teams, communication, market-orientation, collaboration with suppliers and customers, and networking. Theories concerning a changed pattern of innovation were also added to the literature review to understand some of the innovative changes for the Process Industry.

Further, as my research progressed, I investigated similar aspects (as in product development) linked to the Process Industry. A review of theories concerning product development in the specific Process Industry showed only minor research attempts. However, Table 4 reveals some interesting factors found in the literature concerning the Process Industry, i.e. new product development, determinants of innovation, product-process interaction, technological innovation, techniques and tools, customer integration, supplier collaboration, market-orientation, and networking.

As stated previously, to understand product development in the Process Industry I found it essential to include some aspects concerning Management of Technology, e.g. the concept of MoT, technology development/innovation, supplier collaboration, networking, technological competence, and changing pattern/approaches in the area of MoT. Table 4 provides a brief overview of the main focused areas of my literature review, i.e. literature on Product Development, Process Industry, and Management of Technology. I also included a fourth area in my literature review: Organization – general issues. The articles in this area were central to increasing my understanding of the integration of different disciplines, in-

formation technology, the view of the value chain and the view of strategy. Since these articles did not specifically concern the other three areas of Product Development, Process Industry or Management of Technology, I created this fourth area, *see Figure 5*.

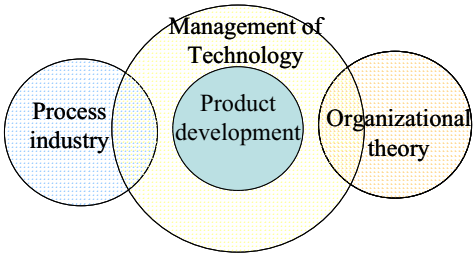

Figure 5. The four integrated parts of the literature review; theories on product development, Process Industry, and selected part of Management of Technology and Organizational theories.

Table 4. The literature review

Main areas	Factors of interest				
Product development	*New product development* Clark & Fujimoto (1991) Fujimoto *et al.* (1996) Hart & Baker (1996) Jones (1997) Sands (1983) Smith & Reinertsen (1991) Takeuchi & Nonaka (1986) Wheelwright & Clark (1992a) *Success factors* Allen (1993) Balachandra & Friar (1997) Bruce *et al.* (1995) Cooper (1994, 1999, 2001) Gruner & Homburg (2000) Ottum & Moore (1997)	*Information technology* Allen (1986) Bondra & Davis (1996) Boutellier *et al.* (1998) Court *et al.* (1997) Howe *et al.* (2000) Leenders & Wierenga (2002) *Concurrent engineering* Andreasen & Hein (1987) Gerwin & Susman (1996) Olsson (1976) Ulrich & Eppinger (1995) Pahl & Beitz (1988)	*Integration (function)* Carlsson (1991) Griffin & Hauser (1996) Gupta (1990) Moenaert *et al.*(1994) Olson *et al.* (2001) Sherman *et al.* (2000) Smulders *et al.* (2002) Song *et al.* (1996) *Cross-functional teams* Song *et al.* (1997) Song *et al.* (1998) *Communication* Fischer *et al.* (1997) Griffin & Hauser (1992) Van den Bulte & Moenaert (1998)	*Market-orientation* Kok *et al.* (2003) Kärkkäinen *et al.*(2001) Mello (2001) Slater & Narver (1998, 1999, 2000) *Networking* Biemans (1990) Harryson (1997) Håkansson (1990) Håkansson & Ford (2002) Pearce & Papanastassiou (1996)	*Supplier collaboration/ development* Comer & Zirger (1997) Handfield *et al.* (2000) Hartley *et al.*(1997) Petersen *et al.* (2003) Ragatz *et al.* (1997) Swink & Mabert (2000) Wynstra *et al.* (2001) *Customer collaboration* Tollin (2002) *Change of patterns* Galbraith (2002) Gupta & Wilemon (1996) Phillips *et al.* (1999) Shepherd & Ahmed (2000)

Table 4. The literature review *(cont.)*

Process Industry/ Process Technology	*New product development* Huang *et al.* (2002 Jokinen & Heinonen (1991) Rochford & Rudelius (1997) *Determinants of innovation* Gana (1992) Harmsen *et al.* (2000)	*Product-process interaction* Etienne (1981) Ettlie (1995) *Technological innovation* Freeman *et al.* (1963, 1968) Nyström (1990) Walsh & Lodorfos (2002) *Techniques and tools* Lee *et al.* (1996) Tottie & Lager (1995)	*Customer integration in PD* Heinonen (1994) Roberts (1999) *Supplier collaboration* Ferguson (2000) *Market-orientation* Strezo (1999) *Networking* Bower & Whittaker (1993) Hutcheson *et al.* (1995, 1996)	*Process industry in general* Gunnarsson (1998) Fritz (1997) Melander (1997) Rohweder (1993) Rydberg (1990) Sjöberg (1996)	*Change of patterns* Bower & Keogh (1996) Burgess *et al.* (2002) Ita & Gross (1995) Moen (1994) Nisser (1997) Närhi (1997) Rönnbäck (1992) Schriefer (1996) Teoh (1988) Tomiura (1997) Tottie (1997)
Management of Technology	*Concept of management of technology* Chanaron *et al.* (2002) Christensen (2002) Ford & Saren 1996) Khalil (2000) Lowe (1995)	*Technology development/ innovation* Drejer (2002) Sheasley (2000) *Innovation* Utterback (1996)	*Strategic management of supplier collaboration* Sobrero & Roberts (2002)	*Technological competence* Danneels (2002) *Networking* Möller & Halinen (1999) Rycroft & Kash (1999)	*Change of patterns/ Approaches* Drejer (1996) Edler *et al.* (2002) Germeraad (2001) Rothwell (1994)
Organization – general issues	*Integration of disciplines* Drejer *et al.* (2002) Tatikonda & Stock (2003)	*Information technology* Dewett & Jones (2001) Jarvenpaa & Ives (1994) Powell & Dent-Micallef (1997) Scott (2000)	*Value chain* Walters (1999)	*Strategy* Blankenburg Holm *et al.* (1999) Galbraith (1983)	

5. CHANGED PERSPECTIVE IN DEVELOPMENT WORK

This chapter will give a selective overview of the results from the six appended paper. The key areas of interests, methodology/analysis techniques, and the main conclusions are summarised. The following papers are included in this thesis:

1. Have process industries shifted their centre of gravity during the 90s? (Paper I).
2. Understanding changes in product development in Swedish process industries (Paper II).
3. Are some process industries more product-focused than others? (Paper III).
4. The impact of supply chain information and networking on product development in Swedish process industry (Paper IV).
5. A change in supply chain information in Swedish process industries and its consequence on a changed development focus (Paper V).
6. Effective product development process: Towards a conceptual framework for process industry (Paper VI).

The research focuses on some of the consequences of a changed perspective in development work for Swedish process industries (i.e. towards a more customer- and product-focused development). The main consequences of a changed perspective in development, indicated in *Paper I*, are related to the organization (e.g. team and project work), the pattern of collaboration (cross-functional and in networks) and the use of information (e.g. systematization and acquisition), *see Figure 6*.

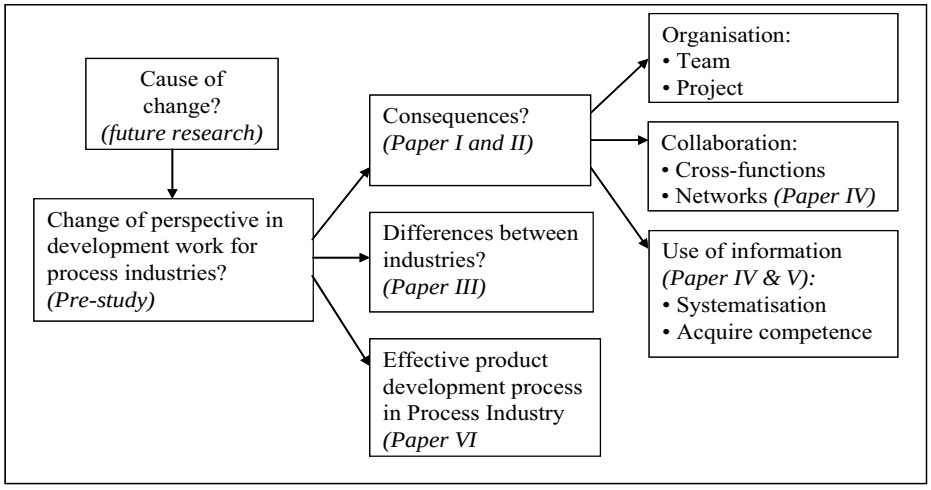

Figure 6. Some consequences of a changed perspective in development work for process industries.

The research shows the majority of the process industries in the study to indicate a more customer- and product-oriented strategy concerning development work. This means that Swedish Process Industry companies are striving to find their niche products and develop competitive advantages related to their products, not just within their production processes. Integrating different internal and external actors in the product development process is not easily achieved and requires some organizational changes and means. A change of perspective also requires the acquisition of new competences. One way to incorporate new competences and information is through collaboration with internal (e.g. between functions, within units) and external actors (e.g. with suppliers and customers). Therefore, analysing the changed information need in development work will be important. The research, based on the cases and the survey, resulted in six papers that are briefly summarised in the following sections.

5.1 Consequences of changed perspective - summary of papers I & II

What has happened to Swedish process industries during the 1990s concerning product development work? How do they manage the turbulent change from being process-oriented to being product-oriented in development work? Papers one and two emphasize some indications of a major change during the 90s in development focus for Swedish process industries in Sweden. Production parameters no longer dictate product development work. Today, product development incorporates an understanding of customer needs, and product development in process industries is more about managing upstream and downstream relationships.

5.1.1 Paper I

The first general findings of the research in this thesis are presented in paper I: *Have process industries shifted their centre of gravity during the 90s?* Here, some of the indicators pointing to a changed orientation towards a more customer-oriented view in Swedish process industries during the 90s are described. The paper emphasizes a major change during the 90s in development focus for process industries in Sweden, impacting the industries' centre of gravity. Further, the paper discusses what makes a company choose a certain strategy or perspective in product development issues, as well as debates the changed position in the supply value chain in accordance with the concept of centre of gravity developed by Galbraith

(1983). According to Galbraith (1983), a company and its management are formed by the tradition and values of the industry it belongs to. However, if markets and customers change process industries, what implications will this have on the company's position in the supply value chain? If customers outsource part of their business to suppliers, what impact does this have on a company's actions in its value chain and its organization of product development teams in the future? This paper first discusses the implication a changed perspective on development has for process industries and on the company's position in the supply value chain, followed by the changed need for networks and improved integration of resources and activities for companies within process industries.

Process-based companies are usually characterized as upstream companies, i.e. they have standardized products and focus on process development. However, is this true today? The framework of the research is based on the changing market/customer needs for process-based companies, thereby impacting the company's position in the supply value chain, and initiating a need for improved integration mechanism towards its actors involved in development work. The objective of the study is to emphasize the change of perspective in development projects for process industries, from process-orientation to customer-orientation. The following two research questions address this objective:

- What has changed in development concerning project work and collaboration for companies in various process industries during the last decade?
- What are the implications of this change of a more customer-oriented view in development for process industries?

This study is divided into two parts. The first part investigates the current development work of the process-based companies' and analyses four indicators: product type, development focus, customer collaboration and the use of cross-functional teams in each of the companies. According to Galbraith's (1983) definition, these four indicators should be different in an upstream vs. downstream company.

The second part compares the companies' strategy statements from 1985 and 2000. The choice of a 15-year-period is because the second half of the 1980s was a period of great change for various industries in Sweden. This part of the study indicates if the companies had changed their statements during that period of time and relates it to stated changes in development focus and organization (stated in part one of the research). Further, the second part enables a categorization of the companies as an "upstream" or a "downstream" company in 1985, according to Galbraith's definition.

The four studied factors, i.e. product type, development focus, customer collaboration and use of cross-functional teams in development projects, indicate that upstream companies are headed towards the same perspective in development issues as downstream companies. This change of perspective will imply a change of gravity, i.e. other aspects will be of interest in development work, and that other working methods and networks must be implemented and understood. As a result, a change of perspective must be enhanced to a managerial level of strategic renewal. The findings in the paper detected the following changes for traditional Swedish upstream companies:

- *Product type*: customers play a more distinguished role in development today than 10-15 years ago, and the focus to find niche products that can generate higher margins has increased.
- *Changed perspective in development*: one effect of developing niche products is the use of other kinds of knowledge by developers in development projects today.
- *Customer collaboration*: customer collaboration early in product development projects is desirable; an increasing number of upstream companies are collaborating with customers in development projects.
- *Cross-functional teams*: a majority of companies work with cross-functional teams when it concerns development work.

For an upstream company, these changes imply a closing of the gap towards a downstream company, and that development procedures and management tend to be the same for both upstream and downstream companies. Distinguishing between companies today in terms of upstream and downstream is, from this specific perspective, of no particular relevance. A change for process industries concerning the focus in the value chain was also found, which is not easily obtained. The industry's centre of gravity will affect the efforts to change procedures, though this gravity is well rooted in the management and organization of projects. For process industries, this gravity is still very focused on the production process and not the customers.

5.1.2 Paper II

Paper I indicates a change of development focus for companies in the Process Industry. Since these indicators were just illustratively described, the second paper entitled *Understanding changes in product development in Swedish process industries* has a more analytical approach and analyzes the indicators showing so-called

upstream companies having approached downstream companies regarding development issues. This paper aims to answer the following question: Have so-called upstream companies changed their development focus during the 90s and/or has R&D moved to more competitive countries? That is, have upstream companies come closer to their customers concerning product development, and if so, how is this achieved?

The main purpose of this paper is to investigate product development in the Swedish Process Industry. Therefore, a two-stage methodology is used. In the first exploratory stage, 21 semi-structured interviews were conducted in 4 case study companies, 2 steel companies and 2 paper companies. Based on a survey among 50 companies in various industries, i.e. mining, steel, paper, chemical, rubber, plastics, and food & dairy, the second stage involved a quantitative study to gain a better representation some of the changes concerning product development in the Process Industry. To investigate what is happening to product development in the Swedish Process Industry, the following hypothesis was tested: "Traditional upstream (process-based) companies in Sweden have changed development focus during the 90s and therefore also their strategy towards value-added products".

An increased focus of product development in Process Industry requires that other areas of knowledge and competence must be incorporated in development projects. This implies a need of further research of how Swedish process industries viewed their own product development, i.e. if product development is part of process development, where product development issues are discussed in relation to internal production-related questions, or if it is separated from process development.

The results from the case studies are presented with a descriptive approach and indicate a change of development focus for the four companies in the steel and paper industries. Further, the study indicates an increasing role of product development for all four companies; an indicator of this change is the formation of special product development teams and separate product development departments. Customers demanding more specific products with certain material properties lead to a re-organization occasionally involving special product development committees. Hence, current product development is not merely a result of process development, even if they are still closely interrelated.

To test if any differences exist in the Swedish Process Industry concerning a change of development focus, the 50 companies in the survey were first divided into 2 groups according to traditional characteristics for 'upstream vs. downstream company', as per Galbraith's (1983) categorisation of the supply chain. The product types of the companies in 1985 determined the categorization, as based on

Galbraith's spectrum of product characteristics (the degree of value-added) combined with their stated development intentions in 1985. To test if a relationship exists between strategic change for Swedish process industries and a change for upstream companies towards a customer-focus in development, a cross-tabulation and a chi-square test with nominal variables were made. The tested variables were the following;

- change of strategy towards customer/product focus
- upstream vs. downstream characteristics

The results emphasise a change for Swedish process-based companies, and that development work incorporates a large part of the value chain today. However, not only does it require the mindset of the development team to change, but also the "mindset" of the organization. Therefore, a change towards a product focus will be insufficient; a change towards a market focus is needed. A consequence of changing development focus is the means to "understand market signals", to obtain a holistic view in development, to view trends, etc., therefore requiring a change of philosophy and traditions. Further, networking cannot depend on the interests of a single person, it requires hard work from all actors involved in development to build suitable work processes and models that facilitate acquiring competences and building networks.

The main finding in the paper is that to succeed with development work today, process industries must break with tradition of focusing mainly on the technological aspects of development projects and incorporate customer and supplier competences. Product development in Process Industry concerns to a great extent material properties. Therefore, a dilemma for the industry is that the product must be transformable into the customer's production process, requiring developers to be at the customer's site to supervise the process and analyse the result. As well, building sustainable links between R&D and customers and R&D and suppliers is becoming more important.

5.2 Differences between process industries? - summary of paper III

5.2.1 Paper III

The purpose of paper III, entitled *Are some process industries more product-focused than others?- The role of innovation,* is to investigate if any types of process industries have come closer to their customers than others. That is, are some categories of process industries becoming more customer- and product-focused than others?

To answer these questions, the companies in the survey were first characterised as upstream or downstream and then clustered according to some development work characteristics. Further, to investigate if any difference exists between the process industries concerning product development, the research was first based on a cluster analysis. The major aim of the cluster analysis was to group the industries into more aggregated groups to illustrate their relationship to each other concerning variables of development and strategic changes. Using a questionnaire, information was gathered within the following categories:

- Company background, e.g. type of business.
- Company categorizing questions: type of product, development focus, definition of product development.
- General questions; e.g. organization of development work, collaboration, future needs.

The first step in the analysis was to formulate the clustering problem by defining the variables on which the clustering should be based. In this study, 50 process-based companies were classified on the basis of 6 variables. The variables were coded on a nominal scale depicting type of products, focus in development, changed development focus, increase of product development, changed strategy towards customer/value-adding from 1985 to 2000, and focused business from 1985 to 2000, i.e. whether or not the companies had become more specialized.

The clustering resulted in three clusters of companies from various process industries. Cluster 1 is a mix of industries, where the majority are categorized as "upstreamers" in the supply chain. The companies have an equal focus on both process and product development, and though a slight majority did not increased their product focus during the 90s, a slight majority did changes their strategy during the 90s. One-third has focused its business and become more specialized. The majority of the companies in cluster 2 are "downstreamers" from the chemical and plastic industries. They have niche products, a focus on product development and the majority already had a customer-focused strategy in 1985. Finally, the majority of the companies in cluster 3 are "upstreamers", from the steel and food industries. The majority have an equal focus on both process and product development, and all have changed their development focus and increased their product focus during the 90s. The majority of the companies have changed their strategy during the 90s.

The analysis shows that there are differences between the industries concerning development issues like product type, increased product focus in development and changed strategy during the 90s. However, these differences indicate a narrowing gap between those who already had product focus in development during early 90s (downstream companies) and those who increased their product focus in develop-

ment during the 90s (upstream companies), i.e. no major difference between industries today and a similar trend in all industries meaning that Swedish process industries are headed towards a product-oriented development.

The paper states that development work aspects for Swedish process industries changed during the 90s. Aspects other than traditional production process-related issues need to be considered in development projects. This research indicates a small change towards selling technological competences during the 90s, and will presumably continue to increase in the future. This also means that new competences must be incorporated through either internal acquisition or external networking to support a changed product concept or to secure the changed need for information in development projects. Development teams and management must therefore evaluate changes together when it concerns competence needs. There must be a fit between the required competence and the integration mechanisms to obtain the required knowledge, as is achieved when both managers and development team members gain a broader business development picture.

Paper III found the disappearance of significant characteristics describing various industries today. Heavy steel and paper industries are just as interested as food and plastic to develop more specific products that gain a higher value-added. However, to achieve this change, a changed "mind-set" throughout the entire organization needs to be implemented, i.e. the role of R&D must change for traditional upstream companies.

5.3 Collaboration and use of information - summary of papers IV & V

Since systematisation and acquisition of information are essential aspects of my research, papers IV and V discuss how an integration of Management of Technology (MoT) and Supply Chain Management (SCM) can support an understanding of what aspects need to be strengthened in the Process Industry product development. Although MoT and SCM have emerged at different times, SCM being the most recent, they seem to be generally concerned with the same managerial problem areas (Drejer *et al*., 2002). Drejer *et al*. imply that MoT and SCM point towards using the same pluralistic approach, i.e. towards a strategic level and with more emphasis on organizational issues. However, there are still a few important reasons why MoT and SCM should not be considered as one discipline. In terms of management perspectives, MoT emphasises technology and SCM logistics. However, their close relationship is one reason to view their main contribution to this research.

The 'fifth generation' innovation process is regarded as a 'system and integration networking model', and as a multi-institutional networking process (emphasiz-

ing strong linkages with leading-edge customers and strategic integration with primary suppliers; Rothwell, 1994). This can be compared to SCM, which often requires the integration of inter- and intra-organizational relationships and the coordination of different types of flows within the entire supply chain structure. Intercompany integration and coordination via information technology has become a key to improved supply chain performance. Barut *et al*. (2002) show that recent advances in information technology enable firms to manage the coordination of not only the physical flow of materials effectively and inexpensively but also the flow of different types of information through a supply chain, such as data on demand, capacity, inventory and scheduling. Related to the concept of MoT, Christopher offers another definition of SCM [1998, p.18]: "The management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole". Here, supply chain integration implies both upstream and downstream process integration, interpreted by Christopher as collaborative working between buyers and suppliers, joint product development, common systems and shared information. Information is hence a key aspect of SCM. Further, Lambert *et al*. (1998) state that SCM is the integration of key business processes from end user through to original suppliers who provide products, services and information, adding value for customers and other stakeholders.

Information has always been an important element of the distribution process (Gattorna & Walters, 1996). During the 1970s and much of the 1980s information was seen as a necessity, for which the distribution system would not have run smoothly without it. Since SCM offers the opportunity to capture the synergy of intra- and inter-company integration and management and therefore deals with the total business process excellence, it represents a new way of managing business and relationships with other members of the supply chain (Gattora & Walters, 1996). From Morgan and Monczka (2003), the purposes of the supply strategy and managing the supply chain are to bring about an integration of the processes required to deliver value to customers.

Successful SCM requires a high degree of functional and organizational integration (Krajewski & Ritzman, 1999). But to achieve an integrated supply chain with customers and suppliers, the company must change its focus from a product or service orientation to a more customer orientation. This new focus means that the company must identify the appropriate competitive priorities for each of its market segments and develop a better understanding of its suppliers' organisations, capacities, strengths and weaknesses (Krajewski & Ritzman, 1999), i.e. an integrated supply chain, *see Figure 7*.

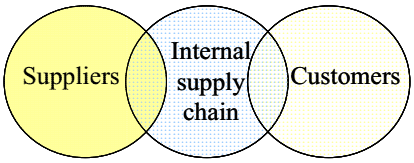

Figure 7. Integrated supply chain (*source: Krajewski & Ritzman, 1999*)

5.3.1 Paper IV

Process industries like steel and paper are approaching other manufacturing industries concerning the need to develop more "customer-specific" products. As stated in the previous papers, Swedish process industries are indicated to have changed their focus in development work towards a more customer-oriented focus and therefore a shift of strategy. But how can this task be achieved and what role has information technologies played in this change of development focus and strategy? Paper IV, *The impact of supply chain information and networking on product development in Swedish process industry,* investigates some of the consequences of a changed perspective in development work for process industries, i.e. the use of information systematization and the view of networks in development projects.

The paper investigates what role information technologies when changing towards a more customer-focused development. Does IT create a need for enhanced collaboration and networking or does the need for collaboration and networking create a need of IT? This paper highlights the issue of SCM offering an opportunity to depict the synergy of both intra- and inter-company integration and management, (Lambert *et al.*, 1998), since SCM represents a way of managing business and relationships with other members of the supply chain. Inter-company integration and coordination via information technology has become a key to improved supply chain performance (Barut *et al.*, 2002). Further, Tatikonda and Stock (2003) summarize a supply chain as being a network of organizations involved in transforming and transporting materials and information to ultimately create and deliver a valued product to end customers. This is because information and materials flow up and down the supply chain, each organization creates and adds value to the entire product in the supply chain, and the supply chain is a network of organizations where individual organizations must interrelate and interact to add value.

The results in this paper are based on the survey of 50 process industry companies. The purpose of the paper is to investigate the relationship between a changed perspective (towards a more product orientation) in development for companies in

the process industry, especially upstream companies, and the impact this change has on the use of information technologies and how networking is viewed. What role does IT play in a change of direction from process-oriented development to product-oriented development for traditional upstream process industries? Further, the analysis is based on a test (cross-tabulation and a chi-square with nominal variables) of a relationship between the variables "strategic change for Swedish process industries", "the use of systematization of information", and "networking". The tested variables are the following;

- *Position in the supply value chain (according to upstream vs. downstream characteristics);*
- *changed strategy towards customer/product focus during the 90s* (comparison between the years 1985 and 2000);
- *the use of information technologies in development projects (all means to systemize information);*
- *networking (i.e. collaboration with institutions, universities and actors with the needed competence).*

The findings in paper IV indicate that the need for "new" information has changed the network structure towards Process Industry suppliers and customers. The need to build sustainable links to customers, suppliers and institutions/universities to incorporate new competence and knowledge has increased. But to facilitate these linkages, a formal facilitator is also needed to build customer-value into the development work, i.e. incorporated in development projects. IT can play a bigger role in facilitating the linkages to customers and supplier by adopting the Supply Chain Management perspective in product development work.

5.3.2 Paper V

Given the difficulty of a changed development focus, its consequences on required new types of information and network-building, and a need for purposeful management of this process, paper V, *A change in supply chain information for Swedish process industries and its consequence on a changed development focus,* aims to answer following questions:

- What has changed in the information flow concerning product development work for process industries?
- How is this change of information connected to the supply chain value of process industries? That is, is the needed information in product development linked to the entire supply chain?

This paper examines if integrating supply chain information in product development supports a changed development focus in the Process Industry, achieved by focusing on two theoretical perspectives, namely MoT and SCM. The results in this paper are based on two studies. The first study has its empirical base in four case studies, two steel and two pulp and paper companies, while the second study is based on a survey of 50 companies in various industries, i.e. mining, steel, paper, chemical, rubber, plastics, and food and dairy. One important issue in this paper is to find variables considered representative of both theoretical perspectives.

Some of the cornerstones of MoT that focus on product development are about connecting technology and strategy (Burgelman *et al.*, 2001), bridging inter-and intra-firm boundaries, management of supplier involvement (Takeishi, 2001), increased understanding of a supplier and sharing of technology information (Petersen *et al.*, 2003), and understanding and managing customer and technological competences (Danneels, 2002). Some of the cornerstones in SCM today are to capture and diffuse customer trends and preferences deep into supply chain member companies (Bechtel & Jayaram, 1997), supply chain collaboration (Sahay, 2003), supplier integration, inter-company integration and coordination via information technology (Barut *et al*., 2002), where each organization in the supply chain creates and adds value to the entire product, i.e. the supply chain is a network of organizations where individual organizations must interrelate and interact to add value.

Is it possible that an awareness of a need to change information in product development work can lead to stronger management support regarding the needs of networking and competence acquisition? This is linked to developing a conceptual model consisting of the integration between MoT and SCM, since achieving a better understanding of how a changed development focus affects both required competence and information in development projects is needed. This change will also affect suitable network-building to support development work in the future for process-based companies.

The purpose of this paper is to investigate the relationships between a changed perspective in development and some of the consequences of the change. The tested indicators of a changed perspective are of a more visualized change, like a changed strategy, and a more "latent" change such as the experience of an increased product focus. The following three indicators are tested as consequences of a changed perspective in development, i.e. "Supply chain information", "Networking" and "Increased collaboration". The variable "increased product focus" indicates a change for the process-based companies towards a more product development focus. This variable is tested since it may be understood to grasp the "trend of a change in progress", because a company can still consider themselves to have

both a product and a process focus in development work even if they feel that there is a tendency to increase the product focus.

The paper investigates if a changed development perspective in process industries (manifested as an increased product focus in development projects) can be understood, explained and supported by changed information content in development projects and an increased need to collaborate and network. The first section of the survey analysis consists of testing the following relationships;

- *Is there a relationship between a changed development strategy, an increased product focus and changed supply chain information?*
- *Is there a relationship between a changed development strategy, and increased product focus and networking, and an increased collaboration?*

The first step was to choose the variables to be tested. What variables are considered representative of the "two philosophies" MoT and SCM? The following variables were chosen:

- *Increased product focus,* i.e. if the company experiences an increased product focus in development (the company can experience an increase in the importance of product development, but do not need to change their development focus requiring substantial changes in development work).
- *Changed strategy towards the customer and value-adding*, i.e. if the company indicates a changed strategy (a comparison of the company statements from year 1985 and 2000 annual reports).
- *Changed supply chain information*, i.e. the respondents express a change of information practices regarding development work, indications of the required information being extended to involve a greater part of the supply chain today.
- *Networking,* i.e. collaboration with institutes, universities and companies with the needed competence.
- *Increased collaboration* (with customer/supplier during the 90's)

The findings in paper V emphasise that SCM can support an understanding of the necessary changes concerning information sources and networking in development projects for Swedish process industries. However, there is no relationship between a changed strategy during the 90s and the changed supply chain information and networking of today, though some of the paper's quotes indicate a future need for companies in process industries to increase their customer collaboration, with product development work incorporating a large part of the value chain. Product development must cover a larger part of today's value chain to realise what gives customers value. Another issue is that working in networks is essential because of the important knowledge possessed by some suppliers.

The main finding is that to succeed with product development today, process industries must evaluate its supply chain and what creates the most value in the product. Technical possibilities and the needs of customers are changing rapidly; therefore it is increasingly important for companies to build sustainable relationships with equipment suppliers and customers. Network activities in product development are increasing for all process industries. In many cases, companies view their suppliers as an integrated part of their own product flow process. An integration of the perspectives MoT and SCM can support an understanding that an increased product focus in development for process industries means a future need to develop information sources and knowledge networks. Acquiring the needed information is not easily achieved, but analysing key sources and building suitable networks based on these information sources will make the process of change more efficient. This is because product development in process industries is interrelated to development conducted further up or down the supply chain, i.e. a process-based company's product often further value-added by customers and material properties can be affected by the customers' production process.

5.4 Effective product development process - summary of paper VI

5.4.1 Paper VI

What makes a product development process effective? What factors from the literature explain the efficiency and effectiveness of the product development process? The purpose of paper VI, *Effective product development process: Towards a conceptual framework for process industry,* is to illustrate state of the art research concerning management and organization of the product development process, and to investigate factors influencing the product development process and organize these factors in a conceptual model adjusted to the Process Industry. But, what creates an effective product development process in Process Industry? The process Industry has often been regarded as a mature industry, with stable products and production processes. Characteristics for the Process Industry have been stable markets, fixed production processes with the focus on economy-of-scale and cost efficiency. The term Process Industry has come to symbolise an industry invested heavily in their technology. But the tradition to solely concentrate on the process development and to minimise costs has changed.

Process industry is often part of a long chain of customers and suppliers who do not always have access to information from the end-user. The production process of a finished product consists of a continuous flow incorporating suppliers who deliver material and not components, and customers who transform the material to

suite their specific purposes. Further, the paper organizes the burgeoning product development literature into three areas: innovation type, technology strategy and organisational aspect. From the literature review, a conceptual framework detailing the elements of intra- and inter-firm processes in the product development process in Process Industry is presented. Our purpose is to increase the understanding of the changed innovation pattern in Process Industry and its implication on the organisation and management of the product development process.

When the pattern of innovation changes, some major areas related to the product development process change accordingly, e.g. the activities in the product development process. These activities can be viewed differently for various companies, but should be related to the need to collaborate with customers and suppliers so that the company acquires the needed competence and knowledge in product development. Understanding the new product development process requires a simultaneous view of customers and technology, i.e. new product development requires joining two competencies related to technology and customers; *see Figure 8*.

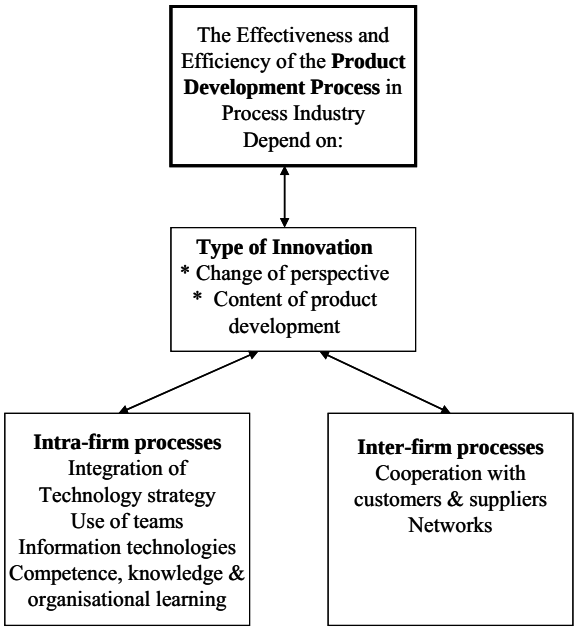

Figure 8. A conceptual model of the determinants of effective product development process in Process Industry

In general, the Management of Technology can be regarded as an innovation process as well a multi-institutional networking process with strong linkages to leading-edge customers and strategic integration of primary suppliers. This is similar to SCM, which often requires integrating inter and intra-organizational relationships and coordinating different types of flows within the entire supply chain structure. Inter-company integration and coordination via information technology has become a key to improved supply chain performance. Further, focusing on the supply chain allows us to focus on strategic decisions that reach beyond the linkages within the chain, which includes a set of organizing principles for the complete product and material flow process (Schary & Skjøtt-Larsen, 1995). The SCM perspective also shows us the complex network of interrelated activities in supply chains (Chen & Paulrai, 2004). Understanding how supply chains will change in the future is important for managers to comprehend (Lancioni, 2000) while SCM offers the opportunity to capture the synergy of intra- and inter-company integration and management (Lambert *et al.*, 1998).

6. CONTRIBUTION AND FUTURE RESEARCH

The overall aim of this thesis is to investigate how Swedish process industries conduct product development and some of the changes during the 1990s. Each paper presents conclusions related to each research question, with the most important being summarized below by the integrated results from the entire study.

Product development in the Process Industry is a complex matter, since process development and product development are very much interlinked. Changes in one will impact the other. This means that those working with product development need to have a deep understanding of how the production process will operate and what parameters are possible to change. The study shows that actors involved in product development often have some process engineering background. However, one dilemma is to then enable creativity and look beyond the constraints of the production process. Another complexity concerning Process Industry product development is its definition, since product development in the Process Industry can have many meanings, e.g. pure material development, application development, service development, development of packages, etc. This makes it difficult to have a general definition of what product development is in the Process Industry.

The *first* main research question concerns the consequences of a changed perspective in development work for process industries. To answer this question, I investigated if, during the 1990s, process industries had shifted their centre of gravity and if upstream companies changed their development focus. The study indicated that Swedish upstream companies are changing their centre of gravity. Today, a company belonging to the Process Industry can choose to focus on process development, i.e. become cost-effective and develop various parameters to make the production process more effective and efficient, and therefore deal with a so-called high-volume product. However, the result of the study shows that the content of development work has changed, e.g. there is a tendency for companies dealing with high-volume products to develop services attached to the product. These services can consist of maintenance to a customer's production process. Another means for companies in the Process Industry to maintain competitiveness is to focus on product development or have a mix of product and process development. However, a dilemma for product developers in the Process Industry is the need to visit customers to gain an understanding and knowledge of their production processes, since the material properties act differently in different production processes. These visits are time-consuming and can only be applied to a limited number of customers.

The *second* main research question concerns whether there are differences between process industries concerning a changed development perspective. Here, I investigate if some process industries are more product-focused than others in de-

velopment work, i.e. if there are any differences between the process industries. The study indicates no major difference between industries today and that the trend is similar in all industries, i.e. Swedish process industries are heading towards a more product-oriented development. The research findings show some changes concerning the perspective of product development in Swedish Process Industry during the last two decades. A majority of the companies in the Swedish Process Industry have a more product-oriented perspective in development work today, implying a decreased development speed in projects and a more shortsighted perspective in development work with a greater focus on modified products than "new" products. This also means that much development work is based on commissions from, e.g. marketing. Theses implications make long-sighted development work impossible.

The *third* main research question investigates the use of information systematization, the view of networks in development projects and the changed needs of information in product development work, i.e. the link to the entire supply chain. Product development work in the Process Industry is much more complex today than 20 years ago, meaning that other aspects in product development must be considered. For example, the content of development work has changed, such as the material properties, the parameters of customers' production processes, the utilization of a package, etc. Further, a new type of project team is required to collaborate both internally and externally from the company, and acquire information along the supply chain. The findings also show that so-called upstream companies are approaching downstream companies regarding their need to be close to customers and end-customers. Also, there is an increased wish to directly involve both customers and suppliers in product development. But to understand the consequences of a changed perspective in development, a company in the Process Industry should understand its part in the entire supply value chain and how the product is further value-added by actors further down the chain. Obtaining information from the entire supply chain into product development projects was found to be critical. This is more essential for companies in industries where products are transformed and further value-added downstream of the supply chain.

This research indicates that since much product development work in process industries depends on the product development work of either suppliers or customers, there is a need to build sustainable networks, and specifically networks of capabilities. Managers have to build formalized integration mechanisms involving both suppliers and customers earlier and deeper into product development because much of the networking in a process industry is formally built on a personal basis. This requires a deep analysis of suppliers and customers, obtained through the following steps, *see paper V*.

Step 1: Identify key sources of customer and supplier value, the customers' needs concerning the product and the processes, and supplier capabilities concerning raw material and equipment (through interviews, QFD etc.).

Step 2: Identify critical capabilities within the company, and the required competence in product and process development.

Step 3: Identify possible information and communication flows to both suppliers and customers. It has to be systematized through, e.g., a common database so that project members have access to the information.

Step 4: Plan for a network structure, and build sustainable links to both customers and suppliers. The development team has to have a formalized facilitator with the main responsibility towards a specific customer or supplier.

As previously stated, no major research attempts concerning product development in Process Industry exist. The theoretical contribution of this research concerns incorporating the complexity of product development in the Process Industry with the general framework of product development. Since much product development work in the Process Industry is technology driven either due to their or their customers' production processes, the discipline Management of Technology can be a support in evaluating the product development constraints and possibilities for a company in the Process Industry. Additionally, SCM helps in visualizing the critical linkages between suppliers and customers and the essential information flow. An integration of the two perspectives, i.e. MoT and SCM, can formalise and visualize some of the implications of a changed perspective in development projects for process industries on both operational and strategic levels. The results of this research indicate today's product development projects today in process industries to greatly need information concerning the entire supply chain, i.e. required to understand the entire supply value chain.

The last main research question contributes with theory concerning what makes a product development process effective in the Process Industry. The critical factors that should be evaluated are the types of innovation and what intra- and interfirm processes must be built to support the product development process.

