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Innovation and Design Processes in Small Established Companies

Licentiate thesis by

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Abstract

This thesis examines innovation and design processes in small established companies. There is a great interest in this area yet paradoxically the area is under-researched, since most innovation research is done on large companies. The research questions are: How do small established companies carry out their innovation and design processes? and How does the context and novelty of the process and product affect the same processes? The thesis is built on three research papers that used the research method of multiple case studies of different small established companies.

The innovation and design processes found were highly context dependent and were facilitated by committed resources, a creative climate, vision, low family involvement, delegated power and authority, and linkages to external actors such as customers and users. Both experimental cyclical and linear structured design processes were found. The choice of structure is explained by the relative product and process novelty experienced by those developing the product innovation. Linear design processes worked within a low relative novelty situation and cyclical design processes worked no matter the relative novelty. The innovation and design processes found were informal, with a low usage of formal systematic design methods, except in the case of design processes for software. The use of formal systematic methods in small companies seems not always to be efficient, because many of the problems the methods are designed to solve are not present. Customers and users were found to play a large and important role in the innovation and design processes found and gave continuous feedback during the design processes. Innovation processes were found to be intertwined, yielding synergy effects, but it was common that resources were taken from the innovation processes for acute problems that threatened the cash flow. In sum, small established companies have the natural prerequisites to take advantage of lead-user inventions and cyclical design processes. Scarce resources were found to be the main factor hindering innovation, but the examined companies practiced several approaches to increase their resources or use existing scarce resources more efficiently in their innovation and design processes. Examples of these approaches include adopting lead-user inventions and reducing formality in the innovation and design processes.

Keywords: Innovation process, Design process, Small companies, Novelty, Context

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Possible readers and target group of this thesis are small company managers, small company employees involved in innovation and design, policy makers involved in support programs targeting small companies, large company managers dealing with innovation and design processes in collaboration with small companies, and of course my fellow scholars.

I hope all of you reading this thesis will enjoy it and learn something new that you can put into practice.

Gävle, October 2009

Lars Löfqvist

Table of Contents

Appended Papers

1 Introduction

Research, small companies, and innovation are topics that are mentioned together increasingly frequently by governments (Swedish Government, 2008), policy makers (Jones & Tilley, 2003; European Union, 2008) and researchers (Bessant & Tidd, 2007; PIEp, 2006). When large companies are down-sizing to meet increased competition in a globalized world, the idea to notice, support, and research small companies is popular. Innovation is believed to be a key to success in these small companies because of its purported link to future welfare, job creation, and economic growth (European Union, 2005). Innovation and renewal policy initiatives aiming at small companies have become a common approach to stimulate economic development (Jones & Tilley, 2003). For example, the largest part (46 percent) of growth programs financed by the government in Sweden aims at small company innovation (Nutek, 2009).

Small companies are numerous. 99 percent of all companies in the