Table 5 gives a brief summary of the main findings related to each research questions.

Table 5. A summary of the findings

Main Research questions	**Sub-questions**	**Findings**
What are the consequences of a changed perspective in development work for process industries?	Have process industries shifted their centre of gravity during the 1990s? Have upstream companies changed their development focus during the 1990s or has R&D moved to more competitive countries? That is, have upstream companies come closer to their customers concerning product development, and if so, how is this achieved?	There is indication of a shift in the centre of gravity. Upstream companies have moved closer to their customers. Swedish upstream companies and downstream companies have a product-focused development. The content of development work has changed, e.g. development teams need to visit customers, which is time-consuming.
Are there differences between process industries concerning a changed development perspective?	Are some process industries more product-focused than others? Are there differences between process industries concerning product-focused development?	No major differences exist between the various categories of process industries.
How do process industries collaborate and use information in development work?	What impact does a changed perspective in development for process industries have on the use of information systematization and the view of networks in development projects? What has changed in the information flow concerning product development work for process industries? How is this change of information connected to the supply chain value of process industries? That is, is the needed information in product development linked to the entire supply chain?	There is an increased need to build sustainable links to customers, suppliers and institutions/ universities to incorporate new competence and knowledge. However, it often depends on development team members to create theses linkages. This type of information is difficult to systematize. IT can play a bigger role in facilitating the linkages to customers and supplier. SCM can be a support in visualize the critical linkages.
What creates an effective product development process in Process Industry?	What makes a product development process effective? What factors can be found in the literature explaining the efficiency and effectiveness of the product development process?	The critical factors that should be evaluated are the types of innovation and what intra- and inter-firm processes must be built to support the product development process. There is a mutual interest in both MoT and SCM perspectives to discuss the importance of networking, information sharing, customer & supplier linkages and the link to strategic management,

The main academic contribution of this research is the elaboration of several implications concerning a changed perspective in development work for Swedish process industries. An analysis of the entire supply chain for a process-based company and its actors will also contribute by facilitating this change towards a more product-focused development, i.e. this analysis can visualise vital and needed elements in the development work. The analysis also emphasises important actors who can become key actors in a formalised network involving the development team.

Product development in the Process Industry is an unexplored area of research. This thesis shows that the theories of MoT and SCM can together emphasise some aspects to be highlighted to understand and create effective product development in Process Industry.

MoT research shows more and more large companies to have developed overall strategies for their Management of Technology, while the innovation process is regarded as a multi-institutional networking process with strong linkages to leading-edge customers and strategic integration of primary suppliers (Rothwell, 1994). Managing innovation is one part of Management of Technology and is partly about connecting technology and strategy and integrating product and technology development, i.e. activities connected to innovation. One of these linkages is bridging inter- and intra-firm boundaries, e.g. management of supplier involvement (Takeishi, 2001, Sobrero & Roberts, 2002). An example of a linkage to customers is from Danneels (2002), who states that understanding the product development process requires a simultaneous view of both customers and technology, i.e. competence relating to technology (e.g. manufacturing plant and equipment, manufacturing know-how, engineering know-how and quality assurance tools), and competence relating to customers (e.g. knowledge of customer needs, distribution and sales channels, and company/brand reputation).

SCM research shows the flow of information in supply chain relationships to have changed over the years. Today, new technologies enable customer-related information to be sent directly to suppliers, manufacturers and distributors. This represents the beginning of an SCM revolution to capture and diffuse customer trends and preferences deep into supply chain member companies (Bechtel & Jayaram, 1997). The objective of SCM is to provide a high velocity flow of high quality, relevant information that will enable suppliers to provide an uninterrupted and precisely timed flow of materials to customers. Three distinct sources affect a supply chain: suppliers, manufacturers and customers (Yu *et al*., 2001). Another key in SCM involves supply chain collaboration [Sahay, 2003)], which can be the key to value creation in the supply chain. This value can be obtained by integrating suppliers into product development and the value of information such as inventory, lot size, transportation, etc. (Simchi-Levi *et al*., 2003). The supply chain recognizes

that cooperative arrangements tying companies to each other exist and their success to the chain as a whole. SCM also offers an opportunity to depict the synergy of both intra- and inter-company integration and management (Lambert *et al*., 1998), since SCM represents a way of managing business and relationships with other members of the supply chain. Inter-company integration and coordination via information technology has become a key to improved supply chain performance (Barut et al., 2002).

Figure 9 illustrates a mutual interest in both MoT and SCM to discuss the importance of networking, information sharing, customer & supplier linkages and the link to strategic management, i.e. it is the mutual link between these perspectives that can be a support in understanding some of the implications of changed R&D management practices. Understanding these aspects can help managers to view their product in a chain of users with a variety of demands.

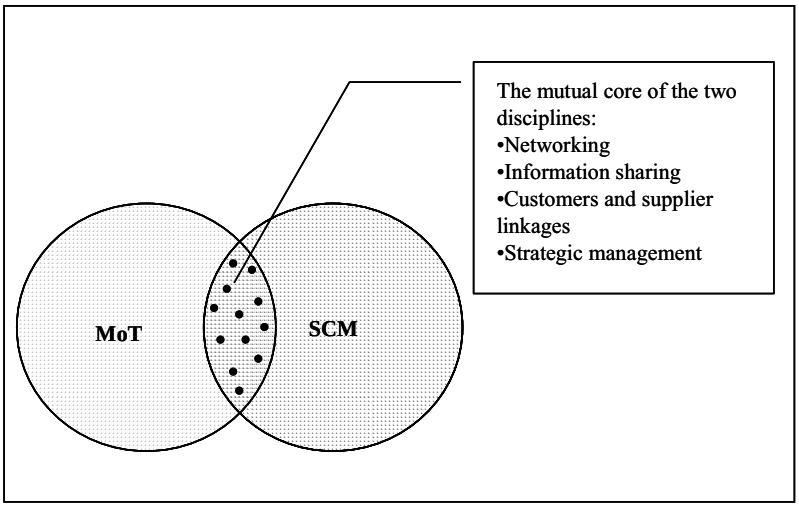

Figure 9. The relationship between the two disciplines; MoT and SCM.

The main managerial implication of this research is the investigation of a changed perspective for Swedish process-based companies and the implications of such a change. Development managers can facilitate the change towards a more product-oriented focus in development projects by thoroughly viewing and analysing product development work as a process in the supply chain. Sources of innovation and key actors can be suppliers (of machine equipment or raw material) and

customers (customers and/or end-customers). However, an analysis of vital sources of innovation can require changes in both organizations and the means to cooperate).

There is a need for extensive research in the future combining Process Industries and product development for two reasons. There is a need to investigate what has specifically changed and what techniques and means can be supportive to conduct development work effectively, since the content of development work has changed. Further, an infringing question is how a future organization that supports both internal and external collaboration can be built. If product development requires more flexible and integrating links to both the customer and supplier, how should these be constituted?

Certain limitations of the study also suggest directions for future research. The research is limited to companies in Sweden, but there is an indication that this is not just an isolated Swedish phenomenon. Therefore, international research on this matter based on cross-national or international data is a future research topic. How process industries will manage production flexibility and product differentiation is an area that needs further research. Moreover, there is a need for extensive research concerning how companies in the Process Industry can become more market-oriented in their development, i.e. research concerning the future role of R&D, how to achieve product differentiation, suitable organizational forms, etc. There is also a need for deeper research in many areas concerning how to integrate actors into a suitable network, and concerns what means are appropriate to systematize information.

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APPENDICES

APPENDIX A: Interview guide 1

APPENDIX B: Text analysis - The case study

APPENDIX C: Interview guide 2

APPENDIX D: Text analysis – The survey

APPENDIX A: Interview guide 1

- Part in PD?
  * Background
  * Function
- Time at the company
- Do you know any official working method for PD?
  * Does it fit with the reality?
  * Advantages/Disadvantages?
- How is the project work organized?
  * Form of organization (Matrix, project, functional)
- Functional cooperation?
- Has there been any major change in the way you work in PD-process (compare previous project with this one)?
- Are there any future plans of changes concerning PD?

Previous project

- Describe the purpose why it started
- How was it initiated?
  * Were you part of the project then?
- The time frame for it.
- Who organized the project (function)?
- How was it organized?
  * Meetings to check how far everybody has reached in the project?
  * How often?
  * Did the whole group meet or just part of it?
- Can you describe your view of the course of the project? (from the beginning to the end)
  * Different phases?
  * Where were you part? (the whole time, just sometimes)
- Who were the other members of the project?
  * Where the same members part of the project the whole time or where they replaced?
- Were there other interested party, partner involved in the project? (except the project members)
- Were there any forms of collaboration?
  * Do you buy competence?
- Do you have any relations/contacts to/with other companies within the Company Group?
- Was there any cooperation with customer/suppliers in the project?
  * How was that relation handled?
  * How were their views brought into the projects?
- What factors did you experienced that limited you work with PD?
- What factors controlled the project, gave it a push forward.

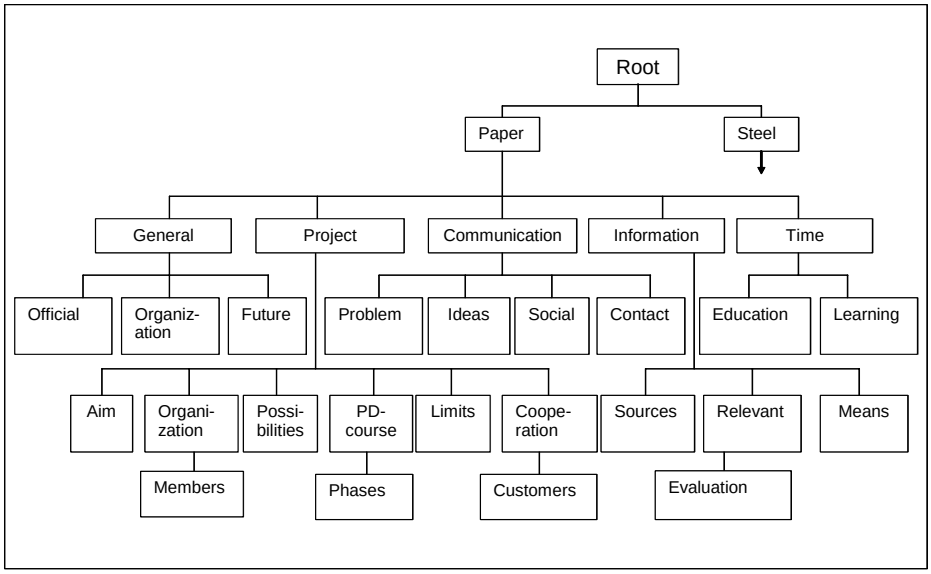
Communication and Information

- If a problem occurred in the project, what could that concern?
- With whom did you discuss it with (internal/external department)
- Did you meet others outside your department, continually (how often)?
- If you had an idea concerning the project, to whom did you talk it with?
  * From where could it has come from, the idea?
- If you encountered a special trick problem within your own area, to whom did you then go to for assistance? (within/outside the organization)
- Think back on the project. Can you try and identify the information sources that were at most help to solve difficult problems?
  * visit conferences/trade fairs
  * journals
  * seminaries
  * informal discussion with colleagues at your department
  * informal discussions with colleagues outside you department
  * verbal or written reports from colleagues
  * other
- What other tasks did you have except the time you spent on the project?(% of total time)
- How much time do you put down to keep yourself abreast on what happens within your field of work, concerning PD?
- Do you try to gain insights in other areas, department, functions?
  * How do you do that?
- How do you thing it easier to meet/contact people within work?(personal meetings, telephone etc.).
- What technology do you have as aid in your work?
- How do you get the information you might need?
  * From whom?
  * in what way?
- How do you assess the relevance in it?
- How do preserve/keep experiences made in the project?
- Have you had any educational possibilities within your work?
  * Within other areas that concern PD

APPENDIX B: *Text analysis - The case study*

To be able to structure the interviews in a proper manner, and then to analyze the material, a software program, Non-numerical Unstructured Data Indexing Searching and Theorizing, was used. It is a computer package designed to aid users in handling non-numerical and unstructured data in qualitative analysis, by supporting processes of coding data in an index system. Searching patterns of coding and theorizing about the data are other qualities of the software.

All interview were typed out and integrated into the software program. The texts were then coded with nodes and organized in a "tree" structure. Nodes were the containers for the ideas about the data and identification of the text could be made. With help of hierarchical Index Tree, categorization and cluster constructions of the text simplified the analysis of the qualitative data. This tree helped to discover and express relationships between emerging ideas.



APPENDIX C: *Interview guide 2*

Industries:
Ore/mining, steel/metal, pulp/paper, rubber, chemical, plastic, food/dairy

Some questions may not be answerable due to your type of business.

1. Type of company? Place in the value chain, from raw material to customer.
   – High-volume/niche products? Both? Share of each?
2. Type of development, i.e. what is it you develop, properties, application areas etc.?
3. Definition of product development?
   - especially your type of business?
4. Separate process development versus product development? Do you separate them?
   - Share of each in percentage?
5. What is considered to be more important? Increasing? Production capacity versus product properties etc. or what?
6. Do you have the required production flexibility?
7. What gives directions in development? (environmental requirements, costs, customers/market or…)
8. How do you organize your development work?
9. Division in functions, project, product groups….
   - integration of process development? How?
   - integrating mechanisms, formal meetings? Company policy, procedures?
   - Development in other units?
10. Which functions are represented (members) are representative in a development project?
    - Responsibility?
    – Other actors?
11. Time frames concerning product development?
12. Have the company experienced any changes concerning the organization of product development during the past ten years?

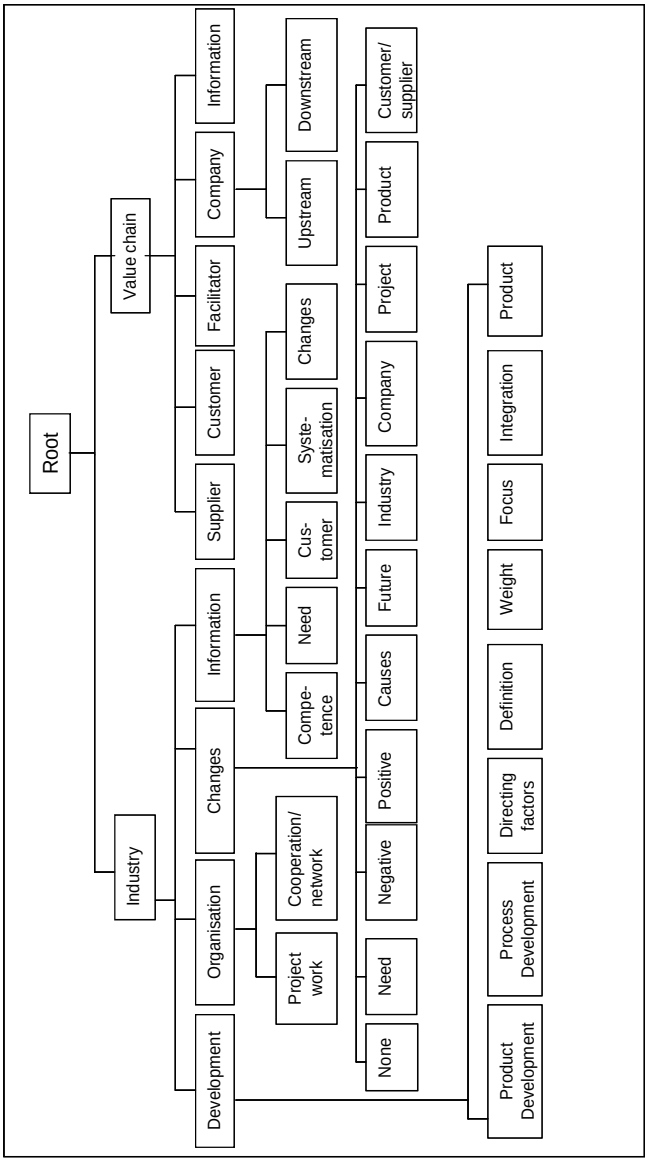
    ⇒ if Yes,
13. What changes?
14. Causes to the change?

15. Experience of difficulties with the change?
16. Has the change lead to any positive effects?
17. Has the change lad to any negative effects?
18. Need of changes in the future concerning development?

⇒ if No,

19. Is there any need of changes today? In the future?
20. Why/why not?
21. Possible difficulties with a change?
22. Positive effects?
23. If/How is customer/suppliers involved in development work? Other external actors?
    – is their presence of importance/not important? Scale 1-5 on each.
    – what factors are important for product development to consider them as possible actors?
24. How is the link to customer/supplier constituted? (work with specification, reclamation etc)
25. How do you collect information to development projects? (Guidelines, company policy or..)
    - what information is needed in development work?
    – techniques?
    – systematisation?
    – storing to future project?
    - something missing?
26. How is the communication exchange for actors involved in projects constituted?
    * meetings formal/informal? Percentage?
    * in the same place?
    * reports/PM?
    * share of other projects?

APPENDIX D: *Text analysis – The survey*



PAPER I

Have process industries shifted their center of gravity during the 90s?

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HAVE PROCESS INDUSTRIES SHIFTED THEIR CENTRE OF GRAVITY DURING THE 90s?

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Product development is often seen as a main tool for competitiveness in organizations. In process industries, like steel and paper, process and product development are seen as an integrated part. Product development has often been the result of a process development. Heavy investments and costly production give process a priority role in product development. The role of customers and suppliers in development work has increased for process-based companies. This change will have implication on how to organize and manage development in the traditional upstream companies. Therefore, this article presents results that show some of the implications of the changed situation for Swedish process-based companies. The article also emphasizes that there are indications of a shift of traditional upstream companies' centre of gravity due to the changed perspective in development work, towards customer focus.

Keyword: Product development; customer-orientation; process industries; centre of gravity.

Introduction

What has happened in the Swedish process industries during the 90ths concerning product development work? How do they manage the turbulent change from being process-oriented towards product-oriented in development work? This article emphasizes that there are indications of a major change during the 90ths in development focus for process industries in Sweden and this change will have an impact on the industries' centre of gravity.

The competitive environment for companies in process industries is undergoing a fundamental change in Sweden. In recent years there have been quite a number

of mergers and acquisitions in e.g. the Swedish chemical industry in order to rationalize production, to optimise research and development and to facilitate international marketing. For most of the high-volume chemicals there is just one main manufacturer today per specific product. The same goes for the steel industry; growth in niche areas has been more rapid than for steel market in general and deliveries of these products have increased substantially during the most recent ten-year period. A lot of effort is put into an increasing focus on developing new applications in co-operation with customers.

What role does product development play in Swedish process industries today and in the future? Process industries like steel and paper industries have traditionally had a process-oriented view in product development projects. The focus has been on the development of their production processes. Therefore, product development has often been the result of major process development. High investments in machines and equipment have promoted economy-of-scale and production of high-volume products. Product development has not been of primary interest due to a quite low value-added.

Within the last decades, the rapid rate of technological change, shortened product life cycles, and increasing global competition have made product development a critical concern of a great number of companies in a range of industries. Today, suppliers and customers are an increasingly important resource for manufacturer. Research shows that building bridges between functions and to suppliers and customers increased the likelihood of success for the company. These bridges can take the form of cross-functional teams with *R&D/ manufacturing/marketing integration* (Kahn, 2001; Olson *et al*., 2001, Song *et al*., 1998; Song *et al*., 1997; Fischer *et al*, 1997) and *R&D/marketing integration* (Ottum & Moore, 1997; Song *et al*., 1996; Griffin & Hauser, 1996; Griffin & Hauser, 1993). Other forms of collaboration are *strategic partnerships* (Comer & Zirger, 1997; Littler & Levrick, 1995; Magrath & Hardy, 1994), which can be with *suppliers* (Swink & Mabert, 2000) and *customers* (Kärkkinen *et al*., 2001; Mello, 2001; Butscher & Larker, 2000; Gruner & Homburg, 2000; Campbell & Cooper, 1999).

Ragatz *et al*. (1997) point out that suppliers can have a large and direct impact on cost, quality, technology, and speed. Research shows that collaborations in all forms are increasingly playing a major role in product development. But this increased need of collaboration with various actors will imply improved integration of resources and activities for the companies. To have a network perspective in development work can facilitate the awareness of needed links to both internal and external actors. A network perspective means focusing on relationships between actors, activities and resources (Håkansson, 1990). In order to obtain a better understanding of the need of changes concerning organization and

management of development in process industries, a possible starting point is to have a network perspective.

What makes a company choose a certain strategy or perspective in product development issues? According to Galbraith (1983), a company and its management are formed by the tradition and the values of the industry it is belonging to. But if markets and customers change for process industries what implication will this have on the company's position in the supply value chain? If customers outsource part of their business to suppliers, what impact does it have on a company's actions in its value chain and its organization of product development teams in the future?

Galbraith (2002) also illuminates that a recent trend in business strategy is to offer solutions to customers instead of just physical products. This means that the suppliers must create an organization that can package and deliver the solutions. Galbraith points out that the company must add a customer-centric component to its organization and then integrate that component with its product-based structure.

This article will firstly discuss the implication a change of perspective in development for process industries will have on the company's position in the supply value chain. Secondly, the article will debate the changed need of networks and improved integration of resources and activities for companies within process industries.

The changed position in the supply value chain will be debated in accordance to the concept of centre of gravity developed by Galbraith (1983). Process-based companies are usually characterized as upstream companies, i.e. have standardized products and focus in process development but is this true today? Have traditional process industries undergone a shift of centre of gravity, towards the "consumers"? Figure 1 illustrates the framework of the research. The market/customer needs have changed for process-based companies. This change will have implication on the company's position in the supply value chain, which will then need improved integration mechanism to its actors involved in development work. But a new organization that creates and delivers solutions to its customers is not easily managed, according to Galbraith (2002). Process-based companies cannot completely abandon their traditional process-oriented view due to their high investments in their production processes. Instead they tend to balance between the two perspectives, process versus customer-oriented development.

The objective of the study is to emphasize the change of perspective in development projects for process industries, from process-orientation to customer-orientation in development projects. The following two research questions address this objective:

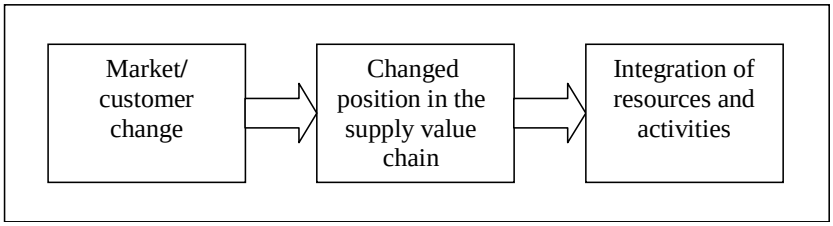

Fig. 1. The framework of changed situation for process-based companies.

- What has changed in development concerning project work and collaboration for companies in various process industries during the last decade?
- What are the implications of this change of a more customer-oriented view in development for process industries?

Manufacturing Industry versus Process Industry

Product development in process industries has other aspects than that of other manufacturing industries. It is for a larger extent focused on the improvements of product properties, the improvements of product quality, and the development of more environment-friendly products.

Until the end of 1970's, product development has received relatively limited attention in process industries. But today, this situation is changing due to an increased international competition and market changes. Customer demands specific products with special material properties. This increased demand of specific products has led to an increased interest in product development issues for process industries. This suggests that there is a change from a traditional perspective on product development towards a more customer-oriented view for companies dealing with high-volume products (Huang *et al*., 2002).

There is a challenge for the 21st century for process industries (and other industries) to survive and to maintain profitable in rapidly changing markets. But to achieve this, it is required to understand the changing environment and to use these changes to their advantage. It is necessary for process-based companies to be able to anticipate customer needs as well as technology that respond to them.

A product in process industry is often characterized as of low technology, long product life cycle, fairly long product development time etc. However, this is about to change for Swedish companies dealing with development of material properties. But it is not easily changed. The underlying assumption is that since product and process are symbiotically related in the production system, then fundamental changes in the one must incite and parallel fundamental changes on the other (Etienne, 1981).

A product in process industry is very complex due to its material property complexity, e.g. a tire is not simply a "black donut" but the end result of complex chemical and engineering processes, which must resist extremes of heat, cold, and stress (Ita & Gross, 1995).

Process industry today must find a way to develop the right products, i.e. to develop niche products and develop value-added products. This means improved functionality, features, and performance. Companies need to bring the new product to market faster. Once they have identified the right product, they need to be able to shorten the development cycle. One way is to make better, more efficient use of technology and human resources (Harkins & Dubreuil, 1993). This also requires sustainable networks with both suppliers and customers.

However, process industries are often characterized with a process-oriented perspective on product development. They have primarily been interested in the technological solutions of the production process. These solutions are often a link in an optimisation of the production process, i.e. finding a more cost-effective process and can give implications in product development projects. Product development will then be a secondary result of the change of the production process, i.e. product development is defensive (Utterback, 1996).

In a study concerning product development in the chemical and oil industry, Heinonen (1994) summarizes some special characteristics of process industry.

- Production is usually continuous and parallel, which complicates the cost calculation of individual products.
- High investment costs hinder progress, which leads to an aim to maintain existing equipment.
- A problem of slowness and inflexibleness in project realization, owing to the long period of time the investment demand, leads to cautiousness.
- Problems caused by the big size of the industry and the difficulty to produce special products.
- Great internal and mutual dependencies among product groups, products, product properties, raw materials and processes.
- Optimisation problems that are related to product yield to change production structure according to changing demand causes difficulties.
- The development of products and processes in process industry is subject to co-operation and coordination with equipment suppliers.

The differences

There are some major differences between process industries and other manufacturing industries.

One major difference is that the process industry, in general, has very inflexible and costly equipment. The production process is often unique for the purpose of manufacturing a specific product. The products that are manufactured are often interdependent. Changes of material properties in the raw material affect the entire product group.

Another difference between process industry and manufacturing industry is the emphasis on material properties and process technology for process industry. There is an absence of the function engineering design, i.e. design of product architecture, building physical prototypes in product development in process industries. However, in process industries there is a close interaction between product and process development. It can be difficult to separate product development from process development. Product development is often done in a laboratory and is often a result of process development. The process technology often states the boundaries within which product development can be performed.

A third difference between the manufacturing industry (i.e. pieces-goods industry) and process industries is the objective for product development. Some of the key product development objectives for the manufacturing industry are; market introduction date, product unit cost, product performance, and development project expense (Smith & Reinertsen, 1998). While the main objectives for process industries can be to improve product properties, to improve product quality, and to develop more environment-friendly products.

However, customer-orientation and improvement of company product development capability in process industry have been emphasized the last decade. It can be difficult to separate resources for R&D in process industries because product and process development are so inter-linked. Lager (2002) means that there should be a sharper distinction between product and process development activities per se, but they should not be completely separated.

Centre of Gravity

Galbraith's ideas of the concept of centre of gravity rest on the fact that an organization has a driving force or a centre of gravity (Galbraith, 1983). This centre of gravity arises from the firm's initial success in the industry in which it grew up. According to Galbraith, a company and its management are formed by the tradition and the values of the industry it is belonging to, it all depends on the position in the supply value chain[1] (see Fig. 2). Galbraith means that the

[1]For discussion of the "value chain", see Porter, (1985).

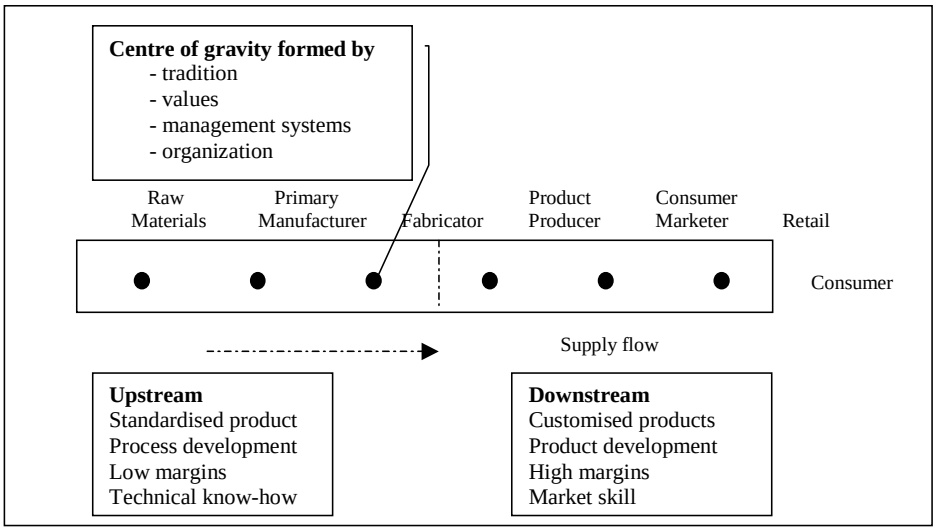

Fig. 2. A value-added supply chain in a manufacturing industry *(Developed from Galbraith & Kazanjian, 1986).* The line splitting the chain into two segments divides the industry into upstream and downstream halves.

companies' values, their management systems, and their organization are all shaped by "the stage of initial success". The company has established an anchor or a centre of gravity by starting operations in a particular industry at a particular stage of that industry. This point is important, because each stage of any industry has different success factors. Strategic changes will then take place through moves around and from this centre of gravity.

Every industry has a value-added supply chain, a sequence of activities that transforms raw materials into end product or service. The value-added supply chain in a manufacturing industry begins with raw material extraction stage, which supplies crude oil, iron ore or logs to the second stage of primary manufacturing. The second stage is a variety-reducing stage to produce a standardized output like petrochemicals, steel, and paper pulp. The third stage fabricates commodity products from primary material. Fabricators produce e.g. polyethylene, sheet steel, or cardboard cartons. The fourth stage is the product producers, who add value usually through product development. The following stage includes the manufacturer and marketer of consumer products. In the last stage come the distributors and the retailers, who sell to the final consumer. These companies add value by creating time and place utility.

The chain can be divided into two halves, i.e. upstream and downstream companies, and each stage has different success factors.

There are some fundamental differences that illustrate the contrast between upstream and downstream companies. Galbraith means that downstream stages add value through producing a variety of products to meet varying customers needs. The downstream value is added through advertising, product positioning, marketing channels, and R&D.

Galbraith points out those characteristics as standardization, line-driven organization, process innovation, capital intensive, and technological know-how illustrate upstream companies. In contrast, downstream companies are more concerned about customisation, line/staff (they produce multiple products that require larger staffs), product innovation, people intensive (critical skills centre on human resource management), and market skills (Galbraith & Kazanjian, 1986).

Can a company's centre of gravity change? Ilinitch and Zeithaml (1995) have operationalised and tested Galbraith's centre of gravity theory. One of the implications from their study point to the fact that firms operating in business which are far removed from their historical centre of gravity, may be inappropriately applying the values and routines which contributed to their initial success.

The term process industry is often associated with the characteristics of standard product, low-cost, process innovation, high investments in process technology, and high technological know-how, i.e. characteristics of upstream companies. But can companies characterized as process industry maintain their path of producing low-cost products and rely on their superb technological competence? This article argues that there has been a shift in Swedish process industries' centre of gravity. That is, old values and tradition has broken when it comes to be competitive today. It is emphasized to develop niche products and to incorporate customers into development work.

What are the consequences of a change of centre of gravity? This change is incremental and it is the people that work with development work that are the ones that first starts the process. However, it is important that this "mental" shift transfers to be stated as a strategic shift, that the development get the appropriate tools and techniques to form suitable networks and base for development.

This article points to the fact that there is a need for a new "way-of-thinking" regarding the division of companies in upstream vs. downstream. However, not all processed-based companies need to change their centre of gravity. There are companies that can continue to manufacture a high-volume product, but the requirement for that it to be a large company that can maintain cost-effectiveness. For example, the steel crisis in the mid-70s gave rise to a period of restructuring in Sweden, with merger of stainless operations. The last decades for Swedish process-based industries indicate that there have been mergers and acquisitions

that enable the companies to be more focused on their development task in specific niches.

Strategic change

Strategic change is a subject of substantial research. Rajagopalan and Spreitzer (1996) have made a comprehensive review of the strategic change literature. They summarize that there are several characteristics that can have an effects on strategic change, environmental variables (e.g. deregulation) and organizational variables (e.g. firm size, age, and top management characteristics). But what implies a strategic shift and a change of centre of gravity for a company? Galbraith and Kazanjian (1986) give a summary of the main strategic changes a company can perform.

One change that an organization makes is to **vertically integrate** within its industry. To move backwards to guarantee sources of supply and secure bargaining leverage on vendors, or/and to move forward to guarantee markets and volume for capital investments and become customer to feed back data for new products. This initial strategic move does not change centre of gravity because the prior and subsequent stages are usually operated for the benefit of the centre-of-gravity stage.

The concept of centre of gravity, according to Galbraith and Kazanjian (1986), allows a discussion of strategic changes in other ways, some are more difficult than others. They introduce four different dimensions of **diversity**. *The first* (by-products diversification) is the number of different industries in which a company operates. This measure of diversity is the simplest and will distinguish among by-product diversifiers. But the strategic implementation problems occur when the new industries are different from those in which the company already operates.

The second (related diversification) measure of relatedness assumes that a company operated at the same centre of gravity, but entered businesses where other business functions were different, such as process technology, customer buying behavior, and so on.

The third (linked diversification) measure is the number of different centres of gravity at which a company operates. The company must learn not only new business but also new ways of doing business.

The fourth measure is the distances between the centres; that is, differences between ways of doing business are proportional to the distance on the industry supply chain. The final type of strategic change is to diversify into unrelated business.

However, another possibility is for an organization to stay in the same industry but change its centre of gravity in that industry. Galbraith points out some attempts of chemical companies to move downstream into higher margin, proprietary products. To move away from low margins and high capital intensity, it implies a shift in the centre of gravity of the company.

Have process industries in Sweden changed their strategy towards diversification or have they changed their centre of gravity? Rumelt (1986) means that diversification as a strategy is defined as the firm's commitment to diversity per se; together with the strength, skills or purposes that span this diversity, demonstrated by the way new activities are related to old activities. Further, he points out that the essence of diversification can be described as "reaching out" into new areas, which requires development of new competences or augmentation of existing ones.

The following hypotheses are posed to test the changes and the current position of Swedish process-based companies:

> ***Hypothesis 1:*** *Process industries in Sweden have moved downstream, away from low margins and high capital intensity into higher margins, proprietary products. It implies a shift of the companies' centre of gravity.*

> ***Hypothesis 2:*** *Process industries in Sweden have shifted their "upstream-thinking" to "downstream-thinking", which implies new managerial systems and closer links to customers.*

The indicators that are used to indicate a "shift of mind" for Swedish process industries are chosen after some of Galbraith's characteristics of upstream and downstream companies. They are type of product, development focus, customer collaboration in development projects, and cross-functional teams, see Table 1. The fourth indicator, the use of cross-functional teams, tests indirectly Galbraith's definition of line-driven organization vs. line/staff. It means that organizations are different. The upstream companies are functional and line-driven that is staff are used in *supporting roles*. The downstream company with multiple products and markets learns to *manage diversity* that is resources need to be allocated across products and markets.

This article argues that traditional Swedish "upstream companies" have changed their "centre of gravity". This change will have implication on how to organize and management development work, but this is not easily achieved due to old tradition and values. So, how has processed-based companies managed this great change? Is it possible today to divide companies into upstream vs. downstream according to Galbraith's definition?

Table 1. The indicators of a change of gravity.

Variables	Galbraith's Upstream/Downstream Definition
Type of product	Standardize/Customize
Development focus	Process/Product innovation
Customer cooperation in development projects	Sales push/Marketing pull
Cross-functional teams	Supporting roles/Manage diversity

In summary, a firm's centre of gravity has a strong influence on diversification options and success. Centre of gravity, in addition the degree of diversification, is a prime determinant of organizational structure, systems, and processes. However, if there is a change in a company's perspective on product development projects, i.e. if it emphasizes customer needs and demands it will be affected by the company's centre of gravity. The routines, the working procedure etc. are well rooted in the tradition of being an upstream company. This tradition will therefore be an obstacle in the change of the organization and the management of product development projects.

Methodology and Objectives

The purpose of this article is to investigate process-based companies' (i.e. upstream company) strategy shift towards product development and its affect on the companies' centre of gravity. This change will have implication how to organize and management development work. 50 companies in various industries, i.e. ore, steel, pulp/paper, chemical, rubber, plastics, and food/dairy participated in the research. However, the purpose is not to state that there has been a strategic shift but to investigate some of the indications that process-based companies might be headed towards a strategic shift. Since the focus in this research is on current development work and project changes during the 90s, it is not possible to affirm that the companies studied have actual changed their strategy.

The research is divided into two parts. The first part of the research consists of an investigation of the process-based companies' current development work. This part analyses the four indicators: product type, development focus, customer collaboration, and the use of cross-functional teams for each of the companies. These four indicators should be different in an upstream vs. downstream company according to Galbraith's (1983) definition of "upstream" and "downstream".

The second part consists of a comparison between the companies' strategy statements of the year 1985 and the year 2000. The choice of a 15-year-period

is due to the fact that the second half of the 1980s was a period of great changes for various industries in Sweden. This part of the research gives indications if the companies have changed their statements during a period of time and relates it to stated changes in development focus and organization (stated in part one of the research). However, an analysis of annual reports does not give proof of actual strategic changes but it gives some indications. Further, the second part enables a categorization of the companies as an "upstream" or a "downstream" company in 1985, according to Galbraith's definition. There was also an analysis of the companies' product range in accordance to Rumelt's concept of diversification. Had the companies diversified their products or found new markets? However, this analysis just consisted of if the companies had changed their product mix or if it was the same in 1985 and in 2000.

The change of focus in development will imply a change of gravity, i.e. that other aspects are of interest in development work than low margins with capital-intensive equipment. This means that the company must implement and understand other working methods and create suitable networks. As a result the change of perspective must be enhanced to a managerial level of strategic renewal.

Data collection and analysis

The data collection is also divided into two parts. The first part consisted of a major investigation of how 50 companies in various industries, i.e. ore, steel, pulp/paper, chemical, rubber, plastics, and food/dairy, conduct their development and their needs in the future concerning both organization of development and information collection, distribution, and storing. The criteria for selecting the companies were that they should be part of the "traditional" process industry, i.e. produce a product that is regarded as a "low-cost product". However, due to scarcity of available companies in the selected industries, the total amount of companies is quite low. The sample of companies was taken from industry lists, which identified those companies that are active in the specific industries mentioned above. Representatives of Swedish branch organizations also came with suggestions of existing companies. Companies were initially contacted by telephone to ensure that they had/were involved in development projects, to identify the key respondents, and to solicit cooperation. 50 companies agreed to participate in the research (from 55). To ensure reasonable reliability of the data, respondents received a copy of their answers of the questions where they could make alterations etc. Altogether 50 companies participated with one respondent at each company. Since the purpose of the study was to investigate current development work, changes during the 90s, and future needs to development projects, the respondents needed to have deep insights in development work.

Table 2. Number of companies in sample by type of industry and size. The number of employees is the determinant of the size of the company.

Type of Industry	Size of the Company			
	Small (no. employees < 100)	Medium (100 ≤ no. employees < 500)	Large (no. employees ≥ 500)	Total
Ore	0	0	2	2
Steel	0	1	8	9
Paper	0	0	7	7
Chemicals	6	6	3	15
Rubber	1	2	3	6
Plastics	2	2	0	4
Food/Dairy	0	1	6	7
Total	9	12	29	50

Therefore, most of the respondents were R&D managers and in smaller companies some were project leader or member of product development project. Table 2 gives the distribution of the companies in each branch sector and their size. The companies are divided into three groups: small, medium and large depending on the number of employees.

Data was gathered from structured telephone interviews with open-ended questions. This enabled a rich understanding of the companies' current development work that could be used to explain certain phenomenon. Most of the interviews were recorded and typed. All interview materials were then coded with a software technique called "Non-numerical Unstructured Data Indexing Searching and Theorizing" (N5). It is a computer package designed to aid users in handling non-numerical and unstructured data in qualitative analysis. The texts were first coded with nodes and organized in a "tree" structure. This enabled thorough analyses of the material. Since the questionnaire format was based on open-ended questions, and the respondents, in some cases, found it difficult to grade the answers, they were coded in the frame of dichotomy in SPSS 11.0 (Statistical Package for the Social Sciences). SPSS was a tool that enabled a summary of the answers that then could be analysed. But the basic analysis of the material is a combination of both a qualitative and a quantitative analysis. There is no statistical significant test done due to the purpose of the research is to illustrate some of the indicators of a "changed mind" for traditional process industries.

The second part consisted of a comparison of the 50 companies' strategies (i.e. the Groups' strategies), in the seven process-based industries, over a period

of 15 years (facts from annual reports in 1985 and in 2000). The comparison consisted of finding key words like product development, higher margins, value-added products, and customer need in the strategy statements from 1985 and 2000. The implication that there has been a change of mind for the company is when the company emphasizes some of these key words in the year 2000 and not in the year 1985. Had the companies diversified their products or found new markets? This analysis consisted of a comparison the companies' product mix in 1985 and in 2000 (data from annual reports). However, no deeper conclusions can be derived from the annual reports. They are merely used as an illustration of a possible change of strategy. Further sources are required to enable deeper analysis if the companies actually have changed their strategies.

The framework of the research

The main framework of the research is to investigate how the four factors: product type, development focus, customer collaboration, and the use of cross-functional teams in development projects are indicators that upstream companies are headed towards the same perspective in development issues as downstream companies. This change of perspective will imply a change of gravity, i.e. that other aspects are of interest in development work and this means that other working methods and networks must be implemented and understood. As a result the change of perspective must be enhanced to a managerial level of strategic renewal (see Fig. 3). This is however a continuous process, a strategic shift will have an impact on the product type, development focus, the need of customer collaboration in projects, and the use of cross-functional teams.

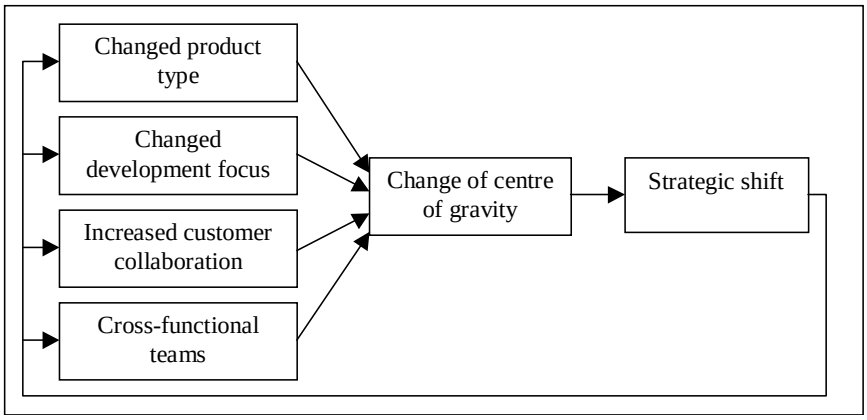

Fig. 3. The framework of the research.

What Are The Results?

The main question of the research is if Swedish process industries have changed their centre of gravity during the last decade, and if so, is there a need of improved integration of resources and activities? To be able to answer the question, the results are presented in four parts; changes for the companies during the 90ths (1), the companies' position in the supply value chain (2), centre of gravity shifts for the companies (3), and finally the companies' way to manage the change (4). Figure 4 illustrates the outline of the results.

The first part of the results presents what explicit have changed for the companies during the last decade. There has been a great deal of changes for companies characterized as process industry in Sweden during the last decades. A brief summary of the respondents' comments about changes during the 90s is followed below. Their comments are divided into following areas; product development, product concept, organization, project work, and customer/supplier relations, see also appendix A.

Product development: Develop better products due to new knowledge; change towards niche products and increased number of niche products; development of new properties; increased product development focus and efforts.

Product concept: Sell development hours; integrate forward in the value chain with assembly and packaging combined to the product; work with customers processes; sell a complete concept — are "problem solvers"; increased responsibility of customers' development; increased personal service to customers; learn them to use the product.

Organization: Now project organization with project leader; flat organization; project organization; organization towards specialization of material; organizational

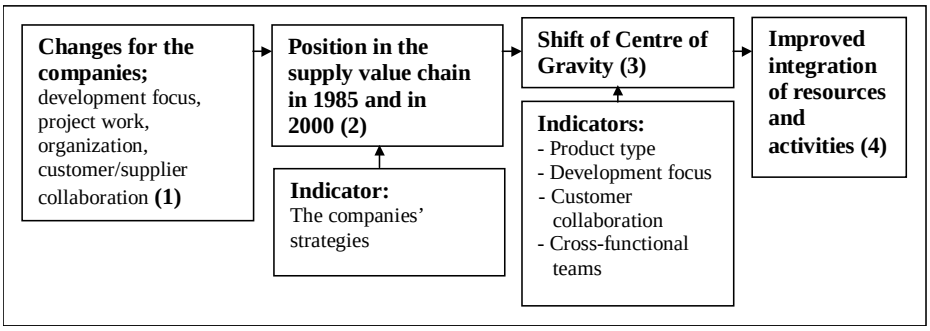

Fig. 4. The outline of the results.

changes toward focusing the business — clear link between development and sale personnel; technique divisions to enable focusing in product areas; direct link between development and marketing, marketing, sale and product development work closely together to make product development more effective; division in three R&D sections: product development, process development and strategic development plus a section that do customer projects in cooperation with the other sections; decentralized R&D organization, a Technology centre work closely with development at production sites, merger; changed product development from technical department to marketing department; sale organization contact with customers' engineers, education of customer engineers.

Project work: Team-building; the Group has common IT platforms that enable project sharing; change in documentation of projects; project management, planning and control of projects; increased market input in development projects; changed working methods, cross functional teams; made product developer to market technicians — to catch customer needs and communicate with procurement and technique — at customer databases to systematize projects.

Customer/supplier collaboration: Customers are involved earlier in projects; work more closely with customers and supplier; development projects with suppliers, more flexibility and quicker response on customer's need; raw material suppliers are viewed as a resource that can decrease product development time; increased customer collaboration to gain insight of customer problems and their product development; more efficient input from customers to projects.

The second part of the results presents the companies' positions in the supply value chain in 1985 and in 2000. The companies are categorized in accordance to Galbraith supply chain (1983). But to enable to decide the companies' position in the chain, the companies are first divided into two groups: upstream and downstream companies. The companies' product types in 1985 determine the categorization and position. This categorization is based on Galbraith's spectrum of product characteristics (the degree of value-added) in combination with stated development intentions in 1985. Table 3 shows the distribution of the division and Fig. 5 illustrates the companies' position in the supply value chain and Galbraith's product characteristics. Every circle indicates one company in the study, with a total of 50 companies.

Some examples of the product type in each industry are as follows:
Ore: *Upstream* — metals, minerals, pellets.
Steel: *Upstream* — magnetic materials, long steel products, stainless steel, steel sheet. *Downstream* — value-added aluminum profiles.
Paper: *Upstream* — Pulp, paper. *Downstream* - corrugated cardboard.

Table 3. Number of companies in sample by type of industry and number of upstream vs. downstream companies (divided after the companies' product type in 1985).

Type of Industry	Traditional Characteristics of the Companies	
	Upstream	Downstream
Ore	2	0
Steel	7	2
Paper	4	3
Chemicals	9	6
Rubber	2	4
Plastics	0	4
Food/Dairy	4	3
Total	28	22

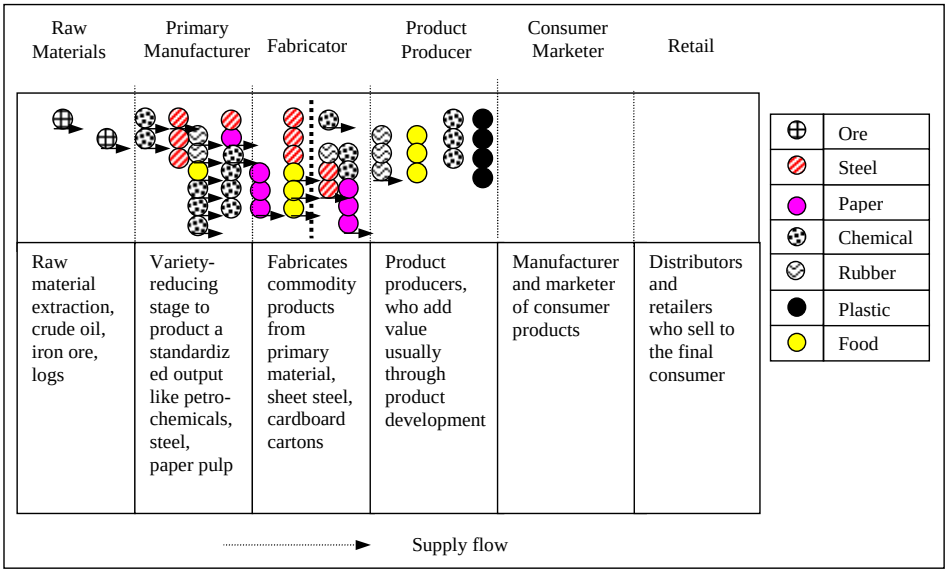

Fig. 5. The position of the companies (50) in Galbraith's model of the supply chain. (The arrows imply that the company has changed its strategy from the year 1985 to the year 2000. These companies emphasize value-added products, higher margins, and product development in their strategies in the year 2000, which they did not do in the year 1985).

Chemicals: *Upstream* — starch, lubricate, paint, chemicals for pulp and paper industry, oil. *Downstream* — subcontracted work.
Rubber: *Downstream* — tires, injection moulded components, compression moulded products in polymer materials.
Plastics: *Downstream* — fibre composite components, PVC-compounds.
Food/Dairy: *Upstream* — dairy products, sugar. *Downstream* — consumer products, agro-chemicals.

Have the companies changed their strategies during a 15-years-period? Figure 6 shows that, from the sample of 50 companies, a total of 22 companies (44%) have some indications of a customer-focused strategy and a total of 23 companies (46%) do not have any indication in 1985. The comparison of the strategy statements indicate that 21 out of 50 companies (42%) that did not have a customer-focused strategy in 1985 had changed the strategy statements in 2000, i.e. towards finding products with higher margins and satisfying customer needs. 17 out of 28 upstream companies indicate a change of strategies (61%). Nine upstream companies already had customer-focus in 1985. Five of the companies do not have any records available that can be compared. The purpose of this paper is not to make a comprehensive analysis if the companies have actually changed their strategy. But a comparison of the companies' strategy statements, between certain intervals (1985-2000), can give an indication of their intentions. In this paper, a company is considered to have a customer-focused strategy if the strategy contains some of following concepts: product development, higher margins, value-added products, and customer need. The absent and occurrence of product development in 1985 and in 2000 is also reviewed.

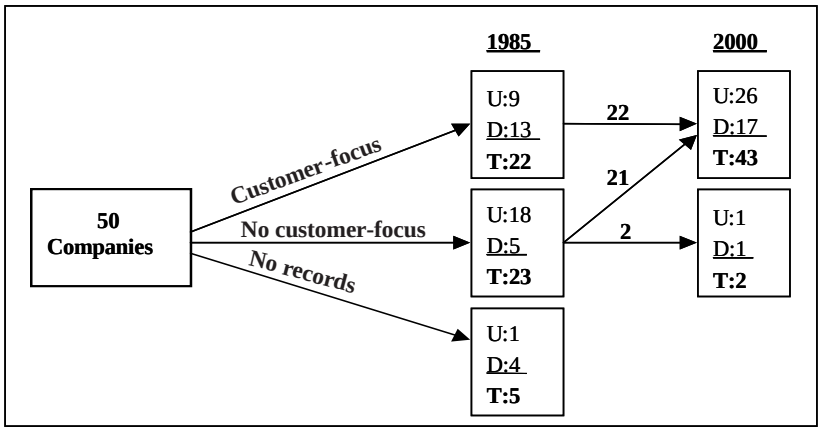

Fig. 6. The change of strategies for the 50 companies from 1985 to 2000. (U is upstream companies, D is downstream companies, and T is the total amount of companies in each group).

The third part of the results focuses on the variables that indicate that there has been a shift of the centre of gravity for some companies in the study. The indicators are *product type, development focus, customer cooperation, and use of cross-functional teams in development projects.* These variables indicate that there has been a shift of mind for some process-based companies towards "downstream-thinking" (a shift of the centre of gravity).

The first indicator to investigate is the companies' **type of product.** According to the definition of an upstream company, it manufactures a standardized product. So, what type of product does the companies in the study manufacture? Table 4 shows the distribution of the tendency of increased product focus during the 90s and the companies' character of products, i.e. high-volume (standardized), niche (customized) or if they have a mixed product type, i.e. both high-volume and niche. The major difference here between upstream versus downstream companies is that it is more likely that an upstream company has a mix of high-volume products and niche products. 15 out of 28 (54%) upstream companies emphasize the category "mixed", while it is only 4 out of 22 (18%) for the downstream companies. However, altogether 20 (out of 28) upstream companies (71%) and 20 (out of 22) downstream companies (91%) indicate some degree of niche product focus today. Two downstream companies indicate a change from niche products to high-volume products today. This might depend on product maturity and increased competition.

There is an interest for upstream companies to find value-added niche products. Table 4 also shows that 17 out of 28 upstream companies (61%) indicate an increase of product focus in their development work. The majority of the companies

Table 4. Number of companies in sample by increased product focus and product type (in 2000). U equals upstream companies and D equals downstream companies.

Product Type	Increased Product Focus		
	Yes	No	Total
High-volume	U: 3 D: 0	U: 5 D: 2	U: 8 D:2
Niche	U: 4 D: 6	U: 1 D: 10	U: 5 D: 16
Mixed	U: 10 D: 3	U: 5 U: 1	U: 15 D: 4
Total	U: 17 D: 9	U: 11 D: 13	U: 28 D: 22

that have not increased their product focus are downstream companies dealing with niche products, 10 out of 22 downstream companies (45%). They already have a high level of product focus in their development projects. On the contrary, the majority of the companies that have increased their product focus are upstream companies with a mix of high-volume and niche products, 10 out of 28 upstream companies (36%).

This indicator "product type" shows that the majority of the companies are not "upstreamers" today, i.e. traditional high-volume producers.

The second and third indicators to investigate are the companies' **development focus** and **customer collaboration** in projects**.** According to the definition of an upstream company, it is a low-cost producer and has its focus in process development, not in product development. Table 5 shows that only 4 out of 28 upstream companies (14%) focus solely on process development. 24 (86%) upstream companies mean that process and product development are at least equally important. This indicator "development focus" implies that the majority of the companies are not in their mind "upstreamers". According the definition of an upstream company, it focuses on technology know-how and not market skills. As Table 6 shows the majority of the upstream companies (24 out of 28,

Table 5. Number of companies in sample by focus in development and characteristic of the company (in 2000)**.**

Focus in Development	Characteristic of the Company		
	Upstream	Downstream	Total
Product	7	15	22
Process	4	0	4
Equal	17	7	24
Total	28	22	50

Table 6. Number of companies in sample by customer collaboration and characteristic of the company (in 2000)**.**

Customer Collaboration	Characteristic of the Company		
	Upstream	Downstream	Total
Yes	24	22	46
No	4	0	4
Total	28	22	50

86%) indicate that it is important to have customer collaboration in development projects. This indicator shows that the majority of the upstream companies do not fit with the definition of an upstream company.

Traditionally, process-based companies do not need to integrate several functions in development work since the focus was in process development. However, the fourth indicator in the study, use of **cross-functional teams**, shows that 86 % of the companies (43 out of 50) have cross-functional teams in development projects, see Table 7. Cross-functional teams can have various constellations with members from different functional areas. Since the companies studied are different, e.g. in size and available resources, the development teams can have different constellations. The definition here of a cross-functional team is that the team should both have a technical (e.g. production, development, material department) and a market input (e.g. marketing, sales, product department) into the project. In this research, there is no major different between upstream versus downstream companies.

Table 7. Number of companies in sample by cross-functional teams and characteristic of the company (in 2000).

Cross-Functional Teams	Characteristic of the Company		
	Upstream	Downstream	Total
Yes	22	21	43
No	6	1	7
Total	28	22	50

None of the four variables above, selected to measure the current situation of Swedish process-based companies, were in coherence with the traditional view of a process-based company; standardized product, process development, and focus on technological know-how. The tables above indicate that there has been a “change of mind” for traditional upstream companies. But how can this change be illustrated? Figure 7 shows a matrix, which illustrates the companies’ “change of mind” when it concerns development focus, customer collaboration, the use of cross-functional teams, and the strategy statements. If the company considers, at least, that product and process development are equally important and that it has both cross-functional teams and customer collaboration in development projects, then it is considered in this article a “change of mind”.

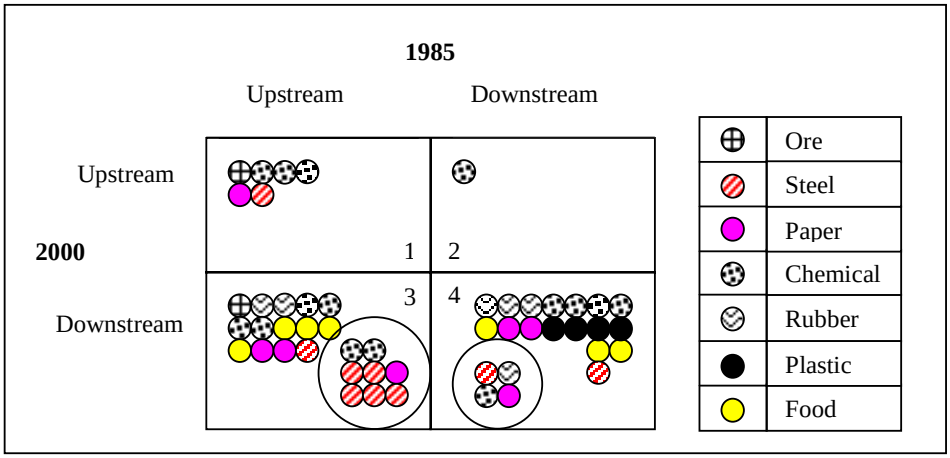

Fig. 7. The changed thinking for the companies when it concerns development focus, customer collaboration, cross-functional teams, and customer-focus in strategy statements. (There are special comments about the companies surrounded by a circle.)

Comments About the Matrix

The matrix has four quadrants and all of the 50 companies are positioned in it depending on their positions in 1985 and in 2000. The division of companies in upstream versus downstream is based upon the type of product the company had in 1985. However, this matrix is an attempt to view the companies "thinking" when it comes to development aspects like the development focus (that product and process development are at least equal important), customer collaboration in development projects, the use of cross-functional teams in development, and a customer-focus in strategy statements.

1. The six upstream companies (in ore, steel, paper, and chemical industry) in the first quadrant do not have cross-functional teams in development, however their strategies point out a change of focus towards customer-focus and value-added for customers. Also, four of the companies do not have customer collaboration in the development projects. These six companies have not changed their working methods according to their indicated strategy. All but one company are just dealing with high-volume products, but three of the companies find at least that product and process development are equal important. A reason for still acting like an "upstreamer" is that it takes time to change working procedures and in some cases there is no need to have market input and incorporate customers in development projects due to the characteristics of the product, (e.g. petrochemical).

2. This downstream company does not have customer-focus in its strategy statement and it produces a high-volume product today. A former niche product can become a "high-volume" product due to product maturity and increased competition.
3. One upstream company does not have customer-focus in the strategy statement, but indicate cross-functional teams, customer collaboration and product development focus. (No records of strategy for one of the upstream companies). The companies surrounded by a circle already had customer-focus in their strategy statements in 1985. A reason for the fact that 22 (out of 28) upstream companies have an urge to "become a downstreamer" can be the will to find specific niche products that gives higher margins and profits (and to maintain competitive). This requires new working methods and incorporation of customers in the development.
4. Four downstream companies have changed their strategy towards customer-focus (surrounded by a circle). One of them does not have cross-functional teams in 2000. The other companies had customer-focus in their strategy statements in 1985 (no records for four companies).

As the matrix shows, there is no major difference between the two groups, upstream versus downstream companies today. In 2000, 86 % of the companies (43 out of 50) act, as they are downstream companies with some degree of product development focus, cross-functional teams and customer collaboration in development projects. However, there are some differences between the groups "upstream" and "downstream" when it concerns to the variables "type of product" and "development focus". The majority of the upstream companies (15 out of 28, 54%) produces both high-volume and niche products, see previous Table 4. But, the material indicates that there is an increased interest for upstream companies to develop niche products.

Further, the variable "development focus" also shows a difference between the two groups. An "upstreamer" is more likely to emphasize equal development focus, 17 out of 28 companies (61%), i.e. product and process development are equally important. Only 7 out of 22 downstream companies (32%) find them equally important. They emphasize product development, see previous Table 6.

Finally, the fourth part of the results is a summary of some of the results stated above. Since there is a change for the majority of the process-based in this research, there is a need for improved integration between resources and activities in development today. This need for integration of various activities is shown in the need of cross-functional teams and improved links to both customers and suppliers. However, Table 8 shows that there is a low number of companies that feel a need for improved networks — 6% (only 3 out of 50 companies). But as

Table 8. The different needs/changes in the future for the companies.

	Future Needs in Development							
Type of Industry	Continuous Change	Decrease Costs	Customer Collaboration	Supplier Collaboration	Data-bases	Competence/ Knowledge	Networks	Other Needs
Ore	2	0	0	0	0	0	0	0
Steel	2	1	0	0	1	4	0	1
Paper	0	0	4	0	1	1	0	1
Chemical	5	0	5	1	0	2	1	1
Rubber	1	2	0	0	1	0	0	2
Plastic	0	0	2	0	1	0	1	0
Food	1	0	1	0	1	3	1	0
Total	11	3	12	1	5	10	3	5

many as 24% feel that collaboration with customers could be better (12 out of 50 companies).

What has happened in process industries during the 90s? Have process industries in Sweden diversified to related business, which is shown in an increase of product development efforts and change of strategy? Have the companies changed their strategy towards diversification?

No, none of the companies in the research have indicated a diversification to other businesses or changed the product mix. On the contrary, 8 upstream companies have focused their businesses (i.e. decreased the range of product groups) to enable an increased effort in product development for certain product groups that are interrelated, see Table 9. There is also an emphasis today to sell more than just the physical product. The meaning of “a package” in this study is that developers need to have knowledge about customers’ processes, to help the customers use the product, to teach customers of the use of the product, to test the product in the customers’ processes. The product package can include service attached to the product, support activities etc. 19 upstream companies

Table 9. Number of companies in sample by focused business and characteristic of the company.

Focused Business During the 90th	Characteristic of the Company		
	Upstream	Downstream	Total
Yes	8	2	10
No	20	20	40
Total	28	22	50

Table 10. Number of companies in sample by product content and characteristics of the company.

Product Content	Characteristic of the Company		
	Upstream	Downstream	Total
Physical	9	10	19
Package	19	12	31
Total	28	22	50

(68%) and 12 downstream companies (55%) include more than just the physical product in their development today (Table 10).

Discussion and Future Directions

The findings of this research contribute to the existing body of product development research in at least two ways. A first contribution concerns the implication of a change strategy with the focus on higher margins, proprietary products, and customer needs for process industries. The second contribution is the test of the situation of Swedish process industries, towards "downstream-thinking, based on Galbraith's (1983) centre of gravity approach. He argues that it is very difficult to achieve a change from being an upstream to a downstream company. To be able to discuss the subject above, following questions are posed:

- What has changed in development concerning project work and collaboration for companies in various process industries during the last decade?
- What are the implications of this change of a more customer-oriented view in development for process industries?

Today, there are two dimensions that enable product development in process industries. At one end of the spectrum, individual customer demands can enable major changes concerning product concepts and modifications of existing products. Various organization and action programs to shorten development time support that approach (Utterback, 1996). At the other end of the spectrum, there is process development, i.e. the know-how in the technology. The development of production processes is mainly based on improvements and major market evolutions. The most important factors in process development are; reduction of production costs, improvement of production volumes and product recoveries, and to make a more environment-friendly production.

For process-based companies, it can be easier to change the basic characteristics of their production equipment that enable new product ideas than to start with a new product concept without process development. Their production processes are often too inflexible to manufacture a range of different products.

The first contribution of the research was to investigate how the four factors: product type, development focus, customer collaboration, and the use of cross-functional teams in development projects are indicators that upstream companies are headed towards the same perspective in development issues as downstream companies. This change of perspective will imply a change of gravity, i.e. that other aspects are of interest in development work and this means that other working methods and networks must be implemented and understood. As a result the change of perspective must be enhanced to a managerial level of strategic renewal, see Fig. 8.

Another influential factor on strategic change, that must not be neglected, is the impact of information technology. It has come to influence all types of organizations during the 90s. It is shown in the study that information technology facilitates cooperation and information distribution/sharing. There is an increased use of e.g. databases in development projects today. However, the focus of this paper is not to elaborate this matter any deeper[2].

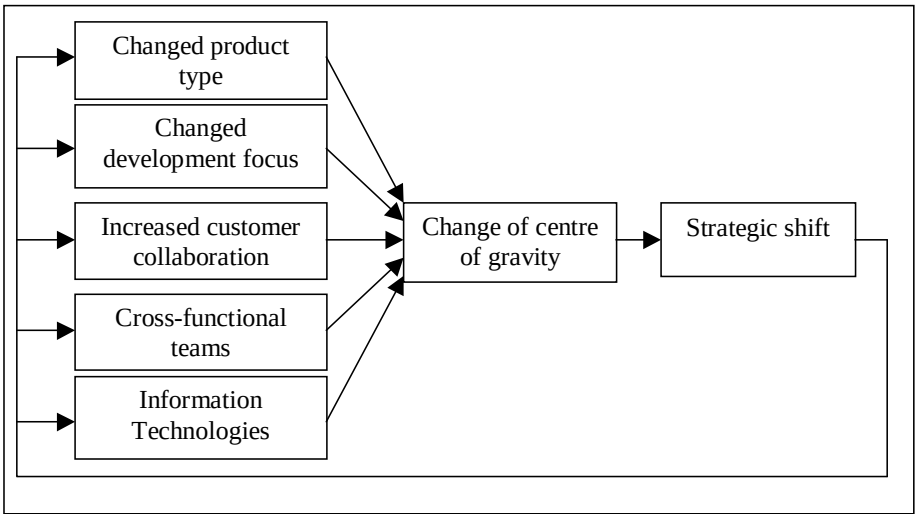

Fig. 8. The framework of the research.

[2]It is under elaboration in an additional paper, Chronéer, D., 2002 “Future relationships and networks in development work for process industries”.

There is a trend towards a more customer-oriented view within Swedish process industries, but what has explicitly changed in development work for companies in various process industries during the last decade? The result of this research shows that process industries no longer solely focus on development of the production processes, i.e. on technological issues that implies a defensive product development strategy (Utterback, 1996). Today, there are two roads to choose between for process industries, either to maintain a high-volume producer and have a cost-effective production processes, or to focus the business and find niche products that generate higher margins and profitability.

Many Swedish process industries choose the road to focus their businesses and develop higher margin products, because it is difficult to compete with low-cost countries. It has to be stated, that one major cause of the change is that, from a perspective of 20–25 years, there is an obvious change in the trend of the economical development for process industries in Sweden, a diminished consumption of e.g. steel products and an increased competition. Also, at the end of the 1980's and during the 90s the restructuring of the industry had resulted in a new ownership structure (mergers, acquisitions etc), which encompassed a wide spectrum of companies — from international giants to small-specialized niche producers.

Today, it is possible to develop more specific products due to the fact that customers demand more value-added products. This has led to an increased emphasis, for Swedish process industries, in product development, which is shown in a changed product type, changed development focus, and increased customer collaboration in development projects.

The first change for traditional Swedish upstream companies is the change of the product type since the customers play a more distinguished role today in development than for 10–15 years ago. There is an increased focus to find niche products that can generate higher margins for the companies. This has led to that the concept of the product has changed. Today it can contain services or competence attached to the product (sell a package). It can concern selling developing hours or other services connected to the customers' production processes.

The second change concerns the changed perspective in development. The effect of develop niche products is that developers need to attach other knowledge in development projects today. Developers are required to have knowledge about customers' processes, markets etc. to enable a more effective development exchange and sophisticated products. For example, it is required to visit customers at their own workshops to be able to show benefits of the product, the product's material properties. There are other aspects (new knowledge) that need to be included in development today, which a traditional development team does not

have. This new knowledge must be acquired ether internal or external. Development has another context today, e.g. development of services or competence attached to the product (sell a package).

A third important change for traditional Swedish upstream companies is the need to collaborate with customers and with other actors that can contribute with new knowledge into development projects. It is also indicated in the study that it is desirable to have customer collaboration early in product development projects. The research shows that there are an increased number of upstream companies that collaborate with customers in development projects. A large amount of the companies have undergone organizational changes during the last decade in order to create suitable integration mechanism to the market and the customers. It is essential to have a formalized link to the customers. This link can take different forms. The responsibility can be on

- development, i.e. a direct link to customers, especial when development concerns competence and service,
- marketing (with technical competence), i.e. marketing is the facilitator between development and the customers,
- technical service, i.e. technical personnel that have competence in both development issues and market aspects.

A fourth change is the need of cross-functional teams in development work today. As research has shown, collaboration in any form is often important, i.e. R&D/manufacturing/marketing integration, R&D/marketing integration, partnerships with supplier, customer integration, and strategic partnership. Collaborations in all forms are increasingly playing a major role in process industries. One reason can be that human resources are seen as more valuable today for companies. Another reason can be that there has been an extended amount of research on collaboration during the last decades and that team members have changed their attitudes towards cross-functional work. A third reason can be that it is easier to collaborate today due to information technologies.

But not only is the integration of internal functions important, integration of external actors like suppliers and customers have been emphasized in process industries during the 1990s. So, to have a network perspective can facilitate the analysis and understanding of critical actors in development work, which continuously change. Links to new competences and new knowledge that the product developer does not have must continuously be analysed and evaluated so that product development will be effective.

To change the view in product development projects, from production-oriented to be more customer-oriented, also involve a change in management and

organization of the project. The change of mind concerning a focus towards product development will have implications on future strategy for the company.

The implication of the change for an upstream company is that it is closing the gap to a downstream company. The procedures and management of development tend to be the same for both an upstream company and a downstream company. To make a distinction between companies today in terms of upstream and downstream is of no relevance. The specific characteristics between the two groups that Galbraith (1983) emphasizes have changed.

The second contribution of this research is the argument that there is a change for process industries concerning the change of focus in the value chain, which is not easily obtained. The industry's centre of gravity will affect the efforts to change procedures. Because this gravity is well rooted in the management and organization of projects (Galbraith, 1983). For process industries, this gravity is much focused on the production process and not the customers (see also Fig. 9).

Further, the results indicate a shift of the centre of gravity since there is an increased interest in product development and customer collaboration.

Today, it is not possible to divide companies according to traditional "upstream" characteristics as standardized product, low-cost producer etc. The result of the research indicates that upstream companies

- strive to gain higher value-added in their products by changing the concept of the product (e.g. selling competence and service),
- need to collaborate with customers in development projects,
- need to find suitable networks that integrate knew knowledge to development projects
- need to work with cross-functional teams in development

The main message in this research it is possible to be a traditional upstream company, but with a combination of product and process development.

But a changed product concept will have implications on the structure of networks and how to integrate resources and activities connected to development work. A general conclusion is that personal contact is the integration mechanism product development teams require to build trust and longsighted relationships with key suppliers and customers. However, this is both time-consuming and requires resources. Much of the network buildings are depending on the individual itself in development team. But, it is important that the company have a clear strategy concerning the importance and possible links to both suppliers and customers. If the link between a customer and development is through sales, marketing or technical service than this function needs to be known as a formalized facilitator in the development work.

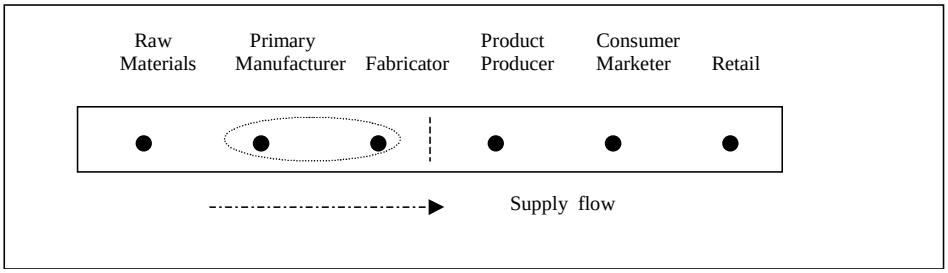

Fig. 9. The centre of gravity for steel and paper industries *(source Galbraith & Kazanjian, 1986).*

In sum, process industries in Sweden have shifted their "upstream-thinking" to "downstream-thinking", which implies new managerial systems and closer links to customers and process industries in Sweden have moved downstream, away from low margins and high capital intensity into higher margin, proprietary products. It implies a shift of the companies' centre of gravity.

Today, technical changes are happening rapidly, therefore it is of more importance for companies to build sustainable relationship with suppliers of equipment and processes. This is critical for traditional upstream companies if they need to keep up with technological changes in customers' production processes. However, network activities in development are increasing for process industries, there are no longer separate supplier vs. customer development. In many cases the companies view their suppliers as an integrated part of their own product flow process. The study indicates that all industries have the need to build sustainable networks. The principal point is to build networks of capabilities. Managers have to build formalized integration mechanisms to involve both suppliers and customers earlier and more deeply in the development process because much of networking in process industry is of personal basis. This requires a deep analysis of both suppliers and customers. The change of gravity will have implication of the strategy of the company, i.e. a strategic shift must be analysed and evaluated from the management.

Certain limitations of the study suggest directions for future research. The research is limited to companies in Sweden, but there is indication that this is not just an isolated phenomenon. However, international research on this matter as comparison is a future research topic. How process industries will manage production flexibility and product differentiating is an area that needs further research in the future.

Appendix A

The areas of changes within ore (O), steel (S), paper (Pa), chemical (C), rubber (R), plastic (Pl), and food (F) industry during the 1990s. One company can address several changes in the table.

The areas of changes	Comments about the actual changes concerning development work at the companies in the study
Product development focus	Develop better products due to new knowledge (O) Focus on niche products, specialized on material with unique properties (R) Change towards niche products (C) Increased number of niche products (F, Pa, S) Development of new properties (2 F) Increased product development focus and efforts (2 Pa, 2 Pl, 4 S)
Product concept	Sell development hours, integrate forward in the value chain with assembly and packaging combined to the product (R) Work with customers processes, has gained increased knowledge about customers' processes (C, Pl) Sell all products with technical service in a "package" even with niche products (C) Sell a complete concept, the experience, are "problem solvers" (2 C) Have increased responsibility of customers' development, sell a complete package with competence and a product. (Pl) Put price on customer profit (S) Increased personal service to customers, learn them to use the product (S)
Organization	Early line organization, now project organization with project leader (R) Flat organization (R) Organization towards specialization of material (R) Organizational changes toward focusing the business, clear link between development and sale personnel, through Project Manager (gather information and analyse the market) (R) Link development labs within the Group together to achieve economy-of-scale (C) Project organization (C) Continuous change due to changed needs from customers and the company (C) Organizational change due to focus on concept development (C) A division in technique divisions to enable focusing in product areas, channels to customers has changed, development closer to customers (C) Changed product development work to be the same in the whole Group (F) Direct link between development and marketing (F) Changed marketing function (F) Merger with company (F) Increased resources at development department with organized product development, merger with company (F)

The areas of changes	Comments about the actual changes concerning development work at the companies in the study
Organization	Centralized product development to gain economy-of-scale (F) Marketing, sale and product development work closely together to make product development more effective (F) Division in three R&D sections: product development, process development and strategic development plus a section that do customer projects in cooperation with the other sections (Pa) Decentralized R&D organization, a Technology centre work closely with development at production sites, merger. (Pa) Decentralize development closer to market units (Pa) Organizational change with the focus on product development process (Pa) Organizational fit within the divisions, continuous change (Pl) Changed organization (Pl) Decentralized product development, shorten communication ways (S) Technical market support, support activities towards customers and marketing (S) Changed product development from technical department to marketing department (S) Delegate responsibility to units (S) Sale organization contact with customers' engineers, education of customers engineers (S)
Project work	Team-building (R) IT-links that create virtual work groups to enable exchange of information. The Group has common IT platforms that enable project sharing (C) Change in documentation of projects (C) Project management, planning and control of projects (C) Functional food and behaviour science more important (F) Health, convenience, development consist of more today, more niche products, combination of marketing and the content of the product, packaging more important (F) More structure in product development (F) Packaging more important (F) Increased market input to development projects (Pa) Changed working methods, cross functional teams (Pa) Control pf projects (Pa) Made product developer to market technicians to catch customer needs and communicate with procurement and technique at customers (Pl) Databases to systematize projects (O, 4C, 2S)

The areas of changes	Comments about the actual changes concerning development work at the companies in the study
Customer/ supplier collaboration	Focus on few customers (R) Customers have changed (C) Customers are involved earlier in projects (C) Work more independent with customers (C) Work more closely with customers and suppliers (C) Focus on suppliers of parts (C) Development projects with suppliers (C) More flexibility and quicker response on customer's need (F) Raw material suppliers are viewed as a resource that can decrease product development time (F) Increased customer collaboration to gain insight of customer problems and their product development (Pa) More efficient input from customers to projects (Pa) Increase productivity at customer's process, higher demands on supplier collaboration in projects (Pa) Increased customer-focus in projects (Pl) Increased collaboration with customers (Pl) Towards customer demands (S)

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PAPER II

Understanding changes in product development in Swedish process industries

Submitted for publication

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Understanding changes in product development in Swedish process industries

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Abstract

The management of research and development (R&D) has dramatically changed in the last few decades. But what is happening to product development in Swedish Process Industry? The paper shows that Swedish Process Industry has experienced significant changes in the past decade, towards product-focused development. The research is based on 4 case studies and a survey of 50 companies within Swedish Process Industry. The findings show that upstream companies in Process Industry have changed their strategy in the 90s towards a more product-focused development. Factors that dictate product development work is not longer just production parameters. Today, product development incorporates an understanding of customer needs. Product development in process industries is today more about managing upstream and downstream relationships.

1. Introduction

New product development, i.e. how to develop new products faster and more effective, is a phenomenon that gained a lot of interest during the 90s, leading to R&D management practices having changed significantly for a range of industries. Today, innovation is essentially a knowledge production process that requires creativity and involves great uncertainty about innovation output (Guangzhou Hu, 2003). But how have these changes come to affect product development in Process Industry, which has a costly and fixed production process? This paper examines how Swedish Process Industry can maintain its competitive power with a focus on product development. The traditional view of Process Industry is that product development is a result of process development, i.e. process and product development are interlinked. This has led to a process-oriented perspective on product development, which involved primarily an interest in the technological solutions of the production process. But this paper argues that this has changed.

Process Industry contains a number of process equipment items that are supported in structures, linked by pipework, and controlled by instrumentation (Whittaker, 1995) and the processing of material occur in a continuous flow. It can be described as following: "Process Industry is Production Industry using (raw) materials to manufacture non-assembled products in a production process where the (raw) materials are processes in a

production plant where different unit operations often take place in a fluid form and the different processes are connected in a continuous flow" (Lager, 2002, p.108).

During the last two decades, the phenomenon of innovation, and especially product development, has expanded to incorporate issues like finding success factors in R&D projects (Balachandra and Friar, 1997), co-location (Van den Bulte and Moenaert, 1998), internal cross-functional integration (Song et al., 1998; Kahn, 2001; Olson et al., 2001), and external collaboration with suppliers and customers that enhance product development performance (Gupta and Wilemon, 1996). In these networks, marketing plays an essential role in coordinating the information flow from customers to the development projects (Bondra and Davis, 1996). Knowledge of customers, markets, and commercialization processes can be gained by closely working with marketing as well as co-developing products with customers (Gupta and Wilemon, 1996). Rothwell (1994) introduces the so called fifth-generation innovation process, a 'system and integration networking model', as a multi-institutional networking process (strong linkages with leading-edge customers, strategic integration of primary suppliers. The 'fifth generation' innovation process is regarded as a 'system and integration networking model', as a multi-institutional networking process, i.e. strong linkages with leading-edge customers, strategic integration of primary suppliers (Edler et al., 2002). This implies that the content of innovation is changing, e.g. the role of R&D (Germeraad, 2001) and the pattern of innovation (Gupta and Wilemon, 1996). A decentralized mode of managing innovation can reflect the overall organisational structure of the company or an innovation strategy or both, giving high priority to incremental innovation with a primary concern for downstream and inter-functional relations (Christensen, 2002).

A change in the innovation process also implies a change of competence in product development work. Danneels (2002) states that understanding the new product development process requires a simultaneous view of both customers and technology, i.e. that new product development brings together two competences (e.g. manufacturing and engineering know-how versus knowledge of customer needs, distribution and sales channels). That two types of competences merge in new product development has implications for the types of new products the company pursues. The processes of knowledge and individual competence management constitute a potentially rich source of innovation for firms that are not completely contained within the structures of an R&D organisation (Paraponaris, 2003). However, whether product development will be successful is difficult to measure. Johne (1996) states that many managers continue to regard product development as successful if it does not fail, meaning that this is a dangerous way to measure success and that product developers need to achieve a broader business development picture.

As shown,, product development has come to encompass new challenges. Companies in some industries have moved to a new paradigm of competitiveness, namely solutions innovation, i.e. package and deliver solutions (Shepherd and Ahmed, 2000). The company must then add a so-called customer-centric component to its organisation and then integrate that component with its product-based structure (Galbraith, 2002).

While management of product development in the manufacturing industry has been researched for more than two decades, it has received very little attention from researchers when concerned with Process Industry. However, it has been indicated that Swedish Process Industry have changed their "centre of gravity" (Chronéer, 2003), i.e. old tradi-

tions and ways of working are changing. This is most obvious regarding development issues where product development is increasingly gaining a higher interest in Process Industry. But how can Process Industry change its direction in development work? Can Swedish Process Industry maintain its competitivity?

This paper reports the results of two studies. Study 1 involved case studies and was conducted to achieve a better understanding of product development work in Process Industry. The results lead to Study 2, involving a survey concerning the change of direction in development work, i.e. from process-orientation towards a more product-oriented development in Swedish Process Industry. Therefore, this paper aims to answer the following question: Have so called upstream companies changed their development focus during the 90s or has R&D moved to more competitive countries? That is, have upstream companies come closer to their customers concerning product development, and if so, how is this achived? Before a presentation of research methods and findings, it will be helpful to briefly discuss the characteristics of Process Industry and some of the changes concerning innovation.

2. Process Industry - characteristics

The literature on the Process Industry has focused primarily on cost reduction and economies of scale (Barnett and Clark, 1996) and the production process, e.g. production control (Fransoo and Rutten, 1994). Part of this interest can be attributed to a belief in the economics of scale and an unwillingness to invest in emerging technologies. Process Industry has characteristics that are very different from assembly/fabrication industries and may require a different type of management emphasis (Utterback, 1996). Process development is the difficult and constraining aspect of product development in the Process Industry. Lager (2002) points out that there is seldom a clear definition of process and product development in literature concerning Process Industry.

However, if market needs change and a business need to change from a production-orientated perspective on product development projects to a more customer-oriented perspective, then the entire organization of the projects will also have to change. But should product development then be a part of process development, where product development issues are discussed in relation to internal production-related questions, or if it should be separated, i.e., form a separate unit that focuses on the product, not the technological issues (Utterback, 1996)?

The underlying assumption, concerning R&D in Process Industry, is that since product and process are symbiotically related in the production system, then fundamental changes in the one must incite and parallel fundamental changes on the other. Etienne (1981) argues that innovation involves bringing together expert knowledge of a diverse character to form a consistent, unified package, i.e. the product.

In Process Industry, the products are processed with minimal interruptions in any one production run or between production runs of products that exhibit process characteristics, such as liquids, fibres, powders and gases (Gunasekaran, 1998). The general characteristics of this industry add value to materials by mixing, separating, forming, or chemical reactions. Process Industry obtains their raw materials from mining, forest or agricultural industries. These raw materials have natural variation in quality and many products

are produced from a few kinds of raw materials, compared to the usual schedule in discrete manufacturing, in which end items contains many different components (Gunasekaran, 1998). However, recently there has been a reawakening; companies in Process Industry are cutting costs and repositioning themselves in the market place. Since technological developments are moving at an ever more rapid pace, product life cycles are becoming shorter (Ita and Gross, 1995).

Changes for Process Industry

What has happened to Process Industry during the last decades? Burgess et al. (2002) found that the UK chemical industry is increasingly moving from commodity to speciality production. The chemical industry is built on both product and process innovation, but with customers increasingly demanding better products, lower prices and more tailored services, the industry is changing its approach to innovation (Roberts, 1999).

The Process Industry in the Western World has moved from a position of power and wealth in the 1960s to a struggle for survival in the 1990s (Anderson, 1997). Today, the Process Industry comprises a large segment of the economy. From commodity raw materials like steel, paper, and glass to value-added materials such as advanced ceramics, the Process Industry is a unique set of industries built around the production processes that manipulate material properties to produce raw materials for use in a variety of applications (Barnett and Clark, 1996). Barnett and Clark (1996) also present a four-dimensional characterization of technological newness for product development projects in the process industries in which product development is closely tied to process innovation. They focus on a second arena of innovation in the process industries – the development of new modified materials.

In the international perspective, Sweden is one of the large actors on the global pulp and paper market (Melander, 1997). Steel industries are also one of the Swedish main industries. But, Swedish industry has undergone far-reaching changes over the past decade. The overheating of the late 1980s gave way in the early 1990s to the worst recession since the depression of the 1930s (The Federation of Swedish Industries, 1998). The crisis hit some sectors of industry more than others. Traditional industries such as metal products, the automotive industry and machinery saw substantial parts of their production capacity eliminated, while pulp and paper, pharmaceutical and electronics sectors all expanded. The crisis led to a rapid and extensive restructuring of the Swedish industry (The Federation of Swedish Industries, 1998). Further, in the 70s and the 80s, mini-steel mills achieved an almost complete dominance in certain established products (Teoh, 1988). Continuous growth of steel industry is dependent on developing new product opportunities including the high-value-added products.

After a recession, which started at the beginning of the 1990s, the rate of change increased within various industries, e.g. increased focus on service, rapidly increasing productivity, higher skills requirements. For example, new technologies became more and more important in the steel industry and the steelworks concentrated in a few a special products (Nisser, 1997). Swedish steelworks that made special steel began weeding out their products and changes led to still greater specialization. Several firms merged and took charge of different areas; i.e. one company focused on stainless flat products (sheet, band) and welded tubing. Another focused on stainless steel wire and seamless tubes etc.

Schriefer (1996) found that research and development in the U.S. steel industry dropped dramatically during the 80s and 90s. He argues that R&D emphasized shorter-rang product improvements and process upgrades instead of long-range projects. He also found that steelmakers started to develop products with a focus on how the customer would use the steel to fabricate his products. Today, steel products have properties and performance characteristics that never could be achieved in the past (Schriefer, 1997) and steel markets are internationalized, and the ability to market steel depends on having the right products available and developing new products to meet consumer demands.

Why was the recession harder in some countries? The purpose of this paper is not to give a full answer to this question, it is far too complex. However, Norway experienced a decline of the traditional pulp and paper industry in the early 90s. Moen (1994) suggests that the mix of factors involved was complex. He demonstrates that a wide variety of historical, institutional and environmental factors have to be included also in the analysis of and the explanation of technological change. Moen (1994) points out that a factor of vital importance in pulp and paper making is forest resources and he found that the Norwegian industrialist proved to be less willing in using techniques which did not favour the exploitation of spruce. In Sweden things went differently, according to Moen (1994). Here unexploited forest resources represented an incentive to develop new methods.

Today, environmental and economic pressures are forcing management to look very critically at the operation of existing assets. Companies are cutting costs and are targeting strategic dominance in selected markets by rationalising their product portfolios. Much of industry has concluded that it can not solve its problems by cost-cutting alone. Understanding the larger system requires knowledge of both 'hard' (e.g. engineering) and 'soft' factors (e.g. the systems management, marketing and sales functions) (Anderson, 1997).

In other countries, like China and India, outdated production methods are widely practiced and are a major obstacle to the Steel Industry's growth (Mehta, 1998**)**. Metha (1998) found that although China has emerged as the largest steel production nation, it still relies on imports. The Chinese authorities are concerned over the burgeoning steel plants whose productivity is very low as costs continue to rise meteorically. They have been unsuccessful attempts to sell of steel plants to foreign investors. However, there is one example of a merger between one of China's biggest sheet steel manufacturing companies and a foreign company. Further, Huang et al. (2002) investigated the Chinese steel industry practitioners' perspectives of new product development success factors and the importance of management functions to new product success. They found that market-based factors were ranked ahead of technical and organizational factors in terms of importance for success.

What about networking in Process Industry? Jokinen and Heinonen (1991) pointed out early in the 90s that the Finnish paper industry has a tradition of cooperating, not only in research but in product development and even marketing. Finnish companies saw early universities as suppliers of human resources. Other researchers (Hutcheson et al., 1996) also emphasize that the role of networks in Process Industry has grown. Hutcheson et al. (1996) explored issues concerning technological innovation in the network of firms linked to the chemical industry, with particular reference to the process plant contracting industry. They found that technological innovation plays a significant role in the success of the network of firms involved in designing, manufacturing, supplying and operating chemical process plants.

Understanding market and customer needs is one of the keys to successful innovation in many industries, even though disparate markets and operations naturally lead to different approaches to innovation. Roberts (1999) means that the chemical industry is built on both product and process innovation, but with customers increasingly demanding better products, lower prices and more tailored services, the industry is changing its approach to innovation. However, product development in the chemical industry is still a largely product-focused, rather than a market-focused process. The shift to a market-focused approach is critical and requires changes in philosophy, approach and culture (Strezo, 1999). Strezo (1999) continues that a shift to a market-focused approach is more critical and requires considerable changes in the company's philosophy, approach, and culture, since products in a process industry have several user levels: both an end user and often one or more intermediate users. As a result, R&D is often isolated from the rest of the company and especially from marketing.

There are other changes in Process Industry. Gunasekaran (1998) states that product life cycles are getting shorter, and the close coupling of business and technology strategy has become critical. He found that the current trend in Process Industry includes rapid prototyping and advancement in technology and new materials, increased creative product innovation, increase reliance on automation and increased complexity, performance and reliability of products.

Several researchers state that customer collaboration is increasingly important today in development projects (Neale and Corindale, 1998; Roberts, 1999). To improve customer relationships, feedback is of utmost importance, though difficult to obtain. Närhi (1997) found that customers are reluctant to fill out questionnaires, even if they understand the importance of it. He continues that at mill sites, production planning, quality teams, and production people, i.e. the whole organisation and not only the salesmen, have to work for customer satisfaction. However, Schriefer (1996) states that steelmakers today develop products with a sharper eye on how the customer will use the steel to fabricate their products.

Since there are indications that the developmental focus in a process industry is shifting from process to product (Strezo, 1999), organisation and management of development work need to change with it (Chronéer, 2003; Van Donk, 2000). For example, the steel industry has changed from a natural resource based industry to a market based industry (Tomiura, 1997). Still, it remains a capital intensive industry.

Upstream vs. downstream company

Process Industry consists of a range of different types of companies acting in different types of industries. These companies in various industries adapt to changes in product development easily or with more difficulties. However, every industry has a value-added supply chain, a sequence of activities that transforms raw materials into an end product or service. But the company's position in this supply value chain will play a matter in adjusting to current changes in e.g. markets. Galbraith and Kazanjian (1986) give a description of the value-chain in a manufacturing industry. They state that the value-added supply chain begins with a raw material extraction stage that supplies crude oil, iron ore, or logs to the second stage of primary manufacturing. The second stage is a variety-reducing stage to produce a standardized output like petrochemicals, steel, and paper

pulp. Fabrication of commodity products from primary material makes up stage three. Fabricators produce, e.g., polyethylene, sheet steel, or cardboard cartons. The fourth stage involves the producers of the product, who add value usually through product development. The following stage includes the manufacturer and marketer of consumer products. The last stage consists of the distributors and retailers who sell to the final consumer. These companies add value by creating a time and place utility.

The supply value chain can be divided into two halves, i.e. upstream and downstream companies, with each stage having different success factors. However, there are some fundamental differences that illustrate the contrast between upstream and downstream companies. Galbraith and Kazanjian (1986) state that downstream stages add value by producing a variety of products to meet varying customer needs. Downstream value is added through advertising, product positioning, marketing channels, and R&D.

In sum, Galbraith and Kazanjian point out those characteristics such as standardization, line-driven organisation, process innovation, capital intensive and technological know-how illustrate upstream companies. In contrast, downstream companies are more concerned with customisation, line/staff (they produce multiple products that require larger staffs), product innovation, people intensive (critical skills centre on human resource management), and market skills.

3. Research methods

The main purpose of this paper is to investigate what is happening to product development in Swedish Process Industry. Literature searchers concerning product development in Process Industry showed only few publications. Therefore a two-stage methodology is used. In the first exploratory stage, 21 semi-structured interviews were conducted in four case studies, two steel companies and two pulp/paper companies (in 1997). The main purpose of these interviews was to understand product development work in Process Industry and to provide insights into key issues of R&D management practises in Process Industry. The respondents were working in product development teams and could relate to the same product development project at each case company.

The second stage involved a quantitative study, to gain a more representative view of some of the changes concerning product development in Process Industry. It is based on a survey among 50 companies in various industries, i.e. mining, steel, pulp/paper, chemical, rubber, plastics, and food/dairy (in 2000). Based on the interviews in stage one, a questionnaire was constructed in stage two. However, in order to eliminate possible misinterpretation of the questions and to create discussions of the topic, telephone interviews with one representative at each company were conducted in stage two. Altogether, 50 companies participated with one respondent at each company. Since the purpose of the study was to investigate current product development work, changes during the 90s, and future needs to product development projects, the respondents needed to have deep insights in development work. Therefore, most respondents were R&D managers while in smaller companies some were project leaders or members of a product development project.

Data collection and analysis

The criterion for selecting the companies to the study was that they should be part of the "traditional" process industry, i.e. produce a product that can be further value-added in the next stage of the value-chain (e.g. by customers in their production process). A sample of companies was taken from industry lists to stage two of the research, which identified those companies active in the specific industries mentioned above. Representatives of Swedish branch organizations also came with suggestions of existing companies. However, due to the scarcity of available companies in the selected industries, the total amount of companies is quite low. Companies were initially contacted by telephone to ensure that they had/were involved in development projects, to identify the key respondents, and to solicit cooperation. Out of 55 companies, 50 agreed to participate in the research. To ensure reasonable reliability of the data, respondents received a copy of their answers to the questions where they could make alterations, etc. Table 1 gives the distribution of the companies in each branch sector and their size. The companies are divided into three groups: small, medium, and large, depending on the number of employees.

Table 1. Number of companies in sample by Type of Industry, Size, and Product

Type of Industry	**Size of the company**			**Type of product**		
	Small (no. employees <100)	**Medium** (100≤ no. employees < 500)	**Large** (no. employees ≥500)	**High-volume**	**Niche**	**Mixed**
Mining	0	0	2	2	0	0
Steel	0	1	8	1	4	4
Paper	0	0	7	2	2	3
Chemicals	6	6	3	5	5	5
Rubber	1	2	3	0	5	1
Plastics	2	2	0	0	4	0
Food/Dairy	0	1	6	0	1	6
Total	**9**	**12**	**29**	**10**	**21**	**19**

The second stage also consists of a comparison of the 50 companies' strategies (i.e. the Groups' strategies) from the seven process-based industries over a 15-year period (based on an analysis of annual reports in 1985 and in 2000). That is, the analysis was based on how the companies changed their statement concerning their strategic intention of development work (i.e. what was regarded as important in respectively year and what was the main focus). Key terms like product development, higher margins, value-added products, and customer need were searched for in the strategy statements from 1985 and 2000. There is an indication of a changed strategy if the company emphasizes some of these key terms in the year 2000, but not in the year 1985.

Annual reports are one of the documentary data source for longitudinal studies. Many companies produce them at the same time of the year, and they are readily available. They have been used in past research to assess and explain corporate strategies, to identify key areas of competition, and to explore causal reasoning within firms (Huff and Huff, 2000).

In the two stages, most of the interviews were recorded and typed (in a few cases, circumstances made it impossible to record). All interview materials were then coded with a software technique called 'Non-numerical Unstructured Data Indexing Searching and Theorizing' (N5), a computer package designed to aid users in handling non-numerical and unstructured data in qualitative analysis. The texts were first coded with nodes and organized in a "tree" structure, allowing for thorough qualitative analyses of the material concerning, e.g. future development needs. The material was then tested to investigate if there is a relationship between certain variables.

Finally, the research ended with a comparison between the year 2000 and the year 2004 of the 50 companies location of R&D. This comparison gives an indication if Sweden is capable to maintain a competitive climate of R&D.

4. Results and Analysis

In order to investigate what is happening to product development in Swedish Process Industry, the following hypothesis will be tested.

Hypothesis: *Traditional upstream (process-based) companies in Sweden have changed development focus during the 90s and therefore also their strategy towards value-added products*

The result of the cases

The results from the cases studies, conducted in 1997, are presented with a descriptive approach. The purpose of this study (four cases in the steel and paper industries) was to investigate how Process Industry conducts product development. The study emphasized areas of new product development that needed to be strengthened and enlightened.

Results indicate a change of development focus for Swedish process industries (steel and paper). Further, the study indicated that the role of product development had grown for all four companies; an indicator of this change was the formation of special product development teams and separate product development departments. Customers demand more specific products with certain material properties leading to a re-organisation that occasionally involves special product development committees. Hence, current product development is not merely a result of process development, even if they are still closely interrelated. The main result from this study was an increased interest in product development, though a centralized R&D was handling long-term research or according to instructions from product development teams at production units. Another result was a lack of suitable integration mechanisms to link development teams with suitable actors (both internal and external).

An increase of a product-focused development process industry will require that other areas of knowledge and competences be incorporated in development projects. This required further research of how Swedish process industries viewed their own product development, i.e. if product development is part of process development, where product development issues are discussed in relation to internal production-related questions, or if it is separated.

The survey

To test whether any differences exist in Swedish Process Industry concerning a change of development focus, the fifty companies in the study are **first** divided into two groups according to traditional characteristics for 'upstream vs. downstream company', as per Galbraith's categorisation in the supply chain. The companies' product types in 1985 determine the categorization, which is also based on Galbraith's spectrum of product characteristics (the degree of value-added) in combination with their stated development intentions in 1985. Table 2 shows the distribution of the division.

Table 2. Number of companies in sample by Type of Industry and Number of Upstream vs. Downstream companies (divided after the companies' product type in 1985)

Type of industry	Traditional Characteristics of the Companies	
	Upstream	Downstream
Mining	2	0
Steel	7	2
Paper	4	3
Chemicals	9	6
Rubber	2	4
Plastics	0	4
Food/Dairy	4	3
Total	28	22

There are some fundamental differences between upstream and downstream companies. Galbraith states that downstream stages add value through producing a variety of products to meet varying customers' needs. The downstream value is added through advertising, product positioning, marketing channels, and R&D.

To investigate if any differences exist between upstream and downstream companies concerning development and strategic changes, the companies need to be analysed.

Cross-tabulation and chi-square test

To test if there is a relationship between strategic change for Swedish process industries and a change for upstream companies towards a customer-focus in development, the following section presents a cross-tabulation table and a chi-square test with nominal variables. The tested variables are the following;

- change of strategy towards customer/product focus
- upstream vs. downstream characteristics

The first step is to investigate if any difference between upstream vs. downstream companies exists, when it concerns a change of strategy during the 90s. A cross-tabulation, Table 3, shows the frequency of each response at each company when concerned with the variable upstream or downstream company and if they have or have not

changed towards a customer-focus during the 90s. No records for five of the companies exist (due to for example mergers), so a total of 45 companies are analyzed.

Table 3. The division in upstream vs. downstream and change towards customer focus

Change of strategy between the year 1985 and 2000			
	Changed	Not changed	Total
Upstream	17	10	27
Downstream	4	14	18
Total	27	24	45
Phi = 0,400, Sign. = 0,007			

Table 3 shows a majority of upstream companies, 17, that have changed their strategy during the 90ths. It should be noted that 9 upstream companies and 13 downstream companies already had a customer-focused strategy in 1985. Altogether, only two companies do not have a customer-focus in the year 2000 (one "upstreamer" and one "downstreamer"). But to analyse if there in fact is a difference, a chi-square test is done. While the chi-square test is useful for determining whether or not there is a relationship, it does not indicate the strength of the relationship. Symmetric measures attempt to quantify this and are based on the chi-square statistic. Table 3 also shows that the two-sided asymptotic significance of the chi-square statistic is less than 0.05 (Sign. = 0,007); therefore, a difference between the two groups is shown. The chi-square test measures the discrepancy between the observed cell counts and what you would expect if the rows and columns were unrelated.

Has there been any change concerning location of R&D functions in Sweden? Table 4 shows that in the year 2004 (in comparison to the year 2000), 88% of the companies still have their R&D function in Sweden.

Table 4. Location of R&D

Type of industry	R&D location			
	No change - R&D in Sweden	Merged but R&D still in Sweden	No change, but R&D abroad	R&D incorporated in other company abroad
Mining	2	0	0	0
Steel	7	2	0	0
Paper	6	1	0	0
Chemicals	13	0	1	1
Rubber	4	1	0	1
Plastics	2	0	0	2
Food/Dairy	6	0	1	0
Total	40	4	2	4

The results show that there has been a change for Swedish upstream companies when concerned with development. The phenomenon product development has expanded to incorporate industries other than traditional manufacturing industries. Traditional up-

stream companies, known as high-volume producers, are currently approaching their markets. An implication of a change of development will lead to other changes in organisation, working procedures, integration mechanisms, links to customers, networks, etc.

Factors dictating product development

This section will try to explain how the content of product development work has change for Swedish Process Industry. Process and product development are very interrelated in process industries. Changing a production parameter can greatly impact the material properties of the product. Today, one factor that all industries have as a main driver in development work is the customer. For process-based companies, this means that developers need to be familiar with their customers' production processes, see Table 5. The product's material properties must be transformable further down the value chain.

Table 5. Factors that dictate product development in each industry. (Number of companies within brackets)

Mining	Steel	Paper	Chemicals	Rubber	Plastics	Food
Increase productivity (1)	Customers/Market (5)	Achieve certain properties (4)	Customers/Market (10)	Customers/Market (5)	Customer (4)	Customers/Market (7)
Customers' needs (their process) (1)	Process (2)	Customers/Market (2)	Environment/Law regulations (5)	Production process (1)	Law regulations (1)	Own ideas (1)
	Own ideas (2)	Cost reduction (1)	Economy (3)	Internal ideas (1)	Technology (1)	Achieve certain properties (1)
	Quality improvements (1)		Suppliers (2)		Costs (1)	
	Identify needs (1)		Technology (1)			
	Costs (1)					
	Environmental demands (1)					
	Literature (1)					

For present-day process industries, product development work consists mainly of developing material properties. But the most interesting comments in this study regarding the contents of development are:

- development of the total product concept, i.e. both material properties and technological aspects of the customers' production processes or packaging aspects
- customers' processing , i.e. technological aspects of the customers' production processes
- competence regarding the product

- the functionality of the product, i.e. the total concept of the product including packaging
- knowledge of health, safety, convenience, and experience
- participation in the customers' product development
- technology and material adjustment, i.e. to fit the customers' needs
- finding specialised products

The above comments indicate that not just the stand-alone product is incorporated in development; there are other areas a development team must consider that require new technological and customer competences.

5. Discussion and conclusions

It is shown in this paper that R&D management practices have changed significantly for Swedish Process Industry, but the results show that Swedish Process Industry can maintain its competitive power. One way is to focus on product development and development of specialized products towards customers. There has not been any major restructuring of R&D units during the early 2000; the majority of the companies in the study still have R&D units in Sweden. However, it has to be noted that this matter is complex. There are other variables influencing the competitive power of a Process Industry, e.g. the price on energy.

The results in this paper show that upstream companies in Process Industry have changed their strategy in the 90s towards a more product-focused development. Factors that dictate product development work is not longer just production parameters. Product development has come to encompass new challenges for Swedish Process Industry. Today, it incorporates an understanding of customer needs. But since product development in Process Industry consists of development of material properties and that the material often is further value added in the supply value chain, product development incorporates also a deep understanding of the entire value chain (e.g. customers' production processes), because of the transformation of the material properties. An understanding the product development process requires a simultaneous view of customers and technology, using product innovation to link technology and customer competences (Danneels, 2002). This is especilly true for the Process Industry. It is also indicated in the research that some companies have moved to a new paradigm of competitiveness, namely solutions innovation, i.e. package and deliver solutions. Other aspects need to be considered in product development projects, like selling technological competences

The study indicates a tendency for upstream companies to move closer to their customers when it concerns development. This is in accordance with Strezo (1999), who reports that the focus in development is shifting from process to product in the chemical industries. But as Strezo emphasizes, a shift to a market-focused approach is critical and requires changes in philosophy, approach, and culture. This paper supports this view. A change of development focus for Process Industry, and to incorporate a large part of the supply value chain today requires not only changing the mindset of the development team, but also the "mindset" of the organisation. Product developers need to achieve a broader business development picture Therefore, a change towards product focus will be insufficient; a change towards market focus is needed. A change of development focus

means to ”understand market signals”, to obtain a holistic view in development, to view trends, etc. This requires a change of philosophy and traditions, and that networking cannot depend on the interests of a single person. It requires hard work from all actors involved in development to build suitable work processes and models that facilitate acquiring competences and building networks. One consequence of this change, to succeed with product development today, process industries must break from its tradition of only focusing on the technological aspects in development projects and incorporate customer and supplier competences. Since product development for process industries concerns material properties; a dilemma for industry is being able to transform a product into the customer's production process, requiring developers must be at the customer's site to supervise the process and analyse the result. As well, it is increasingly important to build sustainable links between R&D and customers and R&D and suppliers.

It is important for R&D management to realize that a change of development focus also means a change of how to conduct development work, and perhaps, breakaway from old traditions, which is not easily achieved. A changed development focus means that new knowledge need to be incorporated, new collaboration partners must be integrated, new networks, new means to integrate different disciplines and other actors (both internal and external), etc. Current product development is about sharing information and building suitable networks essential for successful developmental work. Product development in process industries is more about managing upstream and downstream relationships.

There is a need of extensive research concerning how process industries can become more market-oriented in their development, i.e. research concerning the future role of R&D, how to achieve product differentiation, organisational forms, etc.

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PAPER III

Are some process industries more product-focused than others?
- The role of innovation

Submitted for publication

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Are some process industries more product-focused than others? - The role of innovation

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Abstract

The central objective of this paper is to investigate if there are some process industries that are becoming more product-focused than others. How has the view of product development changed in Swedish process industries? The study is based on a survey containing 50 companies, defined as upstream and downstream process-based companies. The study indicates that there is no major difference between different process industries today. The majority of the companies in all industries are to some extent focusing on product development. However, the difference is that some companies and industries have a longer tradition of product development than others. Significant characteristics describing various industries are about to be erased today. Heavy steel and paper industries are as interested as food and plastic to develop more specific products that gain higher value-added. The role of innovation is changing for Swedish Process Industry.

Keywords: Process industry, product development, upstream, downstream, innovation

1 Introduction

R&D management practices have changed significantly during the last decades. The concept has expanded to include not just management of R&D resources but also management and integration of technology with other aspects [1]. In this change, new product development, i.e. how to develop new products faster and more effective, is a phenomenon that has gained a lot of interest during the 1990s. But, what impact has this phenomenon had in Process Industry, which traditionally has had the main focus on the production process and cost effectiveness? That is, how has the view of product development changed and what impact will this have on the overall view of managing innovation? Are there differences between different process industries, i.e. are some categories of process industries that have come more product-focused than other.

While management of product development in the manufacturing industry has been researched for more than three decades, it has received very little attention from researchers concerned with Process Industry. But, it is indicated that Swedish process industries have changed their "centre of gravity" [2], i.e. old traditions and ways of working are changing. This is most obvious regarding development issues where product

development is increasingly gaining a higher interest in process industries. Therefore, the main purpose of this paper is to achieve an understanding of how product development work in process industries has changed and what factors play a matter?

The remaining parts of this paper are organized as follows: section two introduces briefly the framework of innovation; section three introduces the reader to the characteristics of Process Industry and research concerning Process Industry; section four presents the research framework; section five analyzes the innovation practices in Process Industry; and section six gives a discussion and concludes the paper.

2 Changed innovation pattern

The focus in management of technology (MOT) and research and development (R&D) has dramatically changed in recent decades. Today, large firms have increasingly developed overall strategies for their management of technology [3]. Rothwell [4] states that the 'fifth generation' innovation process is regarded as a multi-institutional networking process with strong linkages with leading-edge customers and strategic integration of primary suppliers. This change of innovation will also change the role of R&D [5]. A decentralized mode of managing innovation can reflect the overall organizational structure of the company and/or an innovation strategy that gives high priority to incremental innovation with a primary concern for downstream and inter-functional relations [6]. It is noted that R&D organization and management are heavily affected by the nature of the R&D process and the relative importance of the activities within R&D [7].

There are different approaches to the management of technology, where the strategic MOT seems to be the latest trend in the development of MOT [1]. Lowe [8] found that technology is a branch of human knowledge which applies scientific principles and practical knowledge to physical entities and systems, i.e. a particular technology contains a body of formalized, transmittable scientific knowledge. Technical change is generally confined to changes within one or more of the other constituents of a technology, particular to techniques and know-how.

Today, management of technology is concerned with achieving higher levels of efficiency and productivity while rendering the organization more effective in achieving its desired goals. It is also concerned with being competitive in an increasingly global marketplace to ensure survival [9].

3 Process Industry

Research concerning Process Industry has mainly been related to the production process. During the 80s, various articles appeared regarding production control in process industries and the vast majority focused on the typical characteristics of Process Industry, namely production control [10]. Part of this interest can be attributed to a complacent belief in the economics of scale and an unwillingness to invest in emerging technologies.

Process Industry has characteristics that are very different from assembly/fabrication industries and may require a different type of management emphasis [11]. Process

development is the difficult and constraining aspect of product development in the Process Industry. Since product and process are symbiotically related in the production system, then fundamental changes in the one must incite and parallel fundamental changes on the other. Etienne [12] argues that innovation involves bringing together expert knowledge of a diverse character to form a consistent, unified package, i.e. the product. However, Lager [13] points out that there is seldom a clear definition of process and product development in literature concerning Process Industry.

In Process Industry, the products are processed with minimal interruptions in any one production run or between production runs of products that exhibit process characteristics, such as liquids, fibres, powders and gases [14]. The general characteristics of this industry add value to materials by mixing, separating, forming, or chemical reactions. Process Industry obtains their raw materials from mining, forest or agricultural industries. These raw materials have natural variation in quality and many products are produced from a few kinds of raw materials, compared to the usual schedule in discrete manufacturing, in which end items contains many different components [14]. However, recently there has been a reawakening; companies in Process Industry are cutting costs and repositioning themselves in the market place. Since technological developments are moving at an ever more rapid pace, product life cycles are becoming shorter [15].

Product development in Process Industry

What has happened to Process Industry during the last decades and are there differences between process industries? This section will try to give an insight of the research concerning product development in different process industries.

The Process Industry in the Western World has moved from a position of power and wealth in the 1960s to a struggle for survival in the 1990s [16]. Today, the Process Industry comprises a large segment of the economy. From commodity raw materials like steel, paper, and glass to value-added materials such as advanced ceramics, the process industries are a unique set of industries built around the production processes that manipulate material properties to produce raw materials for use in a variety of applications [17]. Following sections give an insight of existing research related to different process industries.

The steel industry: In Sweden, in the following years after a crisis in the early 1970s for Swedish iron and steel industry, new technologies became more and more important and the steelworks concentrated in a few a special products [18]. That is, Swedish steelworks that made special steel began weeding out their products and changes led to still greater specialization. Several firms merged and took charge of different areas; i.e. one company focused on stainless flat products (sheet, band) and welded tubing. Another focused on stainless steel wire and seamless tubes etc. Also, in the 70s and the 80s, mini-steel mills achieved an almost complete dominance in certain established products [19]. Continuous growth of the steel industry is dependent on developing new product opportunities including the high-value-added products. Today, steel markets are internationalized, and the ability to market steel depends on having the right products available and developing new products to meet consumer demands. Further, steel

products have properties and performance characteristics that never could be achieved in the past. However, Schriefer [20] argued that R&D, in the U.S, steel industry, emphasized shorter-rang product improvements and process upgrades instead of long-range projects and that steelmakers started to develop products with a focus on how the customer would use the steel to fabricate his products. But, Närhi [21] found that at mill sites, production planning, quality teams, and production people, i.e. the whole organisation and not only the salesmen, have to work for customer satisfaction. Further, Huang *et al*. [22] investigated the Chinese steel industry practitioners' perspectives of new product development success factors and the importance of management functions to new product success. They found that market-based factors were ranked ahead of technical and organizational factors in terms of importance for success.

The pulp and paper industry: In the international perspective, Sweden is one of the large actors on the global pulp and paper market [23]. As for the steel industry, this industry was also struck by a recession during the 90s. But the recession struck harder in some countries. Norway experienced a decline of the traditional pulp and paper industry in the early 90s. Moen [24] suggested that the mix of factors involved was complex. He demonstrated that a wide variety of historical, institutional and environmental factors have to be included also in the analysis of and the explanation of technological change. Moen [24] pointed out that a factor of vital importance in pulp and paper making is forest resources and he found that the Norwegian industrialist proved to be less willing in using techniques which did not favour the exploitation of spruce. In Sweden things went differently. Here unexploited forest resources represented an incentive to develop new methods [24]. Networking in process industry is another area that has not been widely research upon. However, Jokinen and Heinonen [25] pointed out early in the 90s that the Finnish paper industry has a tradition of cooperating, not only in research but in product development and even marketing. Finnish companies saw early universities as suppliers of human resources.

The chemical industry: Freeman *et al.* [26] found in the 60s that the chemical industry has been growing more rapidly since the Second World War than manufacturing industry as a whole. They meant that some observers had concluded that vertical integration of chemical firms, contractors, and component-makers is the obvious solution to this problem of cooperation and communication. Also, Burgess *et al.* [27] found that the UK chemical industry is increasingly moving from commodity to speciality production. The chemical industry is built on both product and process innovation, but with customers increasingly demanding better products, lower prices and more tailored services, the industry is changing its approach to innovation [28].

Hutcheson *et al.* [29] explored issues concerning technological innovation in the network of firms linked to the chemical industry, with particular reference to the process plant contracting industry. They found that technological innovation plays a significant role in the success of the network of firms involved in designing, manufacturing, supplying and operating chemical process plants. But Roberts [28] stated that the chemical industry is built on both product and process innovation, but with customers increasingly demanding better products, lower prices and more tailored services, the industry is changing its approach to innovation. However, product development in the chemical industry is still a largely product-focused, rather than a market-focused process. The shift to a market-focused approach is critical and requires changes in philosophy,

approach and culture [30], since the products in process industry have several user levels: both an end user and often one or more intermediate users.

In general, if market needs change and a business need to change from a production-orientated perspective on product development projects to a more customer-oriented perspective, then the entire organization of the projects will also have to change. But should product development then be a part of process development, where product development issues are discussed in relation to internal production-related questions, or if it should be separated, i.e., form a separate unit that focuses on the product, not the technological issues [11]?

There are other notable changes in Process Industry. Gunasekaran [14] found that product life cycles are getting shorter, and the close coupling of business and technology strategy has become critical. Further, he stated that the current trend in Process Industry includes rapid prototyping and advancement in technology and new materials, increased creative product innovation, increase reliance on automation and increased complexity, performance and reliability of products.

Upstream vs. downstream company

Process Industry consists of a range of different types of companies acting in different types of industries. These companies in various industries adapt to changes in product development easily or with more difficulties. However, every industry has a value-added supply chain, a sequence of activities that transforms raw materials into an end product or service. But the company's position in this supply value chain will play a matter in adjusting to current changes in e.g. markets. Galbraith and Kazanjian [31] give a description of the supply value-chain in a manufacturing industry. They state that the value-added supply chain begins with a raw material extraction stage that supplies crude oil, iron ore, or logs to the second stage of primary manufacturing. The second stage is a variety-reducing stage to produce a standardized output like petrochemicals, steel, and paper pulp. Fabrication of commodity products from primary material makes up stage three. Fabricators produce, e.g., polyethylene, sheet steel, or cardboard cartons. The fourth stage involves the producers of the product, who add value usually through product development. The following stage includes the manufacturer and marketer of consumer products. The last stage consists of the distributors and retailers who sell to the final consumer. These companies add value by creating a time and place utility.

The supply value chain can be divided into two halves, i.e. upstream and downstream companies, with each stage having different success factors. However, there are some fundamental differences that illustrate the contrast between upstream and downstream companies. Galbraith and Kazanjian [31] state that downstream stages add value by producing a variety of products to meet varying customer needs. Downstream value is added through advertising, product positioning, marketing channels, and R&D.

In sum, Galbraith and Kazanjian point out those characteristics such as standardization, line-driven organisation, process innovation, capital intensive and technological know-how illustrate upstream companies. In contrast, downstream companies are more concerned with customisation, line/staff (they produce multiple

products that require larger staffs), product innovation, people intensive (critical skills centre on human resource management), and market skills.

4 Methodology and data

The main purpose of this paper is to investigate whether the view of product development has changed in Swedish process industries during the 1990s and if there are some process industries that are becoming more product-focused than others. Further, what impact will a change have on the overall view of managing innovation?

The result in this paper is based on a survey among 50 companies in various industries, i.e. mining, steel and metal, pulp and paper, chemical, rubber, plastics, and food and dairy industries. In order to capture the general view of the phenomenon product development in process industries, the study has a quantitative approach, see Table 1 for the characteristics of the study. The study is based on a questionnaire but the questions were discussed with semi-structured telephone interviews in order to also to capture "how" development is conducted today in process industries and "what" has changed concerning development.

Table 1. The composition of the study incorporated in this paper.

Characteristics of the study	
Time of study	2000
Character of study	quantitative
No. of companies participating	50
Type of industry	Mining, steel, paper, rubber, plastic, chemical, dairy
Number of respondents	50
No. of employees in average	50-1000
Unit of analysis	Product development work

Data collection and analysis

The criterion for selecting the companies to the study was that they should be part of the "traditional" process industry, i.e. produce a product that can be further value-added in the next stage of the supply value-chain (e.g. by customers in their production process). However, due to the scarcity of available companies in the selected industries, the total amount of companies is quite low. A sample of companies was taken from industry lists, which identified those companies active in the specific industries mentioned above. Representatives of Swedish branch organizations also came with suggestions of existing companies. The companies were initially contacted by telephone to ensure that they had/were involved in development projects, to identify the key respondents, and to solicit cooperation. Out of 55 companies, 50 agreed to participate in the research. To ensure reasonable reliability of the data, respondents received a copy of their answers to the questions where they could make alterations, etc. Altogether, 50 companies participated with one respondent at each company. Since the purpose of the study was to investigate current development work, changes during the 1990s, and future needs to

development projects, the respondents needed to have deep insights in development work. Therefore, most respondents were R&D managers while in smaller companies some were project leaders or members of a product development project. Table 2 gives the distribution of the companies in each branch sector and their size. The companies are divided into three groups: small, medium, and large, depending on the number of employees.

Table 2. Number of companies in sample by Type of Industry, Size, and Product

Type of Industry	Size of the company			Type of product		
	Small (no. employees <100)	Medium (100≤ no. employees < 500)	Large (no. employees ≥500)	High-volume	Niche	Mixed
Mining	0	0	2	2	0	0
Steel	0	1	8	1	4	4
Paper	0	0	7	2	2	3
Chemicals	6	6	3	5	5	5
Rubber	1	2	3	0	5	1
Plastics	2	2	0	0	4	0
Food/Dairy	0	1	6	0	1	6
Total	9	12	29	10	21	19

The study also compares the 50 companies' strategies (i.e. the Groups' strategies) from the 7 process-based industries over a 15-year period (based on an analysis of annual reports from 1985 and 2000), i.e. the analysis is based on if the companies have changed their statement concerning their strategic intention of development work (what was regarded as important in the respective year and what was the main focus). Key terms like product development, higher margins, value-added products, and customer need were searched for in the strategy statements from 1985 and 2000. There is an indication of a changed strategy if the company emphasizes some of these key terms in the year 2000, but not in the year 1985.

Annual reports are one of the documentary data source for longitudinal studies. They are produced by many companies at the same time every year, and are readily available. They have been used in past research to assess and explain corporate strategies, to identify key areas of competition, and to explore causal reasoning within firms [32].

The majority of interviews were recorded and typed (due to certain circumstances, two interviews were not recorded, but were typed). All interview materials were then coded with a software technique called 'Non-numerical Unstructured Data Indexing Searching and Theorizing' (N5), a computer package designed to aid users in handling non-numerical and unstructured data in qualitative analysis. The texts were first coded with nodes and organized into a "tree" structure, enabling thorough qualitative analyses of the material concerning, e.g. future needs in concerning development. The material (the hypotheses) was then tested in SPSS 11.0 (Statistical Package for the Social Sciences) to investigate if there are any differences between the industries concerning development issues. This is achieved by using SPSS to see if there are underlying clusters accordingly to e.g. product type, change of development and strategy towards value-added products.

5 Results and Analysis

In order to investigate if there are differences between various process industries concerning their view of product development, following questions are investigated;

- *Are there any characteristics that distinguish one industry from another today concerning development issues like product type and, development focus?*
- *Are some process industries more product-focused than others?*
- *Is the role of innovation changing for process industries?*

In order to give an answer to the questions, the companies in the study are first characterised as upstream or downstream. Secondly, the companies are clustered according to some development work characteristics.

To test whether tradition process industries are changing their view of development work, the 50 companies are first divided into two groups as per the traditional characteristics for 'upstream vs. downstream company', according to Galbraith's categorisation in the supply chain [31]. The companies' product types in 1985 determine the categorization, based on Galbraith's spectrum of product characteristics (the degree of value-added) combined with stated development intentions in 1985. Table 3 shows the distribution of the division. According to their product type in 1985, 28 companies are classified as upstream and 22 as downstream.

Table 3. Number of companies in sample by Type of Industry and Number of Upstream vs. Downstream companies (divided after the companies' product type in 1985)

Type of industry	Traditional Characteristics of the Companies	
	Upstream	Downstream
Mining	2	0
Steel	7	2
Paper	4	3
Chemicals	9	6
Rubber	2	4
Plastics	0	4
Food/Dairy	4	3
Total	28	22

So, is there any difference between upstream vs. downstream companies when it concerns the product type and development focus?

Cluster analysis

In order to investigate if there are any differences between the seven process-based industries concerning product development, the research is first based on a cluster analysis.

The major aim of cluster analysis is to group the industries into more aggregated groups, in order to illustrate their relation to each other with respect to the variables, i.e.

development and strategic changes. However, the use of cluster analysis in strategic management research has been criticized [33]. Because cluster analysis does not offer a test statistic and often clustering dimensions seem to be selected randomly [34]. So this analysis mainly gives an indication that there can be differences between groups.

Using a questionnaire, information has been gathering within following categories:

- Company background, e.g. type of business.
- Company categorizing questions: type of product, development focus, definition of product development.
- General questions; e.g. organization of development work, collaboration, future needs.

The first step in the analysis was to formulate the clustering problem by defining the variables on which the clustering will be based. In this study, I classified 50 process-based companies on the basis of six variables. These variables were coded on a nominal scale.

- Type of product (three alternatives; niche-1, high-volume-2, or a mixed-3).
- Focus in development (three alternatives; product-1, process-2, or equal-3).
- Changed development focus (towards product-1, or towards process-2, no change-3).
- Increase of product development (yes-1 or no-2).
- Changed strategy towards customer/value-adding from the period of 1985 to 2000 (changed strategy-1, have customer focus already-2, no record-3, no change-4).
- Focused business from the period of 1985 to 2000 (yes-1, no-2), that is the companies have become more specialized

There has to be noted that companies can indicate an increased product focus in development without to have changed their development focus during the 1990s. A changed development focus requires more substantial changes for the companies than an increased product focus.

The second step in the analysis was to decide on the type of clustering technique to be used (e.g. hierarchical or a non-hierarchical) and to select an appropriate distance measure. The most common approach is to measure similarity in terms of distance between pairs of objects, i.e. the euclidean distance or its square (the square root of the sum of the squared differences in values for each variable). I used SPSS hierarchical clustering method to evolve different development groups and I chose the Ward's methods due to the coding of the variables (nominal). Sharma [35] recommends that one use various methods, compare the results for consistency, and use the method that results in an interpretable solution. Choice of clustering method and choice of a distance measure are interrelated [36]. Malhotra [36] states that, for example, squared Euclidean distances should be used with the Ward's method.

The third step in the analysis was to decide the number of clusters. A number of different criteria can be used for determining the best number of clusters. A graphic device that can be useful in displaying clustering results is the dendrogram. Three main clusters can be viewed in a dendrogram, see *Appendix A*. However, clustering techniques

can be criticized since by their nature they will break the data available into subsets [33]. Therefore, four clustering methods were employed, each of which has been found to have different strengths and weaknesses. If all four clustering methods give similar results there is a higher confidence that the groups are an inherent part of the data. The clustering techniques used are; centroid, median, complete and Ward's method. All four clustering techniques gave similar clusters, see *Appendix B*.

The fourth step in the analysis was to interpret and profile clusters. The fundamental issue in clustering problems is the definition of a cluster itself. The definition of a cluster provides the means of distinguishing between good and bad classification of samples. Ward's method has been used since it adds cases by keeping the error sum of squares within clusters as small as possible. But what distinguish the material in the three clusters? As seen in Table 4, all but one of the variables have values (below 0.05) that contribute to a significant different between the three clusters. The Levene statistic rejects the null hypothesis that the group variances are equal for the chosen variables.

Table 4. Test of Homogeneity of Variances

Variables	Levene Statistic	df1	df2	Sig.
Type of product	16,572	2	47	,000
Focus in development	17,837	2	47	,000
Changed development focus	27,292	2	47	,000
Increased product focus	80,102	2	47	,000
Focused business	2,844	2	47	,068
Change strategy towards customer/value-adding	200,533	2	47	,000

What are the characteristics of the three clusters concerning the variables? (See *Appendix D* for detailed information about the clusters).

Companies in cluster 1; have a mix of products, have an equal focus on both process and product development, have not changed development focus, almost half of the companies have increased the product focus in development during the 1990s, a slight majority have changed their strategy, and one third have focused their businesses during the 1990s.

The majority of the companies in cluster 2; have niche products, have product focus in development, have not changed development focus or increased product focus, had already customer-focused strategy in the 1980s, and no company has focused its business.

The majority of the companies in cluster 3; have a mixed product type in development, have equal focus on both process and product development, have changed their development focus and increased product focus during the 1990s, have changed their strategy during the 1990s, and no company has focused its business.

In order to assess the validity of clustering, I tested the cluster solution using different methods of clustering and compared the results, see *Appendix B*. I also randomly spited the data into two halves and tested one half with Ward's method. It gave the same cluster solution (see *Appendix B*). Ward's method suggests that there are three main clusters. The differences between the three clusters on the defining variables are tested with ANOVA. In *Appendix C*, the groups mean scores, standard error, relative rankings F-statistics and associated *p* derived from one-way ANOVA are given. The significance test of F test for the variables shows that the null hypothesis that the average assessment scores are equal

across the clusters is rejected, that is the clusters differ. In sum, the analysis shows that the data can be divided into three clusters, as in Table 5.

Table 5. The classification of industries in the three clusters.

Type of	Cluster belonging (no. of companies)			
Industry	1	2	3	Total
Mining	2	0	0	2
Steel	3	1	5	9
Paper	5	1	1	7
Chemical	8	6	1	15
Rubber	5	1	0	6
Plastic	0	3	1	4
Food	3	1	3	7
Total	26	13	11	50
Phi=0,662, Sign.=0,038				

Table 5 shows that cluster 1 consists of following companies; two mining, three steel, the majority of the paper and rubber companies, half of the chemical companies, and three food companies (in total 26). The other half of the chemical companies is classified in cluster 2 among three of the plastic companies (in total 13). Finally, cluster 3 consists of five steel and three food companies (in total 11). Then there are single companies from each industry that are spread equally among the clusters.

In sum, the analysis indicates that the industries are classified in different clusters. Companies in cluster 1, which comes from a mix of industries, have a mix of products, an equal focus on process and product development, almost half of the companies have increased the product focus during the 1990s, and a slight majority have changed their strategy. One third of the companies have also focused its business during the 1990s. Further, the majority of the companies in cluster 2, from chemical and plastic industry, have niche products, have product focus in development work, the majority have not changed development focus or increased product focus, because the majority had already customer-focused strategy in the 1980s. Finally, the majority of the companies in cluster 3, from steel and food industry, have a mixed product type in development, the majority have equal focus on process and product development, all of them have changed their development focus and increased product focus, the majority have changed their strategy during the 1990s.

The analysis shows that there is no major difference between cluster 1 and 3. The dendrogram shows that cluster 1 and cluster 3 are more close to each other that cluster 2, see *Appendix A*. There are an equal percentage of companies in cluster 1 and 3 that have changed their strategy (58 % vs. 55%). One difference between them is, however, that all 11 companies in cluster 3 have changed development focus during the 1990s, towards a more product-focused development. Traditional process-based companies in ore, steel, paper, rubber and food/dairy have increased their product-focus in development during the 1990s and have changed their strategy toward value-added products. Finally, the analysis also shows that the majority of the upstream companies are located in cluster 1 and 3, see Table 6.

Classification in upstream or downstream	Cluster belonging (no. of companies)			Total
	cluster 1	cluster 2	cluster 3	
Upstream	18	2	8	28
Downstream	8	11	3	22
Total	26	13	11	50
		Phi=0,486, Sign.=0,003		

So, can the clusters be explained by the classification of the companies in upstream or downstream in the value chain? Table 6 indicates that there is significant difference (value 0.003) between upstream versus downstream companies concerning cluster classification.

Factor analysis

A factor analysis is achieved to investigate if the chosen variables in the cluster analysis are interrelated with each other and if there are variables that can explain the clusters. Also, it attempts to identify underlying factors that explain pattern of correlations within a set of observed variables [35]. The most popular techniques in factor analysis are principal component factoring (PCF) and principal axis factoring (PAF). However, Malhotra [36] recommends Principal Component Analysis if the primary concern is to determine the minimum number of factors that will account for maximum variance.

The variables in the factor analysis are chosen to enable a test of the relationship between the variables that determined the three clusters in the cluster analysis and variables related to the position in the supply chain, that is upstream or downstream company. They are as following; *Type of product, Focus in development, Changed development focus, Increased product focus, Upstream or downstream, Change strategy towards customer/value-adding, Focused business, and Cluster belonging* (summarized in *Appendix E*). But in order to examine whether or not the data are appropriate for factor analysis, I have chosen to examine Kaiser's measure of overall sampling adequacy and a measure of the sampling adequacy for each indicator, i.e. the Kaiser-Meyer-Oklin (KMO) measure. Sharma [35] states that there are no statistical tests for the KMO measure, but there are guidelines that a measure above .60 is tolerable. In this study, there are eight variables to test concerning development, and the KMO measure for them is tolerable (.625) so it is possible to do a factor analysis of the variables, see Table 7.

Table 7. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,625
Bartlett's Test of Sphericity	Approx. Chi-Square	148,929
	df	28
	Sig.	,000

How many factors can the variables be divided into? A factor analysis shows that two factors are appropriate, see Table 8.

Table 8. Total Variance Explained Extraction Method: Principal Component Analysis.

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,537	31,712	31,712	2,235	27,932	27,932	2,185	27,314	27,314
2	2,282	28,530	60,242	1,751	21,889	49,821	1,801	22,507	49,821
3	,812	10,154	70,396						
4	,735	9,190	79,585						
5	,587	7,342	86,928						
6	,563	7,043	93,971						
7	,399	4,993	98,964						
8	8,287E-02	1,036	100,000						

The leftmost section of this table shows the variance explained by the initial solution. Only three factors in the initial solution have eigenvalue greater than 1. Together they account for approximately 60% of the variability in the original variables. This suggests that two latent influences are associated with the chosen variables, but there remains room for a lot of unexplained variation. Further, the second section of Table 8 shows the variances explained by the extracted factors before rotation. The cumulative variability explained by these two factors in the extracted solution is about 50%, a difference of about 10% from the initial solution. Thus, about 10% of the variation explained by the initial solution is lost due to latent factors unique to the original variables and variability that simply cannot be explained by the factor model. Finally, the rightmost section of the table shows the variance explained by the extracted factors after rotation. The rotated factor model makes just some small adjustments to the factors, but they are virtually unchanged.

The rotated component matrix facilitates the interpretability of the material (Table 9). Following variables can explain the factors:

Factor 1: Changed development focus, increased product focus, and cluster belonging.

Factor 2: Type of product, focus in development, upstream/downstream, changed strategy towards value-adding.

Table 9. Rotated Component Matrix

Variables	Component	
	1	2
Type of product	7,402E-02	**-,707**
Focus in development	-,111	**-,626**
Changed development focus	**,932**	7,384E-02
Increased product focus	**,678**	,354
Upstream or downstream	5,120E-02	**,764**
Change strategy towards customer/value-adding	-8,488E-02	**,733**
Focused business	**-,504**	,452
Cluster belonging	**-,901**	,224

What do the factors represent? High loading of a variable on a factor indicates that there is much in common between the factor and the respective variable. It is suggested that the loadings should at last be greater that .60. Further, the objective of rotation is to

achieve a simpler factor structure that can be meaningfully interpreted by the researcher. In the varimax rotation the major objective is to have a factor structure in which each variable loads highly on one and only one factor.

The analysis shows that there is no relationship between the variables "change of strategy" and "change of development focus". The variable "cluster belonging" and change of development" have a relationship. The variables "focus in development", "upstream or downstream" and change of strategy have a relationship?

In sum, the two factors are each explained by the variables "cluster belonging" and "changed development focus", and "upstream or downstream" and "changed strategy".

How do the companies work with customers and suppliers?

Product development in Process Industry has changed. The results in this study indicate that both supplier and customer are of more importance in product development today. Below follows a brief description of how the companies in the study actual work with customers and suppliers. It is categorized in industries.

Mining industry: The development department makes deep studies of customers' processes with the technique QFD (Quality Function Deployment). The company declares that it is required in the future to make more customer-specific products. However, a company within this industry can never make complete tailor-made products due to logistics and cost aspects. Product development work consists of frequent visits to customers and close collaboration. Development has personal contacts with suppliers to discuss possible process development options.

Steel/metal industry: Much work is required to translate customers' needs and demands into requirements on the process. The link to the customers is, in six cases, through either marketing or sales. Sale personnel have in some cases technical background. Much of development work with customers consists of demonstrating and trying the product in customers' processes. Therefore, discussions with customers require technical competence. A sale team can consists of a person from sale and one from development department.

Pulp/Paper industry: Much of the contacts have been through marketing, but recently these contacts are of a personal character between customer and development department. One of the companies points out that it is vital for development to be able to ask the customers what they need and want. These demands are transformed into a more structured form with QFD to shorten the product development process. It is/and should be an ongoing process to evaluate the customer needs and to design the competence and resources needed in product development. Suppliers take a more active role today in product development project. Five out of seven companies declare that collaboration with chemical suppliers have intensified in the last couple of years. One of the companies declares that they are reviewing their networking and making an analysis of the future need of collaboration, i.e. with whom and how.

Chemical industry: Product developers need deep knowledge and understanding about customers' processes. Some companies have people from technical service that are basically at customers' sites on a daily basis. They deliver a whole package consisting of the product, a design of the customer's line with production run schedule. Much contact

is of personal basis because development needs to make trials at the customer's process. Companies can be a link in the development process between the customer and the supplier. Collaboration can also be through service agreements where companies develop the whole concept consisting of a physical product and a service attached to it. Suppliers can be a link to increase the value-added in product development at the companies' development work. This requires longsighted relationship with suppliers. Suppliers have often more resources and special labs to conduct deep research concerning the raw material properties. The importance of this collaboration is increasing.

Rubber industry: Product developers need to have a deep knowledge about customers' markets, e.g. knowledge about application areas. Small companies work closely with few customers to create deep involvedness in customers development work. Product developers take more responsibility of the outcome of customer's product today. It is important for market personnel to have technical competence. They are the direct link between product development and the customer. But, it is required from development that they have personal contact with customers. Development needs information about the customers' processes, application areas etc. and tries today to integrate more forward in the value-chain, i.e. to develop service attached to the product. A natural way of working is to find solutions through discussion with customers. Suppliers are not part of development projects directly but in some cases they are defined as a resource pool.

Plastic industry: Much development work consists of decreasing the costs for the customers. Collaboration with customers concerning both the product and customers' processes has increased the last decade. The link to the customer is either through development or marketing. An important change is that technical personnel do a great deal of sales work today. One of the companies has built a net of contacts with suppliers. It is possible to follow the development of the product in the entire value chain.

Food/Dairy industry: Large companies have more formalized links through market organizations. Market organizations can buy development service from R&D. Smaller companies have more direct links between development and customers. One of the companies declares that development must have direct links to customers. Because much development works consist of market analysis and development of packages. There are higher demands put on raw material today. The implication is that suppliers must have the competence and skill to develop right raw material. The sale personnel at suppliers are required to have technical competence today. Integrating key suppliers into the development work is a key issue. The links are often through personal contact. Collaboration with suppliers of packaging has increased.

6 Discussion and Conclusions

The purpose of this paper is to achieve an understanding of how product development work in process industries has changed and to investigate if there are some categories of process industries that have become more product-focused than others.

Are there any characteristics that distinguish one industry from another today concerning development issues like product type and, development focus? The study indicates that there is no major difference between different process industries today. The majority of the companies in all industries are focusing, to some extent, on product

development. The difference is that some companies and industries have a longer tradition of product development than others. However, the industries in the study can be divided into three clusters depending on if the companies in the industries have changed their development focus during the 90s. The study indicates that companies in the steel and food/dairy industry have made more substantial changes concerning development work during the 90s. They state that there has been a change towards focusing on product development. Companies in the plastics and chemical industry seem to have a longer tradition of product development. The companies in the paper industry also indicate an increase of product focus in development but they view both product as process development as equally important. The findings are in accordance to the literature research on product development and process industry. There are more findings concerning product development in the steel, chemical and the food industry in the literature.

The division of the companies in upstream and downstream also indicates that so called upstream companies has changed their strategy towards more product-focused development during the 90s. The majority of the upstream companies are from the mining, steel, paper, chemical and food/dairy industry.

The result shows a classification of companies in process industries in three clusters. Companies in cluster 1 are from a mix of industries. The majority of them are categorized as "upstreamer" in the supply chain. They have an equal focus on both process and product development and a slight majority of the companies have not increased the product focus during the 1990s, but a slight majority have changed their strategy during the 1990s. One third of them have focused their business, i.e. they have become more specialized. Further, the majority of the companies in cluster 2 are "downstreamer" from the chemical and the plastic industry. They have niche products, focus on product development and the majority of them had a more product-focused strategy already in 1985. Finally, the majority of the companies in cluster 3 are also "upstreamer" from the steel and the food industry. The majority have equal focus on both process and product development and all of them have changed their development focus and increased product focus during the 1990s. The majority of the companies have changed their strategy. Cluster 1 and cluster 3 are quite similar when it concerns an equal focus in process and product development and a change strategy during the 1990s. The difference concerns a more substantial change towards a more product-focused development.

Are some industries more product-focused than others? The analysis shows that there are differences between the industries concerning development issues like product type, increased product focus in development and changed strategy during the 1990s. However, these differences indicates that the "gap" is closing in between those who already had product focus in development in early 1990s (downstream companies) and those who have increase their product focus in development during the 1990s (upstream companies). This means that there is no major difference between industries today and that the trend is similar in all industries, that is, Swedish process industries are headed towards a more product-focused development. This is in accordance with Strezo [30] who reports that the focus in development is shifting from the process to the product in process industries.

Is the role of innovation changing for process industries? The brief description of how the companies work with customers and suppliers indicates that the content of

development has changed. Other aspects need to be considered in development projects. The research indicates a small change towards selling technological competences during the 1990s. This is something that presumably will continue to increase in the future. This means that new competences have to be incorporated either through internal acquisition or external networking to support a change product concept or to secure the changed need of information in development projects. Therefore, it is important that development teams and management evaluate changes together when it concerns competence needs. There must be a fit between the required competence and the integrations mechanisms to obtain it, something that is achieved when both managers and develop team members gain a broader business development picture. However, changing working methods and building new linkages is not easily achieved because understanding the markets and customers, in specific, require an understanding of an entire chain of several levels of users; an end user and often one or more intermediate users.

The main conclusion from this paper is as follows: significant characteristics describing various industries are about to be erased today. Heavy steel and paper industries are as interested as food and plastic to develop more specific products that gain higher value-added. However, to achieve this change, a changed "mind-set" in the entire organization needs to be implemented. The role of innovation is changing for traditional upstream companies and this will have an impact on the overall view of managing innovation. It is stated by Cavone *et al.* [7] that an R&D organization and management are heavily affected by the nature of the R&D process and the relative importance of the activities within R&D.

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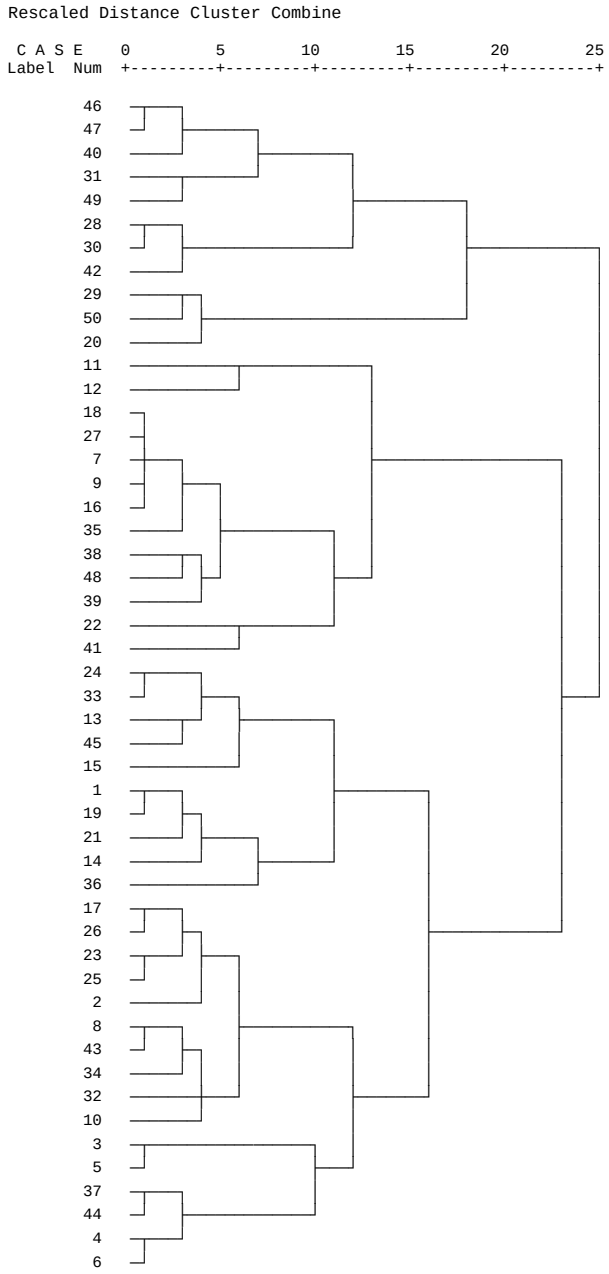
APPENDIX A: Dendrogram using Average Linkage (Between Groups)



APPENDIX B: Cluster belonging

Case	Hierarchical Clustering Methods (100% of the data)				Random cases (50% of the data)
	Centroid	Complete	Median	Ward's method	Ward's method
1:ore	1	1	1	1	
2:ore	1	1	1	1	
3:rubber	1	1	1	1	1
4:rubber	1	1	1	1	
5:rubber	1	1	1	1	
6:rubber	1	1	1	1	1
7:rubber	2	2	2	2	2
8:rubber	1	1	1	1	
9:chemical	2	2	2	2	2
10:chemical	1	1	1	1	1
11:chemical	2	2	2	2	2
12:chemical	2	2	2	2	
13:chemical	1	1	1	1	
14:chemical	1	1	1	1	
15:chemical	1	1	1	1	1
16:chemical	2	2	2	2	2
17:chemical	1	1	1	1	1
18:chemical	2	2	2	2	2
19:chemical	1	1	1	1	1
20:chemical	3	3	3	3	3
21:chemical	1	1	1	1	
22:chemical	2	2	2	2	2
23:chemical	1	1	1	1	1
24:food	1	1	1	1	1
25:food	1	1	1	1	
26:food	1	1	1	1	
27:food	2	2	2	2	
28:food	3	3	3	3	
29:food	3	3	3	3	3
30:food	3	3	3	3	3
31:paper	3	3	3	3	3
32:paper	1	1	1	1	
33:paper	1	1	1	1	
34:paper	1	1	1	1	1
35:paper	2	2	2	2	2
36:paper	1	1	1	2	
37:paper	1	1	1	1	
38:plastic	2	2	2	2	2
39:plastic	2	2	2	2	
40:plastic	3	3	3	3	3
41:plastic	2	2	2	2	
42:steel	3	3	3	3	
43:steel	1	1	1	1	1
44:steel	1	1	1	1	
45:steel	1	1	1	1	
46:steel	3	3	3	3	

APPENDIX B: (Continued)					
47:steel	3	3	3	3	3
48:steel	2	2	2	2	
49:steel	3	3	3	3	
50:steel	3	3	3	3	3

APPENDIX C: Test of variance – ANOVA

Variables		Sum of Squares	df	Mean Square	F	Sig.
Type of product	Between Groups	14,203	2	7,102	12,979	,000
	Within Groups	25,717	47	,547		
	Total	39,920	49			
Focus in development	Between Groups	16,385	2	8,193	13,037	,000
	Within Groups	29,535	47	,628		
	Total	45,920	49			
Changed development	Between Groups	31,711	2	15,855	156,252	,000
focus	Within Groups	4,769	47	,101		
	Total	36,480	49			
Increased product focus	Between Groups	3,365	2	1,682	8,674	,001
	Within Groups	9,115	47	,194		
	Total	12,480	49			
Change strategy	Between Groups	12,970	2	6,485	16,792	,000
towards	Within Groups	18,150	47	,386		
customer/value-adding	Total	31,120	49			
Focused business	Between Groups	1,846	2	,923	7,050	,002
	Within Groups	6,154	47	,131		
	Total	8,000	49			

APPENDIX D: The characteristics of the clusters

	Cluster 1 (26 companies)	**Cluster 2** (13 companies)	**Cluster 3** (11 companies):
Product type	a mix of products (19% have niche, 27% have high-volume, 54% have both niche and high-volume)	niche products (92%), (8% have high-volume)	a mix of products (46%) (36% have niche, 18% have high-volume)
Development focus	a mixed development focus (27% have product focus, 11% have process focus, 62% have an equal focus on product and process)	product focus (92%), (8% have process focus)	equal focus in development (73%); product focus (27%)
Changed development focus during the 90s	No	No (77%); (8% have changed towards product focus, 15% have changed towards process focus)	Yes, towards product
Increased product focus in development projects	No (58%), (42% have increased product focus)	No (69%)	Yes
Change of strategy between 1985 and 2000	Yes, towards customer focus (58%), (42% already had customer focus in 1985)	No, 54% already had customer focus in 1985, (15% have not changed, 31% no record)	Yes, towards customer focus (55%), (36% already had customer focus, 9% no record)
Focused business during the 90s	No (62%), 38% had focused their business	No	No

APPENDIX E: Descriptive Statistics of the eight variables

Variables	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Type of product	50	1	3	1,96	,903
Focus in development	50	1	3	2,04	,968
Changed development focus	50	1	3	2,48	,863
Increased product focus	50	1	2	1,48	,505
Upstream or downstream	50	1	2	1,44	,501
Change strategy towards customer/value-adding	50	1	4	1,76	,797
Focused business	50	1	2	1,80	,404
Cluster belonging	50	1	3	1,70	,814

PAPER IV

The impact of supply chain information and networking on product development in Swedish process industry

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The impact of supply chain information and networking on product development in Swedish process industry

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Abstract: This paper will test the hypothesis that upstream companies in process industries that have changed their strategy to encompass a customer/product focus during the 1990s have also invested in and use some type of information systematisation (e.g. databases) in development. If there has been a change of strategy, then this should imply a need of changing information into development projects through networks. An increased awareness of supply chain information might support and facilitate a change of development perspective. An interesting finding in the paper is the tendency for upstream companies, compared to downstream companies, to be more interested in working in networks to acquire new competences in development projects. This can be since the information needed in projects has changed, thereby increasing the need for upstream companies to find suitable partners when it concerns both suppliers and customers, but also with other actors who can give the needed information. Today, the dilemma for process industries is that much development work requires personal contacts with customers without having suitable information technologies that support that linkage. Therefore, to reach a market-oriented perspective in development, management should, early in the process of strategy change, emphasise evaluation of needed networks and IT systems to make the development process more efficient.

Keywords: information systematisation; network; process industry; product development.

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1 Introduction

During the last two decades, academic researchers have shown an increasing interest in investigating inter-organisational interaction and the functioning of networks in product development in the manufacturing industry. Today, process industries, like the steel and

paper industries are closing in on other manufacturing industries in the need to develop more 'customer-specific' products. This means that process industries need to change their tradition and working methods. There is indication that the Swedish process industry has changed its focus in development towards a more customer focus and therefore also a shift of strategy (Chronéer, 2003). But how can this task be achieved and what role have information technologies played in this change of development focus and strategy? What role can supply chain information play in this change towards more value added products and an increased collaboration?

This paper investigates some of the impacts of a changed perspective in development for process industries, i.e. if this change has impacted on the use of information systematisation and the view of networks in development projects.

The process industry is a mature industry, where products and production processes are regarded as stable. The characteristics for process industry have been stable markets, fixed production processes with a focus on economies-of-scale, and cost-efficiency. However, this tradition to solely concentrate on the process development and hunt costs has changed. Process industry is a term that has come to symbolise an industry that has invested heavily in its technology, but which has a dilemma in balancing the need to develop more customer-specific products and keep the costs down with process development.

An important aspect in product development is to understand and manage customer and technological competences (Danneels, 2002). So, the fact that product development work in process industries incorporates a deep understanding of the entire supply chain is elaborated in this paper, since current product development is about sharing information and building suitable networks essential for successful developmental work. Christopher's definition of supply chain management has therefore been adopted in this paper:

> "The management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole." (1998, p.18)

Product development in process industry is to some extent about managing upstream and downstream relationships. By encouraging the integration of suppliers within the development process, primarily by establishing appropriate partnerships, a wide range of benefits have been achieved in both the process and development of products. Although supply chain management is a universal business practice, Jones (2002) states that comparatively few organisations have achieved effective supplier involvement in product development.

Networking, collaboration and management of supplier and customer relationships are by no means new issues in management research. However, companies in the process industry seem to be entering a new era where traditional relations are being replaced by networks of interrelated companies and other actors, e.g. research institutions, universities, and governmental agencies. In networks, people collaborate with clients, customers, vendors, suppliers and even competitors. IT can be a means for achieving higher degrees of efficiency and effectiveness, but the effects are hard to achieve and measure because information technology requires new skills and capabilities from the personnel to function well. If the organisation structure is not changed the use of IT might be rather pointless (Doeherty and Symne, 1995).

This paper starts with a discussion of the theoretical framework with following sub-sections: the role of IT in the organisation, the role of networks and collaboration in product development projects, and finally a brief discussion about supply chain management.

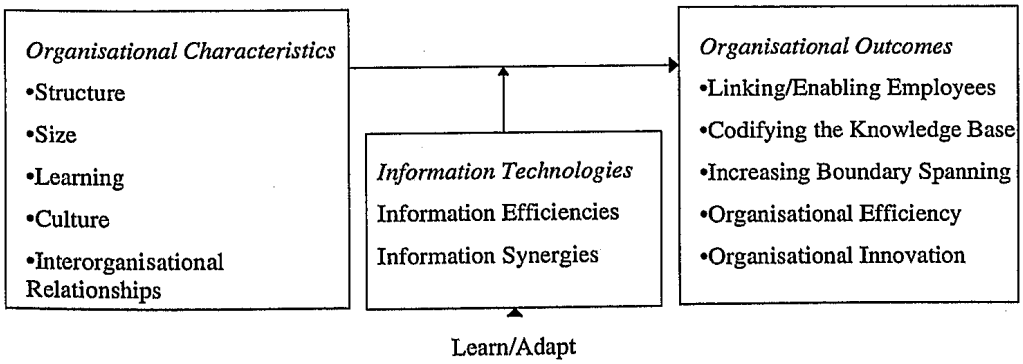
A great amount of research on how to perform product development in the manufacturing industry exists. However, there is limited research on how the process industry should conduct product development. Therefore, the theoretical framework is followed by a brief discussion of the context of the process industry in order to introduce the reader to some special characteristics. Further, there is a discussion of some of the definitions used in this study and a conceptual framework illustrates the hypothesis tested in this paper. The fourth section consists of the methodology and the sample used to collect the data. The final sections present the results and the contribution of the work to both academia and industrial practitioners.

2 A literature review and a conceptual framework

2.1 The role of IT in the organisation

Research shows that IT can be a tool to enhance organisational performance (Doeherty and Symne, 1995). But does the use of IT enhance collaboration and affect a company's strategy? Dewett and Jones suggest IT as a variable that can be used to enhance the quality and timeliness of decision making, thus promoting organisational performance (Dewett and Jones, 2001). They examine IT as a moderator of the relationship between organisational characteristics and several organisational outcomes, most importantly, efficiency and innovation (Figure 1).

Figure 1 The role of IT in the organisation



Source: Dewett and Jones (2001).

Dewett and Jones note that, theoretically, IT must be tightly coupled with strategy because IT affects strategy and strategies have IT implications (2001). Further, they indicate that IT can be instrumental in both shaping core capabilities and integrating capabilities into the organisation context, making them apparent at all organisational

levels. Gunasekaran and Nath (1997) state that IT can/should affect a company's strategy because new changes for a company, like introduction of suitable IT-tools, are interrelated with the company's strategy and supply chain.

Research also shows IT perhaps simultaneously being an enabler and a strategic instigator of a new organisation form (Jarvenpaa and Ives, 1994). The activities of independent nodes in a network can be coordinated through a continuously updated information system so that contributions can be mutually and instantaneously verified. IT can act as a coordinator of activities because IT renders the coordination of inter-organisational activities possible, which is the core of supply chain management (Levary, 2000).

As shown above, IT can enhance collaboration and coordinate activities. New product development, for example, is often a collaborative process, with customers and suppliers contributing complementary knowledge and skills. In almost every industry, it is no longer sufficient to focus on internal productivity. Collaboration with customers, suppliers, and other firms is the key to future prosperity. However, IT cannot always substitute for face-to-face communications, though according to Scott, management needs to create a culture that knows how to exploit IT (2000).

Today, many manufacturers are moving their relationships with component suppliers away from 'traditional arm's length relations driven by a competitive logic toward new arrangements based on a cooperative logic.' (Bensaou, 1997) These take the form of complex cooperative relationships, also described as 'value-adding partnerships' or 'alliances'. An important result from Bensaou's study is that information technology is a significant determinant of interorganisational cooperation.

2.2 *The role of networks*

Managing complex networks is one of the key factors to 21st century innovation success (Rycroft and Kash, 1999). Successful innovation of complex technologies can sometimes require equal complex networks of firms and other organisations, often including universities and institutions. This can be addressed to companies that must achieve organisational changes due to a need to change their products' added value.

Some forms of integration, internal and external, identified in the literature include: *R&D/manufacturing/marketing integration* (Bondra and Davis, 1996; Fischer et al., 1997; Kahn, 2001; Olson et al., 2001; Song et al., 1997, 1998), *R&D/marketing integration* (Griffin and Hauser, 1993, 1996; Kärkkäinen et al., 2001; Ottum and Moore, 1997; Song et al., 1996), *supplier integration* (Araujo et al., 1999; Bruce et al., 1995; Hartley et al., 1997; Ragatz et al., 1997; Swink and Mabert, 2000), *customer integration* (Bailetti and Litva, 1995; Butscher and Laker, 2000; Campbell and Cooper, 1999; Dwivedi and Sharma, 2002; Gruner and Homburg, 2000; Mello, 2001; Pick, 1999), and *strategic partnership* (Comer and Zirger, 1997; Littler and Leverick, 1995; Magrath and Hardy, 1994). Other examples is research about co-location (Lipnack and Stamps, 1997; Kahn and McDonough, 1997; Patti et al., 1997), and factors for success or failure (Balachandra and Friar, 1997; Bruce et al., 1995), and joint ventures (Littler and Leverick, 1995). However, few papers discuss a change of development focus in the process industry and the consequences that a change of focus (towards a more customer orientation) can have on the use of formalised information systematisation.

What is a network? Håkansson and Ford state that a complex market can be seen as a network, where the nodes are business units – manufacturing and service companies – and the relationships between them are the threads (2002). Each node or business unit, with its unique technical and human resources, is bound together with many others in a variety of different ways through its relationships. Although management of supplier and buyer relationships is by no means a new issue in marketing (Håkansson, 1990), we seem to be entering a new era where traditional relationships are being replaced by networks of interrelated companies and other actors, such as research institutions, universities, and governmental agencies.

There are many advantages of collaboration in product development work. Littler and Leverick emphasise it as a possible means to secure access to technologies, skills, or information, to share the costs and risks of product development, and to reduce the time taken to develop the product (1995). The negative effects of collaboration can lead to a considerable loss of control over the development in question, and the leakage of information and skills to a partner. Collaborators may even acquire tacit knowledge and learning from partners to the extent that those unique key competencies can be lost. Therefore, the choice of collaborators and partnerships must be considered very thoroughly.

The problem of customer collaboration is that many organisations do not know what kinds of customer information they ought to be collecting, they do not have the skills to do so even when they do know, they do not have formal processes designed to capture important customer information, and/or are in too much of a hurry to move from ideation (i.e. idea generation) and screening to development phases of New Product Development (Flint, 2002).

Suppliers also play an essential role in networks today when the development process is concerned. Development by supplier has become a viable supply chain management practice across firms from several industries that continue to focus on their core competencies and outsource a significant percentage of the costs of goods sold (Krause and Scannell, 2002). In many industries, manufacturing companies give suppliers increasing responsibilities regarding the design, development, and engineering of components (Wynstra et al., 2001). Supplier involvement in product development holds great potential in the short and long run, but few companies seem to be able to realise these benefits.

2.3 Supply chain management

The flow of information in supply chain relationships has changed over the years. Traditional supply chain relationships, that captured data from sales, were later transferred to suppliers, manufacturers, or distributors. Today, new technologies enable customer-related information to be sent directly to suppliers, manufacturers, and distributors, who can then use this information to respond instantaneously to changing inventory levels. This represented the beginning of a supply chain management revolution to capture and diffuse customer trends and preferences deep into supply chain member companies (Bechtel and Jayaram, 1997). Another key supply chain issue involves supplier integration into new product development and the value of information such as inventory, lot size, transportation, etc. (Simichi-Levi et al., 2003). The supply chain recognises that there are cooperative arrangements tying firms to each other and their success to the chain as a whole. The supply chain embraces the entire set of processes

and organisations from source to final customer; this orientation extends beyond the flow process itself. Schary and Skjøtt-Larsen (1995, p.302] point out that the supply chain includes structure, processes of supply operations and the organisation of business units in an integrated network. This arrangement relies heavily on information and coordination instead of direct authority relationships and hierarchical control.

From a review of the supply chain management concept, Persson (1997) points out that coordination and integration between companies along the supply chain necessitates reducing the number of suppliers. But, in order to achieve coordination and integration along the material flow and end customer focus, sharing of information between members in the supply chain is fundamental.

However, supply chain management offers an opportunity to depict the synergy of both intra- and inter-company integration and management (Lambert et al., 1998), since supply chain management represents a way of managing business and relationships with other members of the supply chain. Inter-company integration and coordination via information technology has become a key to improved supply chain performance (Barut et al., 2002).

Tatikonda and Stock (2003) summarise that a supply chain is a network of organisations involved, from beginning to end, in transforming and transporting materials and information to ultimately create and deliver a valued product to end customers. Firstly, because information and materials flow up and down the supply chain. Secondly, each organisation creates and adds value to the entire product in the supply chain. Thirdly, the supply chain is a network of organisations where individual organisations must interrelate and interact to add value.

3 Process industry – the context for this study

The key business challenge in process industry and other industries in the 21st century will be the same as for the latter part of the 20th century, i.e. to be competitive and to be profitable in rapidly changing markets. But to achieve this, it is required for companies to understand their changing environment and to use these changes (e.g. in markets) to their advantage. This implies development of both the technology and the product concept that anticipates and influences customer needs, as well as technology that respond to them.

Do the characteristics of an industry have implication for the development of a product? A product in the process industry is often characterised as of low-technology, long product life cycle, fairly long product development time etc. However, this is about to change for Swedish companies dealing with products that require development of material properties. But it is not easily changed. The underlying assumption is that since product and process are symbiotically related in the production system, then fundamental changes in the one must incite parallel fundamental changes on the other (Etienne, 1981). A product in the process industry can be very complex due to its material property complexity, e.g. a tyre is the end result of complex chemical and engineering processes, which must resist extremes of heat, cold, and stress (Ita and Gross, 1995). One property change can affect the entire product concept.

If a company in the process industry finds it is impossible to compete with high-volume products, then it must find an approach to develop more value-added products, e.g. niche

products. This means improved functionality, features, and performance. But changes in the content of product development for the company in the process industry (e.g. that a product can include both the physical product and a service attached to it) will have implications on shorter lead times, more efficient and/or flexible use of process equipment, more specialty products, consistently high quality products, adaptable operating systems (linked to market activity), and integrated supply chain systems (Guy and Eng, 1994; Harkins and Dubreuil, 1993). This also requires sustainable networks with both suppliers and customers.

3.1 The industries in the study

What are the characteristics of the selected industries in this paper? Below is a general description of the following industries: mining, steel/metal, pulp/paper, chemicals, rubber, plastics, and food/dairy industry.

Companies in the mining industry can be engaged in the mining, processing, and selling of metals and minerals; for example zinc, copper, and gold. Process development is of importance in this type of industry because of products with low functional content.

The Swedish steel industry focuses largely on special purpose products requiring very high quality. The industry's continuing competitiveness entails substantial investment in research and development. Stainless tool and high speed steels represent important types of Swedish specialty steels. Besides manufacturing steel in the form of sheet, strip, wire, and so on, specialty steel mills carry out extensive production of fabricated goods.

Today's paper industry products can be complex, e.g. a package consists of more than just a paperboard. It is a construction that is glued together, on which information is printed, and perhaps containing a barrier in the form of plastic or metal foil. The paperboard must perhaps be able to remove flavours from the food in the packaging, requiring a specific know-how. Knowing how different parts of the package influence each other and eventually how consumers perceive what is in the package is vital.

Examples of products in the chemical industry include liquid and powder coatings for industrial application, paints and adhesives, surfactants, chemicals and systems for environment compatible pulp bleaching processes, as well as chemicals and systems for paper making.

Within the rubber industry, industrial know-how and state-of-the art polymer technology is of importance. Customers can be within the automotive, engineering, chemicals, building, and construction industries. A development area can be compression-moulded products in polymer material.

Development areas in plastics might concern injection-moulded plastic items as customer-specific tasks involving thermosetting plastics and thermoplastics – from idea stage to finished product.

The trend in the food/dairy industry is towards more sophisticated products. Development work today requires other competence aspects, e.g. behavioural science. That is, competence about how a customer thinks and act, which will give a better understanding of why a customer pick a specific product. A product today can consist of other aspects than just the physical content. That is, a product can involve aspects such as packaging, convenience, etc.

3.2 *Definitions in the study*

In this paper, the definition of process industry is a type of business that has a focus in material/metallurgical/chemical properties and production process in product development projects, i.e., product development and process development are close interrelated. It can be described as follows:

> "Process Industry is production Industry using (raw) materials to manufacture non-assembled products in a production process where the (raw) materials are processes in a production plant where different unit operations often take place in a fluid form and the different processes are connected in a continuous flow." (Lager, 2002, p.108)

Several conditions distinguish process industry from other manufacturing industries (Tottie and Lager, 1995), such as:

- process industry is often a part of a long customer/supplier chain that does not always have access to information from the end-user
- suppliers often deliver material, not components.

The definition of information technologies in this paper concerns all types of systems that can collect, systematise, and distribute information to development projects, e.g. databases.

Respondents were asked if they had some kind of formalised systematisation and distribution of information regarding development work in their projects. The definition of information systematisation includes all kinds of databases or other techniques that somehow systematise information in development projects in a formal way. For instance, development teams may have access to a database where information is collected and can be distributed to those involved in development work. However, an example of 'non-formalised' systematisation is when information is not documented and not easily retrieved.

Further, there is no major distinction between 'product focus', 'customer focus', and 'value-adding' in this article, since the respondents randomly used these terms. But it is important to note for further discussion that the concepts customer-oriented (customer-led) and market-oriented can have different meanings for various researchers. Slater and Narver emphasise the importance to not confuse the concepts customer-led and market-oriented (1998). They indicate that scholars discuss two separate management philosophies, i.e. 'customer-led' is a short-term philosophy in which organisations respond to customers' expressed wants, and 'market-oriented' represents a long-term commitment to understanding customer needs and to developing innovative solutions that produce superior customer value.

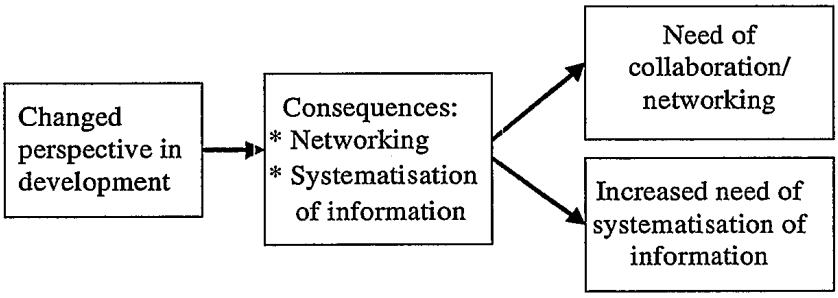
The definition of networking is based on the respondents' views of working in networks concerning development. The company is coded as 'working in networks' if they state that competence, in some parts, is acquired through universities, institutions, or other actors with the required competence for the development work.

3.3 *The conceptual framework*

The purpose of this paper is to investigate the relationship between a changed perspective (towards a more product orientation) in development for companies in the process industry, especially for upstream companies, and the impact this change has on the use of information technologies and the view of networking today (Figure 2). What role does

IT play in a change of direction from process-oriented development to product-oriented development for traditional upstream process industries?

Figure 2 The hypothesis in the research project



From three decades ago, traditional process industries, like steel and paper industries, had stable markets and were mostly concerned with process development focusing on economies-of-scale, i.e. to manufacture products at as low a price as possible. But today these industries are also affected by the rapid changes in both their markets and technology. This means that companies must have an increased awareness of the product's place in the supply chain, thereby having implications in their role towards customers and suppliers, and impacting the needed information in product development teams so that they can cope with this change.

The main focus in this paper will be on the current trend of product-focused development projects in process industries, i.e. how companies in the process industry change their mind towards value-added products and the implications of this change on development work and what role information technologies have played in this change of development focus. This research project will test the hypothesis that upstream companies in process industries that have changed their strategy to encompass a customer/product focus during the 1990s have also invested in and used some type of information systematisation (e.g. databases) in development. If there has been a change of strategy, then this should imply a need of an information change into development projects through networks.

To test the hypothesis, Galbraith and Kazanjian's categorisation of companies in the supply chain (1986) according to upstream and downstream characteristics, is used. That is, some fundamental differences illustrate the contrast between upstream and downstream companies. Galbraith states that downstream stages add value by producing a variety of products to meet varying customer needs. The downstream value is added through advertising, product positioning, marketing channels, and R&D. Further, Galbraith points out characteristics as standardisation, line-driven organisation, process innovation, capital intensive, and technological know-how to illustrate upstream companies. By contrast, downstream companies are more concerned about customisation, line/staff (they produce multiple products requiring larger staffs), product innovation, people intensive (critical skills centre on human resource management), and market skills. This position in the supply value chain is not easily changed. So, is there any difference between upstream vs. downstream companies when it concerns the use of information systematisation and networking?

4 Methodology

The results in this paper are based on a survey among 50 companies in the process industry. The study has a more quantitative approach with the perspective on development projects (Table 1).

Table 1 The composition of the study incorporated in this paper

Time of study	*2000*
Character of study	Quantitative
No. of companies participating	50
Type of industry	Mining, steel, paper, rubber, plastic, chemical, dairy
Number of respondents	50
No. of employees in average	50–1000
Unit of analysis	Product development work

Due to the character of the research (the amount of respondents), telephone interviews were considered to be best at this stage of the research to explore how process industries view their development today and in the future. Another fact is that it is an area of little research. A semi-structured interview technique was applied with a focus on certain issues, i.e. systematisation of information. The main unit of analysis is on the product development project, but also on the company level, concerning means and tools to systematise and spread information.

Another source of information for this research has been the companies' annual reports, where the statements of the companies' strategy intentions were compared (from the year 1985 and the year 2000). Annual reports are one of the most obvious documentary data sources for longitudinal studies. They are produced by all companies at the same time every year, and are readily available. This methodology has been used in past research to assess and explain corporate strategies, to identify key areas of competition, and to explore causal reasoning within firms (Huff and Huff, 2000).

4.1 Sample

The criterion for selecting the companies to study was that they should be part of the process industry, i.e. produce a product that can be further value-added in the next stage of the value-chain (e.g. by customers in their production process). However, due to the scarcity of available companies in the selected industries, the total number of companies is quite low. A sample of companies was taken from branch organisations. Companies were initially contacted by telephone to ensure that they were involved in development projects, to identify the key respondents, and to solicit cooperation. Out of 55 companies, 50 agreed to participate in the research. To ensure reasonable reliability of the data, respondents received a copy of their answers to the questions where they could make alterations, etc. Altogether, 50 companies participated with one respondent from each company. Since the purpose of the study was to investigate current development work,

changes during the 1990s, and future needs into development projects, the respondents needed to have deep insights into development work. Therefore, most of the respondents were R&D managers while in smaller companies some were project leaders or members of a product development project. Table 2 gives the distribution of the companies for each sector and their size. The companies are divided into three groups: small, medium, and large, depending on the number of employees.

Table 2 Number of companies in sample by type of industry, size and product

Type of industry	*Size of the company*			*Type of product*		
	Small (no. employees <100)	*Medium (100 ≤ no. employees <500)*	*Large (no. employees ≥500)*	*High-volume*	*Niche*	*Mixed*
Ore	0	0	2	2	0	0
Steel	0	1	8	1	4	4
Paper	0	0	7	2	2	3
Chemicals	6	6	3	5	5	5
Rubber	1	2	3	0	5	1
Plastics	2	2	0	0	4	0
Food/dairy	0	1	6	0	1	6
Total	9	12	29	10	21	19

The study also compares the 50 companies' strategies (i.e. the Groups' strategies) from the seven process industries over a 15-year period (based on an analysis of annual reports from 1985 and 2000), i.e. the analysis is based on if the companies have changed their statement concerning their strategic intention of development work (what was regarded as important in the respective year and what was the main focus). Key terms, like product development, higher margins, value-added products, and customer need, were searched for in the strategy statements from 1985 and 2000. There is an indication of a changed strategy if the company emphasises some of these key terms in the year 2000, but not in the year 1985.

Data was gathered from structured telephone interviews with open-ended questions, enabling a rich understanding of the companies' current development work that could be used to explain a certain phenomenon. The majority of interviews were recorded and typed (due to certain circumstances, two interviews were not recorded, but were typed). All interview materials were then coded with a software technique called 'Non-numerical Unstructured Data Indexing Searching and Theorising' (N5), a computer package designed to aid users in handling non-numerical and unstructured data in qualitative analysis. The texts were first coded with nodes and organised into a 'tree' structure, enabling thorough qualitative analyses of the material concerning, e.g. future needs in concerning development. The material (the hypotheses) was then tested to investigate if there was a relationship between the variables: strategic change, the use/need of information technologies (i.e. databases in development projects) and the view of networks in development.

5 Analysis and results

This research project tests the hypothesis that upstream companies in process industries that have changed perspective in development have also invested in and used IT (e.g. databases) and are aware of the importance of building suitable networks to support development work. Further, what role does IT play in a change of direction from process-oriented development to product-oriented development for traditional upstream process industries?

5.1 Position in the supply value chain

To test the hypothesis, the 50 companies were first divided into two groups as per the traditional characteristics for 'upstream vs. downstream company', according to Galbraith's categorisation in the supply chain (Galbraith and Kazanjian, 1986). The companies' product types in 1985 determine the categorisation, based on Galbraith's spectrum of product characteristics (the degree of value-added) combined with stated development intentions in 1985.

So, is there any difference between upstream vs. downstream companies when it concerns the use of information systematisation and networking? Table 3 shows the distribution of the companies in the upstream vs. downstream category. According to their product type in 1985, 28 companies are classified as upstream and 22 as downstream.

Table 3 Number of companies in sample by type of industry and number of upstream vs. downstream companies (divided after the companies' product type in 1985)

Type of industry	*Position in the supply value chain*	
	Upstream	*Downstream*
Ore	2	0
Steel	7	2
Paper	4	3
Chemicals	9	6
Rubber	2	4
Plastics	0	4
Food/dairy	4	3
Total	28	22

5.2 Cross-tabulation and chi-square test

To test if there is a relationship between the variables strategic change for Swedish process industries, the use of systematisation of information and networking, the following section presents a cross-tabulation table and a chi-square test with nominal variables. The tested variables are the following;

- position in the supply value chain (according to upstream vs. downstream characteristic)
- changed strategy towards customer/product focus during the 1990s (comparison between the year 1985 and 2000)

- the use of information technologies in development projects (all types of means to systematised information)
- networking (i.e. collaboration with institutions, universities, and actors with needed competence).

The first step is to investigate if there is a difference between upstream vs. downstream companies concerning a changed strategy. The cross-tabulation, Table 4, shows the frequency of each response at each company concerning the variable upstream or downstream company and the change of strategy towards value-adding (customer focus). The total sample of companies is 50, but there is no record of strategic intentions for five of them (i.e. there were no annual reports to compare), so the total number of companies in this analysis are 45.

Table 4 The frequency of the position in the supply value chain and changed strategy

Position in the supply value chain in 2000	*Changed strategy towards customer/value-adding*			*Total*
	Changed	*Had already customer focus in 1985*	*No change*	
Upstream	17	9	1	27
Downstream	4	13	1	18
Total	21	22	2	45
		Phi=0.447 Sign.=0.019		

Table 4 shows that a majority of upstream companies have changed their strategy during the 1990s (17 of 27 companies) and that the majority of downstream companies had already a customer-focused strategy in 1985 (13 of 18 companies). All except two companies in the year 2000 had customer-focused strategy. To analyse if there in fact is a difference, a chi-squared test is done.

The two-sided asymptotic significance of the chi-square statistic is less than 0.05 (sign.=0,019), indicating a difference between the two groups (Table 4). However, a chi-square test is useful for determining if there is a relationship, not the strength of the relationship.

The second step is to investigate the relationship between the position in the supply value chain (upstream vs. downstream companies) and the use of information systematisation and networking. The result shows that 64% of the upstream companies (18 companies) use some type of systematisation of information in development projects and 41% of the downstream companies (nine companies). Of the upstream companies, 57% (16 companies) declare the importance of working in networks concerning development today and only 18% of the downstream companies (four companies) (Table 5). (Since there is no record for five of the companies concerning their strategy, the total number of companies in the left column is 45 instead of 50).

Table 5 The frequency of the variables position in the supply value chain, strategy in 2000, systematisation of information and networking (customer-oriented strategy – CO)

Position in the supply value chain	*Strategy in the year 2000*		*Systematisation of information in 2000*		*(View of) networking in 2000*		
	CO	*No CO*	*Yes*	*No*	*Yes*	*No*	*Total*
Upstream	26	1	18	10	16	12	28
Downstream	17	1	9	13	4	18	22
Total	43	2	27	23	20	30	50
Phi	0.044		0.233		0.395		
Sign. V.	0.768		0.100		0.005		

The results show that all types of companies (both 'upstreamers' and 'downstreamers') seem to apply the same strategy today, i.e. a customer-oriented strategy (CO). But an interesting result is the fact that more upstream than downstream companies emphasise the importance of systematisation of information and networking. The two-sided asymptotic significance of the chi-square statistic concerning position in the supply value chain and networking is less than 0.05 (the significance value shows 0.005), indicating a difference between the two groups (Table 5). Hence, there is indication that upstream companies are more aware of the importance of collaboration in networks in development than downstream companies. However, for the variable systematisation of information, the significance value showed 0.100, i.e. no significant difference between the upstream vs. downstream companies. Can this difference be explained by the fact that more upstream than downstream companies have changed their strategy towards customer-orientation during the 1990s? Tables 6 and 7 show no difference between those who already had a customer-oriented strategy in 1985 and those who have changed strategy during the 1990s.

The difference between upstream and downstream companies concerns those who do not have systematisation of information and do not view networking as particularly important. This difference is because there are more upstream companies that have changed their strategy than downstream companies. The significance test values for the two types of companies regarding changed strategy or not are 0.006 for upstream and 0.027 for downstream (Tables 6 and 7).

So, what does this analysis tell us? The results indicate that the gap between upstream and downstream companies is closing, i.e. upstream companies have changed their strategy towards a more customer-oriented strategy. The results also indicate that upstream companies are more aware of the importance of working in networks today. However, the analysis does not state if there is a relationship between 'a changed strategy' and the two variables 'systematisation of information' and 'networking', though there is a difference between 'upstreamer' and 'downstreamer' considering networking.

Is there also a difference between upstream and downstream companies regarding a future investment need in systematisation of information and networking? Table 8 indicates no difference between the two groups, i.e. upstream vs. downstream companies. However, collaboration with customers and the awareness of utilising new competences and knowledge in development projects are two major needs regarded as important in the future. ('Other needs' in the future can, for example, be continuous change, decrease cost.)

Table 6 Cross-tabulation of the variables; position in the supply value chain, changed strategy, and use information systematisation

Systematisation of information	*Position in the supply value chain in 2000*	*Changed strategy between 1985 and 2000*		*Total*	*Phi (Sign.)*
		Changed strategy	*Not changed*		
Yes	Upstream	9	9	18	
	Downstream	1	6	7	
	Total	10	15	25	0.327
					(0.102)
No	Upstream	8	1	9	
	Downstream	3	8	11	
	Total	11	9	20	0.616
					(0.006)

Table 7 Cross-tabulation of the variables; position in the supply value chain, changed strategy, and networking

Networking	*Position in the supply value chain in 2000*	*Changed strategy between 1985 and 2000*		*Total*	*Phi (Sign.)*
		Changed strategy	*Not changed*		
Yes	Upstream	9	6	15	
	Downstream	0	2	2	
	Total	9	8	17	0.387
					(0.110)
No	Upstream	8	4	12	
	Downstream	4	12	16	
	Total	12	16	28	0.417
					(0.027)

Table 8 Needs concerning changes in the future

Position in the value chain	*Future needs*						*Total*
	Customer info/ collaboration	*Supplier collaboration*	*Information systematisation*	*Use new competence/ knowledge*	*Networks*	*Other needs*	
Upstream	7	0	2	6	2	11	28
Downstream	5	1	3	4	1	8	22
Total	12	1	5	10	3	5	50

5.3 'Supply chain information' in product development work

But what type of information is required today in product development work? An illustration of some of the quotes (expressed by some of the respondents) of what kinds of information steel and food and dairy companies require in development follows below. The industries and companies are chosen because they give good illustrations from upstream companies on the changing needs of supply chain information in development projects, followed by a changed need of networking. The quotes indicate that information concerning the entire supply chain is needed today in product development and a way to support this information need is through networking and other relationships.

5.3.1 Steel industry

- "An important component in development work is technical market support, which comes from input about trends and customers' demands. In development, teams work very closely with equipment suppliers. Networking with suppliers, which is more formal, has increased. It is important to have the customer presence', possibly through the sales team with qualified technicians, i.e. part of the marketing organisation."
- "It is important that end-users are involved in development."
- "Product development is generally about adjusting the product to fit the customers' process and product."
- "Development must cover a larger part of today's value chain and realise what gives customer value."
- "Development should be more observant and sensitive so as to grasp the market signals."
- "Today, development needs information concerning the customers or further down the chain (end-users)."

5.3.2 Food and dairy industry

- "Ideas come from customers while development conducts the preliminary work, i.e. to get it right from the beginning. The product must fit the customers' processes."
- "Development covers a large part of the current value chain. Those who work with development must have contact with the customers because development needs to incorporate new ideas and knowledge into projects."
- "Viewing trends early is vital; something that product functionality demands more of today. Also, in development today, knowing how a product's material properties are transformed in both the customers' processes and products is another important aspect. Obtaining information from the entire product chain is vital, from raw material to packaging and transportation, along with knowing how customers will use the product."
- "Working in networks is essential because of the important knowledge possessed by raw material suppliers. Networking is relatively new to the company, but it is an important means of incorporating competence when development demands it. Development has closer contact with suppliers than before by being able to meet and discuss trends and possible new products."

6 Discussion of results

The purpose of this paper is to investigate the change of development focus for Swedish process industries and the impact this change has had on the use of information technologies and networking.

The results showed that upstream companies are more aware of the importance of using some type of means to systematise information in development projects, and they also view networking as important compared to downstream companies. Why? One might expect that companies that have had a longer customer-oriented strategy also have a tradition of systematising information and working in networks. However, the results do not support Dewett and Jones (2001), who state that IT must be tightly coupled with strategy because IT affects strategy and strategies have IT implications. The results indicate no connection to a change of strategy and the utilisation of some means to systematise information. As well, IT does not play a major role concerning a changed strategy of development focus for the companies in this study. But, the results in this study can give certain indications concerning the Swedish process industry.

To answer the question 'Why upstream companies are more aware of the importance to systematise information and to work in networks in development work?' the results must be viewed together with some of the respondents' statements (quotes).

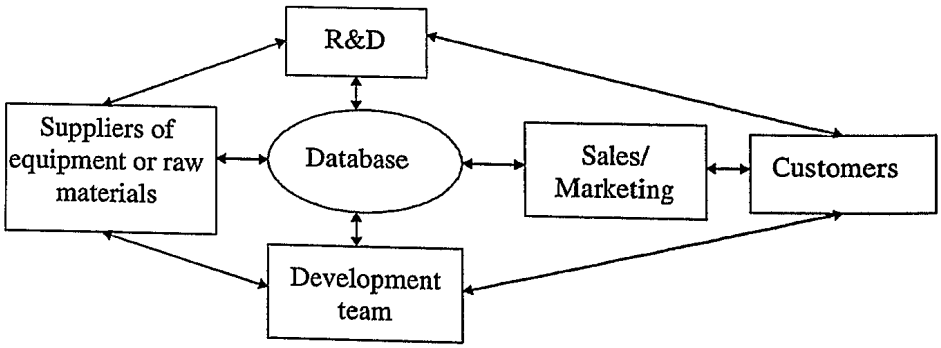
Much development work today requires more and deeper collaboration with customers due to the need of 'reading market signals'. There is an indication of a trend to integrate forward in the supply value chain, i.e. to be a development partner to customers, to take more responsibility for customers' development work for process industries. One way to choose for process industries concerning development is to stay focused on economies-of-scale, i.e. keep the cost low and produce a high-volume product. This is, however, difficult for Swedish companies, who generally have high costs (e.g. personnel and production processes). Another way is to develop niche products (specific products), with special properties or a combination of product and service concepts. If a company cannot develop the physical product, it might then develop a service attached to the product. But it requires a change in finding and building sustainable relationships with suppliers and customers. Implications of this change are that companies in the process industry must work more structurally and systematically with sources of information.

The study indicates that if a company cannot develop a product's properties any further, then other aspects can be attached to the development work, e.g. development of a service combined with the product or development of customers' production processes. This also requires more focus on systematisation of information and especially networking. One factor that makes upstream companies more aware of the need of systematisation of information and networking can be that it is difficult for them to involve, for example, end-users in product development, so they need to formalise the linkages to secure the information from them.

However, the study also indicates that a means to systematise information in an appropriate way is still lacking. Information concerning product development in process industries is more complex today than it was two decades ago. Other aspects need to be considered in product development projects today. Aspects in dairy products (like milk) can be properties connected to health or convenience. For example, the package must be easy to carry and open. Another aspect can be product adjustment according to the various parameters in the customers' production processes. The amount of information needed in projects has increased. Development projects need information from various

sources today, i.e. customer information, production data (from customers' processes and the company's own process), and product information (parameters and properties). Sales personnel possess a great deal of information about the customers' needs, but transferring the information to development projects is difficult. Therefore, to facilitate information collection, distribution, and spreading, a mutual database linking several information sources can be effective to constitute formalised information links (Figure 3), i.e. IT can act as a coordinator of activities. These links can run from centralised R&D functions, customers, and suppliers. This figure only depicts how a mutual database (or other means of information systematisation) can be the link to some actors in product development projects. The R&D function symbolises a central unit of research.

Figure 3 Formalised linkages to database in product development work



It will be essential for Swedish companies in the future to systematically gather and distribute information to enable effective development work. A database is one means to achieve this effectiveness. However, it requires resources and can take 2 to 3 years to yield any benefits. An important issue in the future is to penetrate problems at the customers' location and be able to solve them rapidly, requiring a focus on networking and building sustainable webs of information sources. Much network building depends on the individual themselves in the development team. But it is vital that the company has a clear strategy concerning the importance and possible links to both suppliers and customers.

Today, technical changes are happening rapidly; therefore it is great importance for companies to find and build sustainable relationship with suppliers of equipment and processes. Network activities in development are increasing for all process industries. In many cases, companies view their suppliers as an integrated part of their own product flow process. Research (Bensaou, 1997) shows that information technology can be a significant determinant of cooperation.

7 Conclusions

There has been and there will be considerable changes for Swedish process industries. The purpose of this paper has been to investigate some impacts of the change of focus in development for process industries. The role IT plays concerning a change of direction

to customer-focused development cannot be stated with this research. However, does IT create a need of enhanced collaboration and networking or does the need of collaboration and networking create a need of IT?

Has the need of 'new' information changed the network structure to both suppliers and customers within process industry? Yes, it has changed. There is an increased need to build sustainable links to both customers/suppliers and institutions/universities to incorporate new competence/knowledge. But to facilitate these linkages a formal facilitator is needed so that customer-value can be 'built' into the development work, i.e. incorporated in development projects. But as Scott (2000) emphasises, management needs to create a culture that knows how to exploit IT.

Today, the dilemma for process industries is that much development work requires personal contacts with customers without having suitable information technologies that support that linkage. To reach a market-oriented perspective in development, management should, early in the process of strategy change, emphasise evaluation of needed networks and IT systems to make the development process more efficient.

So, the role of R&D is about to change for process industries. It is more about collaboration and networking today to acquire new competences and knowledge into development projects. This study presented in this paper has merely scratched the surface of the dilemma of conducting product development work in process industries. There is a need of deeper research is many areas concerning how to integrate actors into a suitable network, and what means are appropriate to systematise information.

In sum, knowing what gives value in your supply chain can facilitate;

- identification of vital information sources
- what information to collect (both from suppliers and customers)
- building suitable networks.

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PAPER V

A change in supply chain information in Swedish process industries and its consequence on a

Forthcoming in International Journal of Integrated Supply Management

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A change in supply chain information for Swedish process industries and its consequence on a changed development focus

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Abstract

How can process industries cope with a changed need of information in product development? This paper focuses on examining if a changed development focus in process industry can be supported by an integration of supply chain information in product development. This is achieved by focusing on two theoretical perspectives, namely technology management and supply chain management. The research is based on case studies and a survey addressing companies in various process industries. The paper reveals that an analysis of the information that flows in the entire supply chain can help managers obtain a better understanding of what new competences and knowledge are required in product development. The need for this new type of information can be further formalised by building networks that act like a support to product development. This can be one integration sector between the two theoretical perspectives: technology management and supply chain management.

Key words: Process industry, technology management, supply chain management

1 Introduction

New product development, i.e. how to develop new products faster and more effectively, is a phenomenon that gained a lot of interest during the 1990s. Research and development (R&D) management practices have changed significantly during the last decade. Knowledge of customers, markets, and commercialisation processes can be gained by closely working with marketing and co-developing products with customers (Gupta and Wilemon, 1996). However, cooperation with external parties may pose numerous unexpected problems and requires much serious effort and commitment of the people involved to be successful (Bondra and Davis, 1996).

An important aspect in product development is to understand and manage customer and technological competences (Danneels, 2002). The fact that product development for process industries incorporates a deep understanding of the entire supply chain is

elaborated in this paper, since current product development is about sharing information and building suitable networks essential for successful product development. Christopher's definition (p.18, 1998) of supply chain management has been adopted in this paper: "The management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole". Product development in process industries is to some extent about managing upstream and downstream relationships. However, managing upstream and downstream relationships is not easy. Jones (2002) states that comparatively few organizations have achieved effective supplier involvement in product development.

While management of product development in the manufacturing industry has been researched for more than three decades, it has received very little attention from researchers when concerned with a process industry. The definition of process industry in this paper is as following: "Process Industry is a part of Manufacturing Industry using (raw) materials to manufacture non-assembled products in a production process where the (raw) materials are processed in a production plant where different unit operations often take place in a fluid form and the different processes are connected in a continuous flow" [6, p.25]. The interest in process industry in this paper is due to indicated innovation changes. Chronéer (2003) indicated that Swedish process industries have changed their "centre of gravity", i.e. the old traditions and ways of working are changing. This is most obvious regarding development issues where product development is gaining greater interest in process industries.

This paper reports the results of two studies. Study 1 involved case studies with the aim to obtain an understanding of product development in process industries. The results lead to Study 2, involving a survey with the purpose to understand how product development work in process industries has changed and what information and network-building changes will follow.

Given the difficulty of a changing development focus and its consequences on what new types of information and network-building are required, and the need for purposeful management of this process, this article aims to answer the following questions:

- What has changed in the information flow concerning product development work for process industries?
- How is this change of information connected to the supply chain value for process industries? That is, is the needed information in product development linked to the entire supply chain?

In an attempt to understand the above, this paper focuses on examining if a changed development focus in process industry can be supported by an integration of supply chain information in product development. This is achieved by focusing on two theoretical perspectives, namely technology management and supply chain management.

The outline of the paper is as follows: First there is a discussion of the conceptual perspective of the paper, which is based on technology management and supply chain management. Technology management has the focus on product development, competence and information need. Supply chain management has the focus on information flow. The third section of the conceptual framework introduces the reader to some of the special characteristics of process industries. The second part of the paper includes a discussion of the research topic and the method used to collect the data. The third part discusses the analysis mainly based on chi-square tests and the final part states some of the contribution of the research.

2 Conceptual framework

2.1 Technology management

There has been a change in industrial patterns for Swedish process industries during the 1990s (Chronéer, 2003). These changes have great impact on both technology and products in process industries. In process industries, technology and product innovation cannot be separated, i.e. changes in one lead to changes in the other. Today, large companies have increasingly developed overall strategies for their management of technology and a so called 'fifth generation' innovation process is regarded as a multi-institutional networking process with strong linkages to leading-edge customers and strategic integration of primary suppliers (Rothwell, 1994). Managing innovation is one part in technology management and it is partly about connecting technology and strategy (Burgelman *et al.* 2001) and integrating product and technology development (Drejer, 2002), i.e. activities connected to innovation. One activity to manage is product development and one element that must be in place and working harmoniously in order to improve product development, is having new product and technology strategy for the business (Cooper, 2000). Technology management is also about understanding of interdependencies between the overall strategy - structure dynamics associated with the management of innovation and technology (Christensen, 2002).

Since companies are 'outsourcing' greater shares of R&D and increasing the dependency of the company on other external actors and making R&D management more complicated today (Edler *et al.*, 2002). One of these linkages concerning the activity of product development is bridging inter- and intra-firm boundaries, which can mean management of supplier involvement (Takeishi, 2001; Sobrero and Roberts, 2002; Birou and Fawcett, 1994). Primo and Amundson (2002) strongly encourage researchers to continues examining the topic of supplier involvement and Petersen et al. (2003) imply that increased knowledge of a supplier and sharing of technology information is more likely to result in greater involvement of the supplier.

To understand and manage customer and technological competences is also part of technology management. Danneels (2002) states that understanding the product development process requires a simultaneous view of both customers and technology. He discusses how product innovation contributes to a renewal of the firm through its dynamic and reciprocal relation with the company's competences (see Fig. 1).

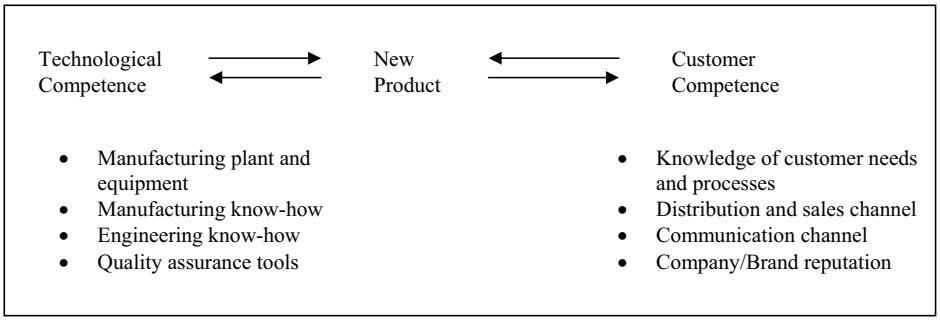

Fig. 1. Product innovation as linking of technology and customer competences (Danneels, 2002).

Danneels (2002) continues that product development joins two competences, namely competence relating to technology (e.g. manufacturing plant and equipment, manufacturing know-how, engineering know-how, and quality assurance tools), and competence relating to customers (e.g. knowledge of customer needs, distribution and sales channels, and company/brand reputation). The merger of two types of competences in product development has implications for the types of new products a company pursues.

2.2 Supply Chain Management

The flow of information in supply chain relationships has changed over the years. Traditional supply chain relationships that captured data from sales was later transferred to suppliers, manufacturers, or distributors. Today, new technologies enable customer-related information to be sent directly to suppliers, manufacturers, and distributors, who can then use this information to respond instantaneously to changing inventory levels. This represented the beginning of a supply chain management revolution to capture and diffuse customer trends and preferences deep into supply chain member companies (Bechtel Jayaram, 1997).

The objective of supply chain management is to provide a high velocity flow of high quality, relevant information that will enable suppliers to provide an uninterrupted and precisely timed flow of materials to customers. This information is often related to production scheduling and inventory control (Lee *et al.*, 1997). However, there are numerous causes that can cause supply chain distortions, i.e. known as "the Bullwhip Effect". The bullwhip effect refers to increasing variability of demand further upstream in the supply chain (Fransoo and Wouters, 2000). There are three distinct sources that affect a supply chain: suppliers, manufacturers and customers (Yu *et al.*, 2001). So, it can be important for management to understand the causal factors that create supply chain oscillations.

Another key in supply chain management involves supply chain collaboration (Sahay, 2003), which can be the key to value creation in the supply chain. This value can be obtained by supplier integration into product development and the value of information such as inventory, lot size, transportation, etc. (Simchi-Levi *et al.*, 2003). The supply chain recognizes that there are cooperative arrangements tying companies to each other and their success to the chain as a whole. This arrangement relies heavily on information and coordination instead of direct authority relationships and hierarchical control (Schary and Skjøtt-Larsen, 1995).

Supply chain management also offers an opportunity to depict the synergy of both intra- and inter-company integration and management (Lambert *et al.*, 1998), since supply chain management represents a way of managing business and relationships with other members of the supply chain. Inter-company integration and coordination via information technology has become a key to improved supply chain performance (Barut *et al.* 2002).

Tatikonda and Stock (2003) summarize that a supply chain is a network of organizations involved, from beginning to end, in transforming and transporting materials and information to ultimately create and deliver a valued product to end customers. Firstly, because information and materials flow up and down the supply chain. Secondly, each organization creates and adds value to the entire product in the supply chain. Thirdly, the supply chain is a network of organizations where individual organizations must interrelate and interact to add value.

Swedish industry dramatically changed during the 1990s. After a recession in the early 1990s, there was a rapid and comprehensive restructuring of the industry, leading to present-day industries becoming increasingly skills-intensive. Rapid technological developments and tougher market requirements have also led to greater skills-intensity in other industries, forcing industrial companies to significantly change the way they work. Competition from abroad has increased sharply with companies becoming more internationalised (The Federation of Swedish Industries, 1998). Since technological developments are moving at an ever more rapid pace, product life cycles are becoming shorter (Ita and Gross, 1995).

Since there are indications that the developmental focus in a process industry is shifting from process to product (Strezo, 1999), organization and management of development work needs to change with it (Chronéer, 2003; Tomiura, 1997). Tomiura (1997) states that the steel industry has changed from a natural resource based industry to a market based industry, though still remaining a capital-intensive industry.

Several researchers state that customer collaboration is increasingly important today in product development projects (Neale and Corindale, 1998). To improve customer relationships, feedback is of utmost importance, though difficult to obtain. Närhi (1997) found that customers are reluctant to fill out questionnaires, even if they understand the importance of it. He continues that at mill sites, production planning, quality teams, and production people, i.e. the whole organization and not only the salesmen, have to work for customer satisfaction. However, Schriefer (1996) states that steelmakers today develop products with a sharper eye on how the customer will use the steel to fabricate their products.

There is example of companies in process industry that has successful customer-focused product development. An iron ore producer in Sweden demonstrates that it is possible for process industry to systematically analyse customer requirements to improve product development. The uses a method called QFD, Quality Function Deployment, which systematizes and structures customer information (Tottie and Lager, 1995).

There are also indications of change in process industries other than steel and mining. Strezo (1999) emphasizes that product development in the chemical industry is still mainly a product-focused, rather than a market-focused process. He continues that a shift to a market-focused approach is more critical and requires considerable changes in the company's philosophy, approach, and culture, since products in a process industry have several user levels: both an end user and often one or more intermediate user. As a result, R&D is often isolated from the rest of the company and especially from marketing.

So what distinguish process industry from non-process industry, i.e. other manufacturing industry? Below follow the distinguishing characteristics in the production process that can be related to the supply chain.

Table 1. Some differences in the production process in Process Industry compare to Other Manufacturing Industry (Lager, 2001).

Area	Other Manufacturing Industries	Process Industry
Incoming materials	Components from suppliers	Raw materials
Production plants	Can be small and integrated with plants on different sites	Sometimes very large and often strongly integrated on one site
Customer supply chain	Often producing directly for the end user	Sometimes producing to a long chain of customer and not to the end user
Production chain	Often not a completely continuous production process. Not fully integrated process control	Often a continuous production with on line process control in real time and a central control room
Flexibility	Often flexible production plants not integrated in fixed structures	Often plant configurations that are difficult to change and modify
Product integration	Products are often not interdependent	Products are interdependent and changes in one product or production process can affect other products and processes

There are some major characteristics that distinguish process industry from other manufacturing industry. One is that the incoming material often is raw material and it is transformed (developed) into a product (material) that can be further transformed by customer and customers' customers etc. A dilemma, however, is that the transformation of a product (material) in customers' production processes can vary in different production processes, i.e. material properties can act differently due to parameters and tools used by customers.

Another characteristic that is different is the complex production chain. The production chain may include a number of large and small production plants, sometimes operated and owned by different companies. There can be a long and complex chain structure of production units and interfaces can create artificial obstacles, preventing sound product and process development and disconnecting the total chain of customer demands on the product (Lager, 2001). Successful development of new products and new processes depends to a high degree on an understanding of this total chain structure (Tottie and Lager, 1995).

This paper is an attempt to understand if a changed development focus in process industry can be supported by an integration of supply chain information in product development. An integration of the two perspectives discussed above: technology management and supply chain management, may explain and support an understanding of a changed development focus for both team members and management in companies in process industries? That is, what elements in these perspectives can be as integrating factors?

3 The research framework

The results in this paper are based on two studies. The first study has its empirical base in four case studies, two steel companies and two pulp and paper companies. The

second study is based on a survey among 50 companies in various industries, i.e. mining, steel, pulp/paper, chemical, rubber, plastics, and food and dairy.

With both studies focusing on development projects, the first study has a qualitative (exploratory) approach with case studies consisting of in-depth interviews while the second study has a more quantitative approach (see Table 2).

Table 2. The composition of the two studies incorporated in this paper.

Study no.	**1**	**2**
Time of study	1997	2000
Character of study	qualitative	quantitative
No. of companies participating	4	50
Type of industry	Steel and pulp/paper	Mining, steel, paper, rubber, plastic, chemical, dairy
Number of respondents	21	50
No. of employees in average	300-400	50-1000
Unit of analysis	Product development team	Product development work

Due to the character of the research, to explore how process industries view their development today and in the future, personal and telephone interviews were considered to be best at this stage of the research. Another important fact is that this is an area of little knowledge. A semi-structured interview technique was applied with a focus on some key issues, e.g. organization of product development. In this paper, the main focus of the analysis is on the product development work and its implication of information.

3.1 Data collection

The criterion for selecting the cases to the first study was that they should represent some type of process industry. At each company, respondents were selected due to their participation in completed development projects, since they had to have positive and negative experiences concerning the same product development project. Team members had to reflect on the same project, retrospectively.

The selection criterion for the companies in the second study was that they should be part of the "traditional" process industry, i.e. develop a product (material properties) that can be further value-added in the next stage of the value-chain (e.g. by customers in their production process). However, due to the scarcity of available companies in the selected industries, the total amount of companies is quite low. The sample of companies was taken from industry lists that identified those companies active in the specific industries mentioned above. Representatives of Swedish branch organizations also suggested existing companies. Companies were initially contacted by telephone to ensure that they had or were involved in development projects, to identify the key respondents, and to solicit cooperation. Fifty of fifty-five companies agreed to participate in the research. To ensure reasonable data reliability, respondents received a copy of their answers to the questions, so as to make alterations. Altogether, 50 companies participated with 1 respondent at each company. Since the purpose of the study was to investigate current development work, changes during the 90s, and future needs in development projects, the respondents needed to have deep insights in development work. Therefore, most of the respondents were R&D managers, while in smaller companies some were project leaders or members of product development

projects. Table 3 gives the distribution of the companies in each branch sector and their size. The companies are divided into three groups: small, medium, and large, depending on the number of employees.

Table 3. Number of companies in sample by Type of Industry, Size, and Product

Type of Industry	**Size of the company**			**Type of product**		
	Small (no. employees <100)	**Medium** (100≤ no. employees < 500)	**Large** (no. employees ≥500)	**High-volume**	**Niche**	**Mixed**
Ore	0	0	2	2	0	0
Steel	0	1	8	1	4	4
Paper	0	0	7	2	2	3
Chemicals	6	6	3	5	5	5
Rubber	1	2	3	0	5	1
Plastics	2	2	0	0	4	0
Food/Dairy	0	1	6	0	1	6
Total	**9**	**12**	**29**	**10**	**21**	**19**

The second part also consists of a comparison of the 50 companies' strategies (i.e. the Groups' strategies) from the seven process-based industries over a 15-year period (based on an analysis of annual reports in 1985 and in 2000). That is, the analysis was based on how the companies changed their statement concerning their strategic intention of development work (i.e. what was regarded as important in respectively year and what was the main focus). Key terms like product development, higher margins, value-added products, and customer need were searched for in the strategy statements from 1985 and 2000. There is an indication of a changed strategy if the company emphasizes some of these key terms in the year 2000, but not in the year 1985.

Annual reports are one of the documentary data source for longitudinal studies. Many companies produce them at the same time of the year, and they are readily available. They have been used in past research to assess and explain corporate strategies, to identify key areas of competition, and to explore causal reasoning within companies (Huff and Huff, 2000).

Indications of changed supply chain information are based on the respondents' answers considering changes during the 90s. Key terms that indicate these change are, for example, work with customers and/or suppliers, need to have knowledge about customers' production processes, sell competence, and need of new knowledge.

Data was gathered from structured telephone interviews with open-ended questions, enabling a rich understanding of the companies' current development work that could be used to explain certain phenomena, see appendix A (survey). Most of the interviews were recorded and typed (in a few cases, circumstances made it impossible to record). All interview materials were then coded with a software technique called 'Non-numerical Unstructured Data Indexing Searching and Theorizing' (N5), a computer package designed to aid users in handling non-numerical and unstructured data in qualitative analysis. The texts were first coded with nodes and organized in a "tree" structure, allowing for thorough qualitative analyses of the material concerning, e.g. future development needs. The material was then tested in SPSS 11.0 (Statistical Package for the Social Sciences) to investigate if there is a relationship between certain variables.

4 Analysis

What variables can be said to represent the two perspectives; technology management and supply chain management?

Some of the cornerstones in technology management, with the focus on product development, are about connecting technology and strategy, bridging inter-and intra-firm boundaries, management of supplier involvement, increased knowledge of a supplier and sharing of technology information, and to understand and manage customer and technological competences. Some of the cornerstones in supply chain management today are; to capture and diffuse customer trends and preferences deep into supply chain member companies, supply chain collaboration, supplier integration, inter-company integration and coordination via information technology, each organization in the supply chain creates and adds value to the entire product, i.e. the supply chain is a network of organizations where individual organizations must interrelate and interact to add value.

Is it possible that an awareness of a changed information need in product development work can lead to a stronger support from management regarding needs in networking and competence acquisition? This is linked to a development of a conceptual model consisting of the integration between technology management and supply change management, since achieving a better understanding of how a change of development focus affects both required competence and information in development projects is needed. This change will also affect suitable network-building to support development work in the future for process-based companies, see Fig. 2.

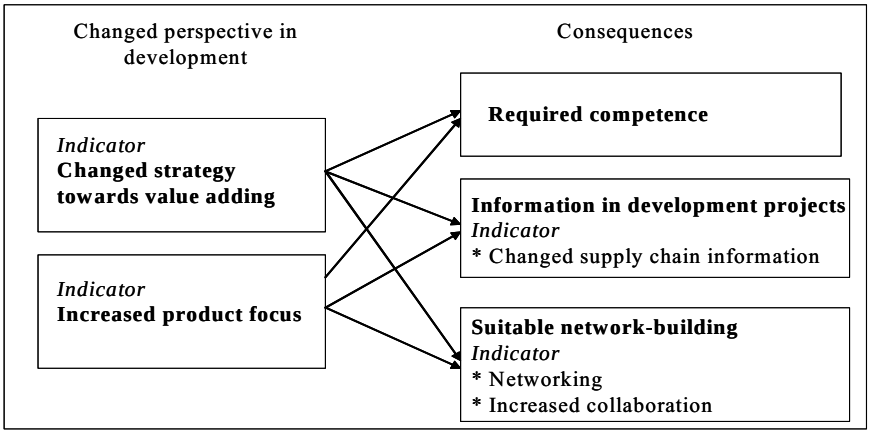

Fig. 2. Consequences of a changed perspective in development.

The purpose is to answer following questions “What has changed in the information flow concerning development work for process industries?” and “How is this change of information connected to the supply chain value for process industries?” Therefore, it is of interesting to investigate the relationships between a changed perspective in development and some of the consequences of a change.

The indicators of a changed perspective that will be tested are a more visual change like a changed strategy and a more “latent” change as an experience of an increased product focus.

Three indicators are tested as consequences of a changed perspective in development, i.e. “Supply chain information”, “Networking” and “Increased collaboration”. An indicator that there is a change for the process-based companies towards a more product development focus is the variable “increased product focus”. This variable is tested due to the fact to grasp the “trend of a change in progress”, because a company can still consider themselves to have an equal focus in development work (both process and product development) but they feel that there is a tendency to increase the product focus.

To enable an investigation if a changed development perspective in process industries (an increased product focus in development projects) can be understood, explained and supported by the fact that there is a changed content of information in development projects and an increased need of collaboration and networking. The first section of survey analysis consists of test relationships, as following

- *Is there a relationship between a changed development strategy/increased product focus and changed supply chain information?*
- *Is there a relationship between a changed development strategy/increased product focus and networking/Increased collaboration*

The second section consists of an analysis of how supply chain information has changed during the 90s. To enable a view of a changed required competence in development projects there is example of some quotations of respondents to illustrate how information has changed for Swedish process-based companies that support a change of competence.

4.1 The analysis of the cases

The results from the cases, conducted in 1997, are presented with a descriptive approach. The purpose of this study (four cases in the steel and paper industries) was to investigate how a process-based industry acts regarding development. The study emphasized areas of new product development that needed to be strengthened and enlightened.

Results show a change of development focus for Swedish process industries (steel and paper). The study indicated that the role of product development had grown for the four companies. One indicator of this change was the formation of special product development teams. Customers demand more specific products with certain material properties, occasionally leading to a re-organization involving special product development committees. Hence, current product development is not merely a result of process development, even if they are still closely interrelated. The main result from this study was an increased interest in product development, but that a centralized R&D was handling long-term research or according to instructions from development teams at production units. Another result was a lack of suitable integration mechanisms to link development teams with suitable actors (both internal and external).

A customer-focus increase in process industry development projects will require other areas of knowledge and competences being incorporated in development projects. This required further research of how Swedish process industries viewed their own development.

4.2 The analysis of the survey

The first step is to choose the variables to be tested. What variables can be said to represent the "two philosophies"; technology management and supply chain management?

Therefore, following variables is chosen:

- *Increased product focus,* i.e. if the company experience an increase of product focus in development (the company can experience an increase importance of product development but they need not to have changed their development focus, which require a substantial changes in development work).
- *Changed strategy towards customer/value-adding*, i.e. if the company indicates a changed strategy (a comparison of the company statements in annual reports in the year 1985 and in 2000).
- *Changed supply chain information*, i.e. the respondents express that it has been a change of information regarding the development work, indications of that the required information is extended to involve a greater part of the supply chain today.
- *Networking,* i.e. collaboration with institutes, universities, and actors with needed competence.
- *Increased collaboration* (with customer/supplier during the 90s)

Table 4 shows that there is no relationship between "Change of strategy" and "Changed information" or "Networking". Also, there is no relationship between "Change of strategy" and "Increased collaboration".

Table 4. The frequency of a "Change of strategy between 1985 and 2000", "Changed supply chain information", "Networking" and "Increased product focus"

Change of strategy between 1985 and 2000	Changed supply chain information		Networking		Increased collaboration	
	Yes	No	Yes	No	Yes	No
Yes	13	8	9	12	9	12
No	14	10	8	16	12	12
Total	21	24	17	28	21	24
Phi = 0,036 Approx. Sig. = 0,806			Phi = 0,098 Approx. Sig. = 0,511		Phi = 0,071 Approx. Sig. = 0,632	

A chi-square test of the relationship between the variables "Increased product focus" and "Changed supply chain information" indicates that the companies who have increased their product focus in development projects have also changed their supply chain information. The significance value is 0.011.

However, there is no relationship between "Increased product focus" and "Networking" or "Increased collaboration", see Table 5. This can be due to the fact that a high number of the companies already have collaboration with both customers and suppliers in development projects. 92% of the companies have collaboration with customers and 64% have collaboration with suppliers.

Table 5. Frequency of "Increased product focus", "Changed supply chain information", "Networking" and "Increased product focus"

Increased product focus	Changed supply chain information		Networking		Increased collaboration	
	Yes	No	Yes	No	Yes	No
Yes	20	6	13	13	13	13
No	10	14	7	17	10	14
Total	30	20	20	30	23	27
	Phi = 0,360 Approx. Sign. = 0,011		Phi = 0,212 Approx. Sign. = 0,133		Phi = 0,084 Approx. Sign. = 0,555	

4.3 What type of information is required today in development work?

The second part of the research analyses the type of information needed in development projects today for process-based companies.

The sections below illustrate some quotes (expressed by the respondents in the second study) of what kinds of information steel and food and dairy companies require in development. Companies in both industries are only chosen as examples to illustrate the changing needs of information in development projects, which can then indicate a changing need of networking (not all companies are shown).

Steel industry:
* An important component in development work is technical market support, which comes from *input about trends and customers' demands*. In development, teams work very closely with equipment suppliers. *Networking with suppliers, which is more formal, has increased*. It is important to have the "customer presence", possibly through the sales team with qualified technicians, i.e. part of the marketing organization.
* *It is important that end-users are involved in development*.
* *Product development is generally about adjusting the product to fit the customers' process and product.*
* *Development must cover a larger part of today's value chain and realising what gives customer value.*
* *Development should be more observant and sensitive so as to grasp the market signals.*
* *Today, development needs information concerning the customers or further down the chain* (end-users).

Food and Dairy industry:
* *Ideas come from customers* while development conducts the preliminary work, i.e. to get it right from the beginning. *The product must fit the customers' processes*.
* *Development covers a large part of the current value chain*. Those who work with development must have contact with the customers because *development needs to incorporate new ideas and knowledge into projects*.
* *Viewing trends early is vital; something that product functionality demands more of today*. *Also, in development today, knowing how a product's material properties are transformed in both the customers' processes and products is another important aspect.* Obtaining information from the entire product chain is vital, from raw material to packaging and transportation, along with knowing how customers will use the product.

** Today's product development not only focuses on the technical aspect, but also in doing things correctly. They also work with developing suppliers to help them develop their products.*
** Working in networks is essential because of the important knowledge possessed by raw material suppliers.* Networking is relatively new to the company, but it is an important means of incorporating competence when development demands it. *Development has closer contact with suppliers than before by being able to meet and discuss trends and possible new products.*

5 Discussion and Conclusions

The focus of this paper is to investigate how integrating technology management and supply chain management can support an understanding of the necessary changes concerning information sources and networking in product development for Swedish process industries.

Some of the mutual areas of technology management and supply chain management are about bridging inter-and intra-firm boundaries, increased knowledge of a supplier and customers, and that each organization in the supply chain creates and adds value to the entire product, i.e. the supply chain is a network of organizations involved from beginning to end to create and deliver valued products to end customers, and individual organizations must interrelate and interact to add value (Primo and Amundson, 2002). It is suggested in this paper that an integration of the technology management and supply chain management perspectives can provide an analysis of mutual relationships and integration throughout the supply chain. Managing innovation today for process industries reflects the overall organizational structure with a primary concern for downstream and inter-functional relations.

One of the major characteristics of process industry concerns the value-added process of the product. That is, the development of the product can be in several steps (by a link of customers) and it is a dilemma that the product can act differently in different production processes due to a varied setting of parameters and tools. Understanding product development requires a simultaneous view of customers and technology, using product innovation to link technology and customer competences (Danneels, 2002). The results in this paper suggest that an increased product focus in development projects for Swedish companies in process industries is related to the changed information flow in the supply chain. The content of required information in product development has changed. It is indicated that a larger part of the supply chain must be covered in product development today. That is, there is a need of integrate information both from suppliers and customers in product development work. However, there is no indication in the study that there is a relationship between an increased product focus and networking or collaboration. Therefore, companies in process industry need to change their view of how to acquire information for product development projects. Inter-company integration and coordination via information technology can become a key to improved supply chain performance.

The result also indicates that there is no relationship between a changed strategy during the 90s and a changed supply chain information/networking. But how has information changed for Swedish process-based companies that support a change of development focus? Some of the quotes emphasis a future need for companies in process industries to increase their customer collaboration, and that product development work incorporates a large part of the value chain. Product development

must cover a larger part of today's value chain and realising what gives customer value. Another issue is that working in networks is essential because of the important knowledge possessed by some suppliers.

The main conclusions from this paper are as follows: To succeed with product development today, process industries must evaluate its supply chain and what creates the most value in the product. Technical possibilities and customers' needs are changing rapidly; therefore it is of more importance for companies to build sustainable relationships with both suppliers of equipment and customers. Network activities in product development are increasing for all process industries. In many cases, companies view their suppliers as an integrated part of their own product flow process.

The generalisability of this research is that companies that are having difficulties in competing with cost-effectiveness need to build sustainable networks, specifically build networks of capabilities. Managers have to build formalized integration mechanisms to involve both suppliers and customers earlier and more deeply in the product development because much of networking in a process industry is of a personal basis. This requires a deep analysis of both suppliers and customers, which can be obtained through following steps.

Step 1: Identify key sources of customer and supplier value, the customers' needs concerning the product and the processes (through interviews, QFD etc.), supplier capabilities concerning raw material and equipment.

Step 2: Identify critical capabilities within the company, and the required competence in product and process development.

Step 3: Identify possible information and communication flows to both suppliers and customers. It has to be systematized through a common database so that project members have access to the information.

Step 4: Plan for network structure, and build sustainable links to both customers and suppliers. The development team has to have a formalized facilitator with the main responsibility towards a specific customer or supplier.

An integration of the two perspectives, technology management and supply chain management, can support an understanding that an increased product focus in development for process industries means a future change of information and networks. Acquiring this information is not easily achieved, but analysing key sources and building suitable networks that depend on these sources will make the process of a change more efficient, since product development in process industries is interrelated to development conducted further up or down the supply chain. This means that a process-based company's product that is often further value-added by customers and material properties can be affected by the customers' production process.

To summarise, an analysis of the information that flows in the entire supply chain can help managers obtain a better understanding of what new competences and knowledge are required in product development. The need for this new type of information can be further formalised by building networks that act like a support to product development. This can be one integration sector between the two perspectives: technology management and supply chain management (Fig 4).

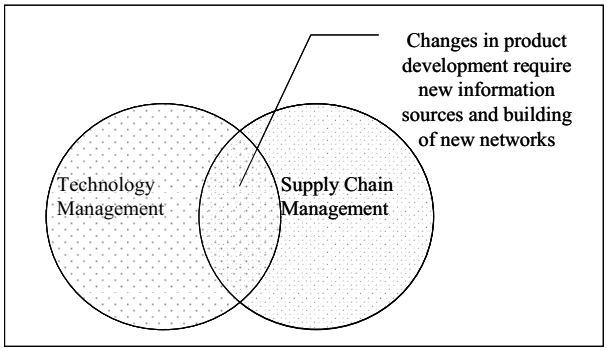

Fig 4. The conceptual model of the research.

The issue concerning the Bullwhip effect in Swedish process industry is a phenomenon that requires further research. The bullwhip effect is often debated in relation to production control and inventory control, but would it be possible to measure the impact information from customers will have on upstream product development work? There are indications in the research that companies in process industry have an increased awareness of the importance to involve customers in product development, but it a difficult task to accomplish. The use of IT in the supply chain can strengthen this relationship and information sharing. Tools and systems designed for supply chain management might be a starting point in integrating information from customers in regard to product development. However, there are no indications in this research of the use of IT in strengthened the supply chain. It is a topic that requires further research.

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APPENDIX A: INTERVIEW GUIDE

Industries:
Ore, steel/metal, pulp/paper, rubber, chemical, plastic, food/dairy

Some questions may not be answerable due to your type of business.

1. Type of company? Place in the value chain, from raw material to customer.
   – High-volume/niche products? Both? Share of each?
2. Type of development, i.e. what is it you develop, properties, application areas etc.?
3. Definition of product development?
   - especially your type of business?
4. Separate process development versus product development? Do you separate them?
   - Share of each in percentage?
5. What is considered to be more important? Increasing? Production capacity versus product properties etc. or what?
6. Do you have the required production flexibility?
7. What gives directions in development? (environmental requirements, costs, customers/market or…)
8. How do you organise your development work?
9. Division in functions, project, product groups….
   - integration of process development? How?
   - integrating mechanisms, formal meetings? Company policy, procedures?
   - Development in other units?
10. Which functions are represented (members) are representative in a development project?
    - Responsibility?
    – Other actors?
11. Time frames concerning product development?
12. Have the company experienced any changes concerning issues linked to organisation of product development during the past ten years?
    ⇒ if Yes,
13. What changes?
14. Causes to the change?
15. Experience of difficulties with the change?
16. Has the change lead to any positive effects?
17. Has the change led to any negative effects?
18. Need of changes in the future concerning development?
    ⇒ if No,
19. Is there any need of changes today? In the future?
20. Why/why not?
21. Possible difficulties with a change?
22. Positive effects?

23. If/How is customer/suppliers involved in development work? Other external actors?
    – are their presence of importance/not important? Scale 1-5 on each.
    – what factors are important for product development to consider them as possible actors?
24. Is there a link?/How is the link to customer/supplier constituted? (work with specification, reclamation etc)
25. How do you collect information to development projects? (Guidelines, company policy or..)
- what information is needed in development work?
– techniques?
– systematisation?
– storing to future project?
- something missing?
26. How is the communication exchange for actors involved in projects constituted?
- Meetings formal/informal? Percentage?
- Reports/PM?/* share of other projects?

PAPER VI

Effective product development process: Towards a conceptual framework for process industry

Submitted for publication

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EFFECTIVE PRODUCT DEVELOPMENT PROCESS: TOWARDS A CONCEPTUAL FRAMEWORK FOR PROCESS INDUSTRY

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Organisation and management of the product development process have been an issue in both the academia and the industry for over three decades. The literature on product development is growing but Process Industry is often lacking in those discussions. Therefore, this paper focuses on linking determinants of effective product development process to Process Industry and the implication this may have on an industry that is traditional very process-oriented by nature. Further, the paper organises the burgeoning product development literature into three areas: innovation type, technology strategy and organisational aspect. From the literature review we present a conceptual framework detailing the elements of intra- and inter-firm processes in the product development process in Process Industry. Our purpose is to give an increased understanding of the changed innovation pattern in Process Industry and its implication on organisation and management of the product development process.

Keywords: Product development process, innovation type, technology strategy, organisational aspect, process industry.

Introduction

What makes a product development process effective? What factors can be found in the literature that explains the efficiency and effectiveness of the product development process? The aim of this paper is to illustrate the state of the art of research concerning management and organisation of the product development process and to investigate factors influencing the product development process in order to organise these factors in a conceptual model adjusted to the Process Industry. However, the existing theory on product development is vast, so to sharpen our understanding of the literature, it is useful to organise this literature into areas of factors that may affect the creation of the product development process.

Academic researchers have during the last three decades shown an increasing interest in investigating organisation of product development, e.g. activities of the product development process, collaboration and the role of networks. Managing the product development process is also a central theme in management research. In the literature, organisation and management of the product development process have different names: New Product Development (NPD) (Hart & Baker, 1996), Simultaneous Engineering (SE), Concurrent Engineering (CE) (Andreasen & Hein, 1987), and Integrated Product Development (IPD) (Ulrich & Eppinger, 1995).

But, what creates an effective product development process in Process Industry? Process Industry has often been regarded as a mature industry, where both the products and production process are stable. Characteristics for Process Industry have been stable markets, fixed production processes with the focus on economy-of-scale and cost efficiency. But the tradition to solely concentrate on the process development and to hunt costs has changed. Process Industry is a term that has come to symbolise an industry that has invested heavily in its technology. However, it is a dilemma to balance the need to develop more customer-specific products and to keep the costs down with process development. Today, companies within the Process Industry, like steel and paper, are closing in on other manufacturing industry concerning the need to develop more "customer-specific" products (Chronéer, 2003). This change of condition in product development for Process Industry will require a change of the content and activities in the product development process. Especially for small countries it is difficult to compete on cost-effectiveness. There are other aspects that must be considered in order to survive, e.g. develop niche products. These changes will have an effect on how to manage the product development process, i.e. what activities must be undertaken, what internal and external forces must be considered, and what competencies must be maintained and/or acquired. The intra- and inter-firm processes are crucial in this matter.

The main ideas to product development in the Process Industry have traditionally come from the production process. Some of the process industries, like mining, steel and paper, have a tradition of being production-oriented in their product development projects, i.e. the production process states the limits within where products can be developed. Chemical and dairy industries have however a more tradition of close interaction with their customers (Chronéer, 2003). The trend of a changed focus, from process development to product development, involves other intra- and inter-firm processes including the relations to customer as well as to the suppliers in the

product development process. However, the characteristics of the development of the raw material into new products are quite different from other manufacturing industries.

Therefore, the purpose of this paper is to develop a conceptual model that describes how the product development literature with the focus on the product development process can be adopted by the Process Industry, which has other conditions to consider in product development work than other manufacturing industry.

In this paper, we have a common definition of product development, namely it can be described as the process that identifies a market opportunity and transforms it into a product available for sales (Krishnan & Ulrich, 2001). The definition of Process Industry in this paper is a type of business that has a focus in material/metallurgical/chemical properties and production process in product development projects, i.e., product development and process development are close interrelated. It can be described as following: "Process Industry is production Industry using (raw) materials to manufacture non-assembled products in a production process where the (raw) materials are processes in a production plant where different unit operations often take place in a fluid form and the different processes are connected in a continuous flow" (Lager, 2002, p.108).

The paper is mainly based on literature research connected to the product development process, including articles published in major English-language organisations-oriented North American and European journals where this work is likely to appear[1]. We specifically focus on literature, which has a focus in the efficiency and effectiveness of the new product development process, i.e. on factors that is found to explain the product development process. Even with these constraints, it is still impossible to cover all studies in one review paper. The literature research has also been conducted in databases with links to other journals discussing the topic of organisation and management of the product development process. The selection of the main determinants of the product development process is described below.

Determinants of product development process

What determinants can be found in the literature that creates an effective product development process? A product development process is part of a broader context in an organisation, i.e. the organisational innovation. But organisational innovativeness is a broad concept involved in a firm's tendency to innovate (Salavou, 2004). Salavou (2004) points out two broader research streams. The first stream is the firm's external or/and internal process of innovation and the second focuses on determinants of innovation or/and its impact on organisational performance. Further, firms have different perspectives to innovation and this perspective can change as the firm matures (Utterback, 1996). Therefore, it is of importance to understand the **type of innovation** the firm is involved with, i.e. to understand the factors that determines innovation (Love & Roper, 1999; Tatikonda & Stock, 2003) and success of innovation (Van der Panne *et al.,* 2003). The concept product innovation is complex. It may even em-

[1] We included Research Policy, Journal of Management Studies, California Review, Journal of Product Innovation Management, International Journal of Innovation Management.

body other innovation types, such as technological and process (Salavou, 2004). In order to understand the process of innovation, it is essential to understand the definition of innovation.

Since the concept of product innovation even can embody innovation types, such as technological and process, one determinant found in the literature that can enable an effective product development process, is the management of the technology and the construct of the **technology strategy,** e.g. the process by which the company constructs its new product development portfolio (Schilling & Hill, 1998) and the use of tools for improving the NPD process (Schilling & Hill, 1998; Gerwin & Barrowman, 2002).

Other determinates found in the literature that have an impact on the management of the product development process, are the contextual factors of the organisation. New product development is **context dependent**. That is, the management of the product development process is dependent on the type of product being developed. A structural way to analyse this context is to divide the wide range of activities involved in the development of a new product into technical and marketing activities (Trott, 1998, p.152). Industrial products (products developed for use by other industries), such as paper or raw steel products, have many different considerations compared to those of a new food product. Cavone *et al.* (2000) identified that R&D organisation and management are heavily affected by the nature of the R&D process and the relative importance of the different activities within R&D. The product development process is contextual, complex and iterative, Rudolph, 1995 emphasises that the food product development process has proved difficult to define and model. He means that progress must be monitored against a planned set of goals in order to be successful. Out of this perspective the contextual factors can be either internal to the firm, i.e. **organisational aspect** or external to the firm, i.e. due to **the industry.**

The **organisational aspect** can be described as a determinant that contains elements that are internal to an organisation (Gerwin & Barrowman, 2002), e.g. within which a new product development project is embedded. Lewis (2001) describes a transformation model with factors driving NPD performance. He means that "starting conditions", which determines success, are often firm-specific in nature and that contextual influences might include e.g. "type of markets", "technological change", "organisational structure", "internal and external communication", "functional relations". Input to the product development process can be; the process of transforming (people and process technology) and transformed (market and technological information) resources (Lewis, 2001), i.e. NPD can be seen as a specific illustration of organisational learning**.** This is in accordance with Saban *et al.* (2000), who mean that organisational learning is a critical component to new product development and have impact on new product performance.

Balachandra and Friar (1999) found that different approaches in innovation are needed for different types of NPD projects. They suggest that any NPD project lies in a contextual space – nature of the innovation (the level of innovation for a new product ranges over a wide spectrum – incremental and radical), nature of market (can be categorised into two types - existing and new), nature of technology (how familiar a company is with the underlying technology of the new product).

Another perspective, when discussing product development, is the focus on intra- and inter-firm processes (Maffin *et al.,* 1997). These processes are concurrent, multi-disciplinary and with characteristics of companies and their competitive environment. Maffin *et al.* (1997) listed not less than thirty-seven factors occurring frequently in the best practice literature concerning product development in manufacturing industry (e.g. strategy, technology management, marketing and project initiation, project management, management and decision-making, organisation, process and integration, design methods, modelling and analysis.

To understand the complexity and to identify the intra- and inter-firm processes, figure 1 organises the areas of factors that may affect the efficiency and effectiveness of the product development process summarized from the references above.

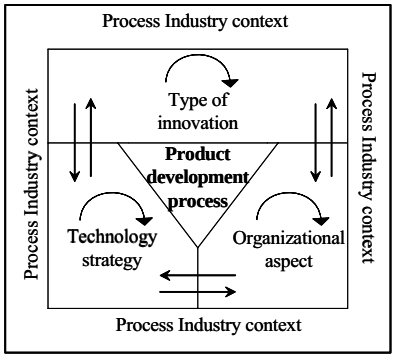

Figure 1. Determinants of product development process
(the arrows illustrate the intra- and inter-firm processes).

Figure 1 highlights the intra- and inter-firm processes within and between the determinants: innovation type, technology strategy, organisational aspect (i.e. the company's own unique attributes), and industry context. The sections that follow will discuss the determinants and their elements in more details in order to illustrate the state of the art of research concerning organisation and management of the product development process.

Product Development Process

What is product development? The literature often states that the main purpose of product development is creation of new products (e.g. Smith & Reinertsen, 1991; Allen, 1993; Cooper, 2001). But what is a new product? Does it mean new to the customer, new to the company or a new application area? Cooper (2001, pp.14) means that there are six different types or classes of new products that can be identified: from new-to-the-world products (the first of their kind, create new markets) to cost reductions (new products designed to replace existing products at a lower cost).

There have been some major developments in the operating environment of manufacturing firms. Many markets and industries have become increasingly interna-

tional. Product development has felt pressure in tighter cost targets, reduced development cycle times, increasing speed of obsolescence of technologies, faster changing customer demands and the need for improved product quality. As a result of these developments there has been an increasing emphasis on the importance of faster development of new products. This has lead to a new way of organising product development projects, i.e., in the literature known as the New Product Development (NPD) (Doz, 1996; Hart & Baker, 1996; Jones, 1997). It means that the rules of the game in new product development are changing due to the importance of speed and flexibility when developing new products today (Takeuchi & Nonaka, 1986; Cooper, 2001). It also means that new products should be processed using a parallel approach (Takeuchi & Nonaka, 1986) instead of the traditional linear approach. In the parallel approach, the activities of new product development process overlap, rather than being performed sequentially. That is, New Product Development is a concept of a new way to organise product development. Cross-functional integration, including project organisation, effective problem solving, transference of innovation etc., are examples of subjects within NPD (Barclay, 1992a, b).

However, as Sands (1983) points out, there exist problems of organising for effective new-product development. What is the "right" organisation for new-product activities? Sands means that there is no "best" new-product organisation, i.e. what is best for one firm might not be best for another. In actual practice, a range of new-product organisation can be found. This is according to other researchers, for example Cavone *et al.* (2000) explore whether a certain managerial/organisational style relates to the type of the R&D process /which varies from industry to industry) and to the different nature of the R&D activities. They identified that R&D organisation and management are heavily affected by the nature of the R&D process and the relative importance of the different activities within R&D. So there is not one best way to organise the R&D activity and that practices cannot be transferred from other industries blindly.

Activities in the product development process

One factor for new product success is found in the activities in the product development process (PDP) and the efficient execution of them. It is therefore important to be able to identify both what activities are present in a particular PDP and what activities should be present (Fairlie-Clark & Muller, 2003). Many manufacturing companies have evolved their own models, and some of these are very comprehensive. But as Gomes *et al.* (2001) emphasis, managing the product development process is more than just identify the activities. They show that the role and intervention of senior managers on the product development process is more complex than previous research has suggested. It is required to continually look for opportunities to improve the process, to do things smarter, faster, and with more synergy (Graber, 1996).

There are numerous ways to describe a product development process. Almost every company has its own description of the product development process. Traditional models for product development have been derived mostly by observation in industries such as the automotive or appliance industry. The literature often describes

product development in manufacturing industry as a process that includes all the activities that take place to transform a product concept to a physical prototype (Trygg, 1991; Wheelwright & Clark, 1992).

The product development process can also be described, not as sequential, but more as a multifunctional process with parallel and iterative processes. It is no longer regarded as "an exclusive product development department business", but as linked to all company activities that are interrelated and participate in the product development process (Hayes *et al.*, 1988; Clark & Fujimoto, 1991).

An early model developed by Olsson (1976), describes a systematic approach of the integrated product development process (later modified by Andreasen & Hein, 1987). According to this model, product development is a creative and a multifunctional process. It means that there is an interaction between the phases within the product development process, i.e., the phases are overlapping each other. This is also visualised by e.g., Wheelwright and Clark (1992). They describe the process with four stages as:

1. *Concept Development*: Product architecture, Conceptual design, Target Market
2. *Product Planning*: Model building, Small-scale testing, Investment/financial
3. *Product/Process Engineering*: Detailed design of product and tools/equipment, Building/testing prototypes
4. *Pilot Production/Ramp*-Up: Volume production prove out, Factory start-up, Volume increases to commercial targets

Other researchers describe the process with more stages, e.g. Trygg (1991) describe the process with eight activities: Market (information about market opportunities), Research (includes activities performed with the purpose of finding new elements of technology), Concept development (conceptual design and product architecture), Product planning (model building, small-scale testing and financial analysis), Engineering design/product engineering (detailed design of the product and prototypes are built), Process planning/process engineering (detailed designs of tools and equipment, prototypes are tested), Operations of the products, and Sales of the products. In the product development process, R&D is a function that is responsible to keep abreast of the latest research within their industry. It includes both basic and applied research. It rarely encompasses product planning activities (Jones, 1997).

Fairle-Clarke and Muller (2003) found it important to identify both what activities are present in a particular product development process and what activities should be present. Successful application of co-ordination processes, such as scheduling, resources allocation and concurrent engineering, also depends on having a complete representation of the product development process activities. They found 18 generic elements in the product development process. So how can the product development process be summarized? It can be described as a process where data is transferred about market opportunities, technical possibilities and important information assets for the production. During the product development process these information assets will be created and then they will be screened, stored, combined, decomposed, and transferred among various media (Clark & Fujimoto, 1991).

Type of Innovation

In order to investigate factors influencing an effective product development process, it is required to understand the type of innovation the firm is involved with. Rudder *et al.* (2001) identify different theories and recognise that there is very little consensus as to the right and wrong way to manage the process of product development. Further, there is little consensus as to what actually constitutes a "new product". It is shown that the process of new product development can be broken into a number of stages. Rudder *et al.* (2001) point out that the actual process of new product development may contain a number of different stages and that it is likely that all processes are very similar in content; it is just the manner in which they have been named that appears somewhat arbitrary.

Rothwell (1994) gives a historical perspective in his article of the innovation process. He introduces the so called fifth-generation innovation process, a 'system and integration networking model', as a multi-institutional networking process (strong linkages with leading-edge customers, strategic integration of primary suppliers. The content of innovation is changing, e.g. the changing role of R&D (Germeraad, 2001) and the pattern of innovation (Gupta & Wilemon, 1996). Some research indicates change from product innovation to a more solution innovation (Shephard & Ahmed, 2000).

Determinants of innovation

What determines innovation? Tatikonda and Stock (2003) integrate literature on new product development, supply chain management and technology management, and builds on organisational theory to present a conceptual model of determinants of product technology transfer success. They identified the process of product technology transfer as a key activity in the process of new product development. This is similar to Love and Roper (1999) who widen the determinants of innovation beyond R&D to include technology transfer and networking effects.

Salavou (2004) suggests a shift in emphasis from organisational to product innovativeness, i.e. a shift from the general question 'what factors influence a firms' tendency to innovate" to 'what factors affect the innovativeness of a new product'. As an example, innovation is regarded essential by most small food firms (Avermaete *et al.,* 2003). Such firms tend to continuously introduce new products, develop new processes, make changes in the organisational structure and explore new markets. Rogers (2004) shows that evidence of persistence in innovative activities and that the use of networks is associated with innovation in some sector-firm size categories. Specifically, small manufacturing firms exhibit a positive association between networking and innovation. But it is not enough to discuss product success. It can be as learning to understand what makes firms fail with innovation. Morris (1993) means that there is no hard data on food product failures. One reason lies in defining a successful product. Other obstacles include lack of strategic commitment; no formal development process; poor decision making; no incentives for managers; lack of leadership; a need for focus and discipline. Top management commitment is critical to new product success.

There are other determinants of innovation. Calderini and Cantamessa (1997) show that exogenous determinant, i.e. computer-aided technologies, design methodologies and organisational structures interact in a complex fashion and adapt themselves to a changing competitive environment.

Technology Strategy

Since the concept of innovation can embody both product and technological elements, one determinants found in the literature to make the product development process more effective, is the management of the technology and the construct of the technology strategy, e.g. the process by which the company constructs its new product development portfolio (Schilling & Hill, 1998) and the use of tools for improving the NPD process (Schilling & Hill, 1998; Gerwin & Barrowman, 2002). Management of technology is a concept that has expanded to incorporate other issues than just R&D Management. Management of innovation and technology is not only confined to what takes place in the firm's R&D department. Thus, management of innovation typically involves elements of other business processes such as marketing and manufacturing, and management of technology may involve managing process technologies, which typically lies outside the domain of the R&D units (Christensen, 2002). Chanaron *et al.* (2002) mean that management of technology can be clustered into two main research tracks, namely: managing technology as an activity and managing technology as a resource. This is based on the assumption that technology and managerial functions are closely related, impacting on each other.

It is stated that innovation is a complex issue. It can incorporate not just the product development itself but also the product and process technology development. Drejer (2002) found that product development deals with technology management on the product/market level, and technology development deals with technology management at the internal level.

He emphasises that important issues for product development are**:**

- What needs does the firm attempt to fulfil with its products?
- How can these needs be met in terms of product functionalities?
- Which products should the firm produce?
- How should the firm compete with its products; on low cost, on differentiation from other products or on focusing on few customers and their needs?

On the contrary, technology development deals with technology management at the internal level. Important issues include:

- Which technologies are needed in order to fulfil the needs of customers?
- Which technologies are needed in order to produce and sell the current portfolio of products?

Further, product development may be market-orientated or production-orientated. A production-oriented perspective on product development involves primarily an interest in the technological solutions of the production process. Development of this

process and equipment is often a link in an optimisation of the production process, i.e., finding a more cost-effective process. Product development will then be a secondary result of the changes of the production process, i.e., product development is defensive (Utterback, 1996). According to Utterback (1996), a project team will then mainly consist of internal personnel such as process engineers and laboratory personnel. External cooperation will mainly be with equipment suppliers. R&D is a support function that can serve the development team with research on specific topics like metallurgical properties. This research is interrelated to the process development, i.e., it is based on the capability of the production process. However, Utterback (1996) states that if markets need change and a business need to change from a production-orientated perspective on product development projects to a more customer-oriented perspective, the organisation of the projects will also have to change. Should then product development be a part of process development, where product development issues are discussed in relation to internal production-related questions, or if it should be separated, i.e., form a separate unit that focuses on the product, not the technological issues? Harmsen *et al. (*2000) mean that for a general overview it seems reasonable to say that there have been two major views on innovation over the years. They argue that innovation in a company to a large extent is driven by its orientation; product orientation, process orientation, or market orientation. The competence that are directly related to the orientation, i.e. for market orientation the market competencies, for product orientation the product competencies, and for process orientation the process competencies will be the most central or in other words the core competencies of that company.

Market- or production-oriented

If there is a change in the organisation of the innovation perspective, it will also affect the phases in the firm's product development process. New members and a new focus on a project lead to a new mix of activities in the product development process, e.g., market activities are more emphasised, from the project start to the product launch. There must also be an interaction between R&D and marketing (Griffin & Hauser, 1996).

There are research that state that product development must be driven primarily by customers' needs rather than by technological possibilities (Butscher & Laker, 2000). However, it is important to separate the terms about what is market-oriented and what is customer-led (Slater & Narver, 1998, 1999). Market-oriented businesses seek to understand customers expressed and latent needs, and develop superior solutions to those needs. A customer-led philosophy tends to be reactive and short-term in its orientation, and focuses on customers' expressed desires and on measures of customer satisfaction.

Many companies wish or claim to be customer-oriented. Customer-driven product development is, however, a demanding and difficult task. The voice of the customer should be taken into account in all the phases of product development, both in definition and design phases (Kärkkäinen *et al.,* 2001). Understanding market and customer needs is one of the key to successful innovation (Roberts, 1999). This holds

true for both commodity and speciality chemical companies, even though their disparate markets and operations naturally lead to different approaches to innovation. Because of the usually high investment and long lead times required to scale up commodity chemicals and plastics, market needs and trends should be more clearly understood over a long time horizon.

Kok *et al.* (2003) argue that market-oriented product development may be regarded as an organisational learning capability, which encapsulate knowledge and skills, technical and management systems that enable learning about markets through information processing. However, Cooper (1999) found that a strong market orientation and customer focus is lacking in many businesses' new product projects.

Information technology

Other determinants of innovation are the use of information technologies (Calderini & Cantamessa, 1997). Tidd and Bodley (2002) review the range of formal tools and techniques available to support the new product development process. The study identifies the potential mediating affect of project novelty on the process of new product development, and some of the dangers of adopting so-called 'best practice' methodologies without taking context or contingencies into account.

Over the past three decades, information technology has gradually revolutionised work in organisations. Product development is no exception. Literature shows research concerning information management opportunities and challenges (Jarvenpaa & Ives, 1994), the role of information technology in the organisation (Dewett & Jones, 2001), the linkages between information technologies (IT) and firm performance (Powell & Dent-Micallef, 1997), and the supporting product development with internet (Howe *et al.*, 2000). The globalisation of product development activities is one of the key management topics of the nineties, so choosing suitable project management is critical (Boutellier *et al.*, 1998; Cooper 1999).

Information technology is significant determinant of cooperation (Bensaou, 1997) and information technology makes it possible to coordinate inter-organisational activities (Levary, 2000). Levary (2000) describes how information technology plays a central role in the development, functioning, and success of virtual corporations and describes an information system that integrates the programmable design of a product and its manufacture with planning activities and the manufacturing process. Court *et al.* (1997) investigated the influence of information technology in new product development. They found that the real problems are being the extensive use of personal information stores and the absence of easy to use indexing systems. Management needs to be receptive to opportunities for exploiting IT capabilities, yet realise IT limitations, both short-term and long-term. Management should assess IT for its business value (Scott, 2000).

Communication is identified to be a critical integrative facilitator in product development project. Project members need the right integration mechanisms to be able to collaborate, but, unless mechanisms are put in to place to modify the information flow so that it is transferred and available when the downstream teams start their work, nothing changes operationally, i.e., the downstream activity can not commence

(Griffin & Hauser, 1996). It is critical that personnel involved in collaborative new product development understand the factors which influence the success of collaboration, such as frequent consultation and communication and timely disclosure of necessary information (Parker, 2000).

For example, Gana (1992) points out that one of the determinants of innovation in cooper mining was prompt access to technical literature as an important source of new ideas. Sharing experience and knowledge - or even equipment - was crucial to overcoming obstacles in the development solutions.

Organisational Aspect

Other determinates found in the literature that have an impact on the management of the product development process, are the contextual factors of the organisation. A great amount of the findings in the literature review of the product development process emphasises the company's capability and the means of collaboration.

Capabilities

In order to manage the product development process efficiently and effectively, it is of importance to understand the company's capability to manage the product development process. The *competence* needed in the process, i.e. technical competencies together with interpersonal and conceptual competencies. Understanding the new product development process requires a simultaneous view of customers and technology, that is, new product development requires bringing together two competencies: competence relating to technology and competence relating to customers (Danneels, 2002). Other researchers also stress the process of acquiring knowledge into development. Sheasley (2000) illustrates the two key fundamental difficulties in managing new technology development - "Technology" is knowledge and the process of developing new technology is one of acquiring knowledge.

Technical competencies comprise knowledge of methods, processes and techniques suited to the activity. Interpersonal competencies involve for example communication and co-operation, and conceptual competencies include analytical capacity, creativity and efficiency in problem solving (Nordhaug, 1993). Organisational competencies are being developed when individuals share their mental models (Kim, 1993) and when individual competencies are absorbed into the organisational structure, e.g. into rules, manuals, reports, networks and information technology systems, (e.g. Edvinsson & Malone, 1997; Sveiby, 1997).

Much work within product development is closely tied to individuals participating in the projects. It is of course essential to have the right competence to be able to conduct the work satisfactory and to enhance the company's competitiveness. Activities within a company that are related to the business strategy and that will use and develop the company's resources in a positive way can be defined as value added activities. One condition for the use of these value added activities is that the company has access to corresponding competencies (Hörte, 1995). Intangible resources

and people-based skills are emphasised as strategically important resources for gaining a sustainable competitive advantage (Grant, 1991).

Ferrari and Toledo (2004) present a model for analysing the *knowledge management* in the organisational processes. Knowledge can be considered as an input, an element of transformation, and as an output of these processes. The results showed a lack of awareness about the presence of these knowledge management elements in the everyday activities of product development process and the importance of the integration of these elements to the success of this management. It is necessary to analyse which types of knowledge are more important for the analysed process. Where does the knowledge come from? How does this knowledge get to the process? How is this knowledge exchanged within each stage and between stages of the process? Further, Hughes and Chafin (1996) emphasise the awareness to turn new product development into a continuous learning process. They mean that in the fast-paced environment of today, customer wants and needs are constantly shifting, and a product's life cycle may be shorter than its development time, product development must be transformed into a continuous, iterative learning process focused on customer value. The objectives of this development approach are continuous learning, identifying the certainty of knowledge used for decision-making, building consensus, iterative, learning process focused on customer value.

Research also shows that *organisational learning* is a critical component to new product development (Saban *et al.*, 2000) and that the product development process demands ongoing improvement (Smith, 1996). Cumming and Teng (2003) found that knowledge transfer success was associated with several key variables, and to hinge upon (a) both R&D units' understanding where the desired knowledge resides within the source, (b) the extent to which the parties share similar knowledge bases, and the extent of interactions between the source and the recipient to (c) transfer the knowledge and (d) participate in an articulation process through which the source's knowledge is made accessible to the recipient. In other words, knowledge that can be readily codified in manuals, diagrams, etc. is less likely to be internalised within the recipient than less articulated knowledge.

Collaboration/integration

There is an extensive research on how to collaborate and with whom in the product development process. Managing complex networks is the key to 21st century innovation success (Rycroft & Kash, 1999). Successful innovation of complex technologies requires equally complex networks of firms and other organisations, often including universities and institutes. However, this is not just equal for development of complex technologies, it should also be addressed to companies that see the need of changes of a product's value-added.

Some of the forms of integration that have been identified in the literature include: *R&D/manufacturing/marketing integration* (e.g. Kahn, 2001; Olson *et al.*, 2001; Song *et al.*, 1997; Song *et al.*, 1998), *R&D/marketing integration* (e.g. Griffin & Hauser, 1996; Kärkkainen *et al.*, 2001; Ottum & Moore, 1997)**,** *customer integration* (e.g. Butscher & Laker, 2000; Campbell & Cooper, 1999; Dwivedi & Pick,

1999; Gruner & Homburg, 2000; Sharma, 2002), *supplier integration* (Araujo *et al.*, 1999; Hartley *et al.*, 1997; Swink & Mabert, 2000)**,** and *networking* (Comer & Zirger, 1997; Magrath & Hardy, 1994).

Research concerning *cross-functional teams* and functional integration has been a topic in product development research for some decades and a number of researchers have found a positive relationship between new product success and the integration of activities (Gupta & Wilemon, 1996; Olson *et al.*, 2001; Sherman *et al.*, 2000; Song *et al.*, 1997; Song *et al.*, 1998; Wheelwright & Clark, 1992). Further, other researchers show the impact of organisational integration and product development proficiency on market success (Griffin & Hauser, 1996; Millson & Wilemon, 2002). Understanding and mastering the integration mechanisms is a prerequisite for companies to be able to manage the complex concept of 'the totally integrated organisation' (Carlsson, 1991). It is shown that formal integrative management process, such as a cross-functional review board is an effective mechanism for foster integration (Leenders & Wierenga, 2002).

The literature also emphasises the importance of the role of the *customer* in the product development process. But, the customers' role has changed during the last decades, from the traditional role limited to just a consultative one to a more active participant (Gardiner & Rothwell, 1985). More often, manufacturers can deal directly with strategically important customers, often collaborating on development programs (Pick, 1999). A close cooperation with customers can play an important part in assisting the early identification of applications and benefits provided by a new technology thus making the early and clear definition of a technology (Cooper & Kleinschmidt, 1993). Customer involvement can be desirable throughout the product development process, not only in the role of refining the technology but also as a test of marketability, where the customer takes a very active role as a team member in a joint development process (Neale & Corkindale, 1998). The term customer integration captures a wide array of methods to import intelligence about customers' values and behaviour in the product development (Tollin, 2002). Partnership collaborations usually speed communications, problem solving, and decision making between partners. In any customer partnership, buyer and sellers may try to improve the exchange of transactions, perhaps through computer-to-computer ordering systems or electronic data interchange. However, exchanges of people and ideas can be just as crucial (Magrath & Hardy, 1994). Therefore, it is important to create mechanisms for ensuring that customer information requirement from various sources is internally consistent (Bailetti & Litva, 1995). Some authors point out that product development must be driven primarily by customers' needs rather than technological possibilities (Butscher & Laker, 2000) and that customers should be involved in product development in an early stage (Gruner & Homburg, 2000; Kärkkäinen *et al.*, 2001).

Other external parties to collaborate with in the product development process are with competitors as well as co-development with key *suppliers* (Petersen *et al.*, 2003; Ragatz *et al.*, 1997). Effective integration of suppliers into the product development can yield such benefits as reduced cost and improved quality of purchased materials, reduced product development time and improved access to and application of technology. It is important that the interface with suppliers are continuously monitored and purposefully managed and that dynamic features are taken into account (Araujo

et al., 1999). One way to build sustainable links to suppliers is through product development partnerships (Swink & Mabert, 2000). Because suppliers should be involved as early as possible in product development regardless of whether they are providing a standard or custom component (Comer & Zirger, 1997; Hartley *et al.*, (1997). Supplier involvement in product development holds great potential but few companies seem to be able to realise these benefits (Wynstra *et al.*, 2001). They summarise that involving suppliers in product development can result in major benefits in terms of money and time. But, it requires a great deal of thinking and efforts.

The interest in external collaboration, in *networks*, has recently arisen. Many studies have attempted to give an in-depth analysis of the networks, to highlight how they are constituted, relationships between the use of physical collocation (Kahn & McDonough, 1997; Patti *et al.*, 1997) and factors for success or failure (Balachandra & Friar, 1997). Research concerning inter-organisational relationships can relate to how to understand the possibilities with networks (Håkansson & Ford, 2002), how to create value through mutual commitment to business network relationships (Blankenburg Holm *et al.*, 1999) and how to manage networks (Biemans, 1990). Organisational networks are becoming the key to successful innovations (Rycroft & Kash, 1999). Harryson (1997) argues that external networking for identification and acquisition of relevant technologies and their related competencies actually enhances a company's ability to implement internal network mechanisms that drive product innovation. A network management framework proposes that there are various domains of managerial capabilities that a firm must master to compete successfully in a modern network environment (Möller & Halinen, 1999).

Today, management can see supply chain cooperation as an important part of its strategy (Morgan & Monczka, 2003) and integration of processes involves going all the way from determination of the product or service that the customer wants and needs to creating that new product or service, that is companies first need to establish a total view of the supply chain (Peck& Jütter, 2000). Schary and Skjøtt-Larsen (1995) state that focusing on the supply chain, allows us to focus on strategic decisions that reach beyond the linkage within the chain, which includes a set of organising principles for the complete product and material flow process. This network approach consists of three components and their mutual relationships in the analysis of industrial networks: activities, actors and resources (Skjoett-Larsen, 1999). Here, the network approach and the resource-based view provide a better description of the inter-organisational processes that develop between the partners in a long-term relationship.

Chen and Paulrai (2004) show us the complex network of interrelated activities in supply chains. Since a supply chain consists of interdependent firms involved in the flow and transformation of goods, services, and related information, as well as funds from point of origin through to the end customer (Simatupang & Sridharan (2002).

Understanding how supply chains will change in the future is important for managers to comprehend (Lancioni, 2000). Supply chain management offers the opportunity to capture the synergy of intra- and inter-company integration and management. Further, it deals with total business process excellence and represents a new way of

managing the business and relationships with other members of the supply chain (Lambert *et al.*, 1998).

The Industry Context – Process Industry

A product development process exists in an industry context. In this paper, the focus is on the Process Industry because there are few research attempts that focus on product development process and Process Industry.

The Process Industry in the Western World has moved from a position of power and wealth in the 1960s to a struggle for survival in the 1990s (Anderson, 1997). For example, for over five centuries Sweden has had a competitive iron and steel industry; and for more than 150 years it was even the leading producer to be trading in iron. However, due to the early crisis in the 1970s and the following years of the reconstruction of the Swedish iron and steel industry, new technologies became more and more important. Furthermore the steelworks concentrated in a few a special products (Nisser, 1997). The Process Industry comprises a large segment of the economy. From commodity raw materials like steel, paper, and glass to value-added materials such as advanced ceramics, the process industries are a unique set of industries built around the production processes that manipulate material properties to produce raw materials for use in a variety of applications (Barnett & Clark, 1996).

Process Industry has characteristics that are very different from assembly/fabrication industries and may require a different type of management emphasis (Utterback, 1996). Process development is the difficult and constraining aspect of product development in the process industries. The underlying assumption, concerning innovation in Process Industry, is that since product and process are symbiotically related in the production system, then fundamental changes in the one must incite and parallel fundamental changes on the other.

Research concerning Process Industry has mainly concerned process innovation. During the 80s, various articles appeared regarding production control in process industries and the vast majority focused on the typical characteristics of Process Industry, namely production control (Fransoo & Rutten, 1994). Part of this interest can be attributed to a complacent belief in the economics of scale and an unwillingness to invest in emerging technologies. Recently there has been a reawakening; companies are cutting costs and repositioning themselves in the market place.

Today, environmental and economic pressures are forcing management to look very critically at the operation of existing assets. Companies are cutting costs and are targeting strategic dominance in selected markets by rationalising their product portfolios. Some companies in the industry have concluded that it can not solve its problems by cost-cutting alone. Understanding the larger system requires knowledge of both ‘hard’ and ‘soft’ factors. In this context ‘soft’ factors include the systems management, marketing and sales functions (Anderson, 1997).

Huang *et al.* (2002) are concerned with new product management practices in the Chinese steel industry. They investigated the industry practitioners’ perspectives of NPD success factors, the importance of management functions to new product success and specific measures of NPD success. Market-based factors were ranked ahead

of technical and organisational factors in terms of importance for NPD success. Further, formulating new product strategy and strengthening market research were identified as the most important internally oriented and externally oriented managerial functions respectively.

However, there is some research showing product development in Process Industry. Jokinen and Heinonen (1991) pointed out early in the 90s that the Finnish paper industry has a tradition of cooperating, not only in research, but also in product development and even marketing. Finnish companies see universities as suppliers of human resources. Strezo (1999) states that new product development in the chemical industry is largely product-focused, but that a shift to a market-focused approach is critical and requires changes in philosophy, approach and culture (Strezo, 1999).

Change of pattern for Process Industry

So, what has happened to Process Industry during the last decades? Since the main literature on the process industries has focused primarily on cost reduction and economies of scale, Barnett and Clark (1996) interest lies in a second arena of innovation in the process industries – the development of new modified materials. They present a four-dimensional characterisation of technological newness for product development projects in the process industries in which product development is closely tied to process innovation.

Further, Burgess *et al.* (2002) found that the UK chemical industry is increasingly moving from commodity to speciality production. But Freeman *et al.* (1968) found in the 60s that the chemical industry has been growing more rapidly since the Second World War than manufacturing industry as a whole. They meant that some observers had concluded that vertical integration of chemical firms, contractors, and component-makers is the obvious solution to this problem of cooperation and communication.

The cooper industry went through a severe crisis during the late 1970s and early 1980s. The most evident signs of the crisis were the dramatic fall of cooper prices and the heavy losses of some of the major companies of the industry (Gana, 1992). Gana found that the firms benefited greatly from the externalities derived from learning processes and that one of the external factors influencing the development of solutions within the enterprise was the informal communication network. Sharing experience and knowledge - or even equipment - was crucial to overcoming obstacles in the development solutions.

Networks have come to grown for Process Industry. Hutcheson *et al.* (1996) explored issues concerning technological innovation in the network of firms linked to the chemical industry, with particular reference to the process plant contracting industry. They found that technological innovation plays a significant role in the success of the network of firms involved in designing, manufacturing, supplying and operating chemical process plants. Roberts (1999) means that the chemical industry is built on both product and process innovation, but with customers increasingly demanding better products, lower prices and more tailored services, the industry is changing its approach to innovation.

Other changes in Process Industry concerns the fact that product life cycles are getting shorter, and the close coupling of business and technology strategy has become critical. Gunasekaran (1998) found that the current trend in Process Industry includes rapid prototyping and advancement in technology and new materials, increased creative product innovation, increase reliance on automation and increased complexity, performance and reliability of products. So, there is indication that the orientation in Process Industry concerning development is changing from production to a more customer-orientation (Chronéer, 2003; Van Donk, 2000). The role of customer and supplier in product development has increased and the content in development projects has changed to include other aspects like material properties and customer service (Chronéer, 2003).

Difference between Process Industry and other Manufacturing Industry

There are several conditions that distinguish process-based companies from manufacturing industry (Tottie & Lager, 1995). Some are:

- Process industry is often a part of a long chain of customer/suppliers who do not always have access to information from end-user.
- Suppliers often deliver material, not components.

Comparing process industry with other manufacturing industries from a production-oriented perspective, there are a number of areas where the differences are important and influence innovation activities (Lager, 2001). Some of the areas that differ and can influence how product development is performed are: incoming material, production plants, flexibility etc., see Table 1.

Table 1. Some differences in the production process in process industry compare to manufacturing industry *(Source: Lager, 2001).*

Area	Other Manufacturing Industries	Process Industry
Incoming materials	Components from suppliers	Raw materials
Production plants	Can be small and integrated with plants on different sites	Sometimes very large and often strongly integrated on one site
Customer Supply chain	Often producing directly for the end user	Sometimes producing to a long chain of customer and not to the end user
Production chain	Often not a completely continuous production process. Not fully integrated process control	Often a continuous production with on line process control in real time and a central control room
Flexibility	Often flexible production plants not integrated in fixed structures	Often plant configurations that are difficult to change and modify
Product integration	Products are often not interdependent	Products are interdependent and changes in one product or production process can affect other products and processes

One major difference between Process Industry and piece goods industry is that the Process Industry, in general, has very inflexible and costly equipment. The production process is often unique for the purpose of manufacturing a specific product. The products that are manufactured are often interdependent. Changes of material properties in the raw material affect the entire product group.

Product development is to a great extent context dependent (Trott, 1998). Trott points out that the management of the process is dependent on the type of product being developed. A way of looking at this is to divide the wide range of activities involved in the development of a new product into technical and marketing activities. It becomes clear that industrial products (products developed for use by other industries), such as paper or raw steel products, have many different aspects compared to those of a new food product. In the latter case there will be much more emphasis on promotion, launching and packaging, whereas the steel product requires technical meetings with customer concentrating on the aspect of material properties.

In sum, product development work in Process Industries has a mix of both product and process-orientation. Harmsen *et al.* (2000) mean that for a general overview it seems reasonable to say that there have been two major views on innovation over the years. They argue that innovation in a company to a large extent is driven by its orientation; product orientation, process orientation, or market orientation. The competence that is directly related to the orientation, i.e. for market orientation the market competencies, for product orientation the product competencies, and for process orientation the process competencies will be the most central or in other words the core competence of that company

Product Development Process in Process Industry

The organising idea behind the conceptual model in Figure 2 is that there are multiple determinants that create an effective product development process in Process Industry. Specifically, we argue that (a) the conditions for conducting product development in Process Industry have changed. Especially for Swedish Process Industry it is difficult to compete on cost-effectiveness. There are other aspects that must be considered in order to survive, e.g. develop niche products. These changes will have an effect on (b) how to manage and create an effective product development process, i.e. what activities must be undertaken, what internal and external forces must be considered, and what competencies must be maintained and/or acquired. The product development process and the creation of new product value will require (c) an integrated approach of organisation and management in the entire organisation.

Today, companies within Process Industry can choose to focus on cost-effectiveness and maintain high-volume products, or they can choose another direction, i.e. towards finding niche products. Research shows evidence that some companies within Process Industry have changed direction. The pattern of innovation in Process Industry has changed from a production-oriented to a more customer-oriented perspective (Van Donk, 2000; Chronéer, 2003;). One implication of this change is that there are other determinants to innovation. That is, the content in development projects has changed to emphasise other aspects than the production process, e.g. material properties, customer service. Product life cycles are getting shorter (Gunasekaran, 1998), and the role of customer and supplier in product development has increased (Chronéer, 2003). So what determinants are of importance in product development in Process Industry today?

Process industry is often a part of a long chain of customer/suppliers who do not always have access to information from end-user. The production process of a finished product consists of a continuous flow that often incorporates suppliers, who deliver material not components, and customers, who transform the material to suite their purposes. The purpose with the conceptual model is to emphasise some of the critical determinants that can have an impact on the product development process. When the pattern of innovation is changing then there are some major areas related to product development process that has to change accordingly, e.g. the activities in the product development process. The activities in the product development process can view different for various companies, but it should be related to the need to collaborate with customers and suppliers so that it acquires the needed competence and knowledge in product development. Understanding the new product development process requires a simultaneous view of customers and technology, that is, new product development requires bringing together two competencies: competence related to technology and competence related to customers (Danneels, 2002). Research also shows that organisational learning is a critical component to new product development (Saban *et al.*, 2000).

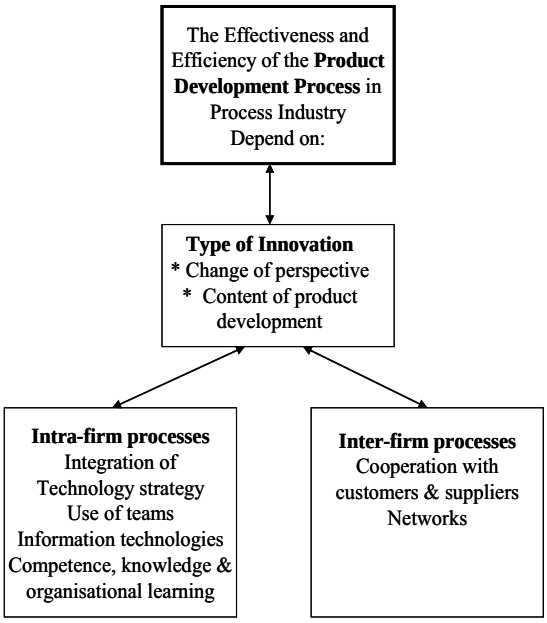

Figure 2. The conceptual model of the determinants of effective product development process in Process Industry

Since technology and product development is close interrelated in Process Industry a key determinant in the product development process is the integration of technology strategy and product strategy, i.e. the activities that create the integration. One means to create this integration is the use of teams and integration of different functions. Since Process Industry often is characterised as a part of a long chain of customer/ suppliers and who do not always have access to or need information from end-user. Companies dealing with products upstream of the value chain need other type of information today in their development projects. They need more information about 'end-customers' today. So sharing experience and knowledge can be crucial to overcoming obstacles in the development solutions (Gana, 1992) and information technology can be a significant determinant of cooperation (Bensaou, 1997).

There is also an increasing influence from suppliers and customers when developing new products within the Process Industry. Today some companies use the suppliers' and customers' knowledge when developing new products and when developing the manufacturing technology. Therefore, the product development process will be dependent on the company's relations to its suppliers and customers.

In the change towards a more customer-oriented view in product development projects, the ability of cooperation and alliances with other companies as well as creativity and problem solving, the question that arise is: has the company the capability to manage the new product development process?

In the product development process, different activities are accomplished within the team, between teams and between the team and other functions within the organi-

sation as well as with suppliers and customers. However, there are problems when organising for an effective product development. Sands (1983) points out the question of the "right" organisation for new-product activities and means that there is no "best" new-product organisation, i.e. what is best for one firm might not be best for another. Other researchers, for example Cavone *et al.* (2000) support this view, when they explore whether how a certain managerial/organisational style relates to the type of the R&D process (which varies from industry to industry) and to the different nature of the R&D activities. Concluding that there is not one best way to organise the product development process and that practices cannot be transferred from other industries blindly. Instead it should be fruitful to study product development as a multifunctional process with parallel and iterative processes.

Three important areas are to be investigated when studying how the market/customers needs are organised and managed in the product development process, such as communication, cooperation and networking. Since the interpretation of market/customers needs is combined with the technical possibilities in the production, networking, communication and cooperation should affect organisational factors, such as technology and human resources as well as companies capabilities.

Organisational and individual capabilities have been discussed in the literature as important immaterial resources creating a competitive advantage. Competence acquisition by recruitment and through external contacts with customers brings new competencies into the organisation. Competencies are also developed within the organisation through formal educational courses and training programs but also in the daily work. Many of the positions within the companies require employees with experiences gained in daily work situations. Individual competencies including many years of experience can be difficult to replace in personnel turnover situations. However, competencies that today are important for creating a competitive advantage may in the future become obsolete.

In the Process Industry, technical competencies consisting of the professional knowledge and skills related to material properties, quality improvements and the development of a wider product range are seen as important competencies when managing the product development process. However, the companies' ability to create the processes of knowledge transformation, both tacit and explicit, as well as group dynamic processes for organisational learning are important when building product development teams relations to suppliers and customers.

Finally, what creates value in the product development for Process Industry? The current change in product development for Process Industry is in some aspects due to the changes in the markets. The product development time is decreasing and the concept of the product is changing. Product developers have a changed role today compared to 20 years ago there is an increased need to work in networks and to have a greater understanding and knowledge of a greater span of the products place in the value chain. They must have knowledge about the raw material, customers' product and processes, and in some cases, have knowledge about end-customers. To develop product value is not just to develop material properties, it is as much to acquire competence and knowledge about customers, e.g. to understand and have knowledge about their production processes. So in order to understand what can bring success in

product development in Process Industry, it is essential to understand what brings value in the product development process.

Management of technology can be regarded as well as an innovation process as a multi-institutional networking process with strong linkages with leading-edge customers and strategic integration of primary suppliers. This can be compared with supply chain management, which often requires the integration of inter and intra-organisational relationships and coordination of different types of flows within the entire supply chain structure. Inter-company integration and coordination via information technology has become a key to improved supply chain performance. Barut *et al.* (2002) show that recent advances in information technology enable firms to manage effectively and inexpensively the coordination of not the physical flow of materials but also the flow of different types of information such as demand, capacity, inventory, and scheduling, through a supply chain. Further, focusing on the supply chain, allows us to focus on strategic decisions that reach beyond the linkage within the chain, which includes a set of organising principles for the complete product and material flow process (Schary & Skjøtt-Larsen, 1995). The supply chain management perspective also shows us the complex network of interrelated activities in supply chains (Chen & Paulrai, 2004). Understanding how supply chains will change in the future is important for managers to comprehend (Lancioni, 2000) and supply chain management offers the opportunity to capture the synergy of intra- and inter-company integration and management (Lambert *et al.*, 1998).

Therefore, we suggest that new methods to organise and manage the product development process, within the Process Industry, should be developed by using methods developed within the field of supply chain management.

In summary, to improve new product performance, managers should consider the following issues:

- Evaluate the current trend in their industry.
- Evaluate the need of the product development team, their role today.
- Investigate the change of competence needed in product development.
- Make resources available so that product development team can create suitable networks with suppliers and customers.

An integration of the two perspectives, i.e. management of technology and supply chain management, can formalise and visualise some of the implications of a changed perspective in product development for Process Industry. The two perspectives discuss the importance of networking, information sharing, customer/supplier linkages and strategic management, i.e. the mutual link between them. The conclusion of this paper is that product development work in process industries to a great extends deals with information concerning the entire supply chain, i.e. it is required to

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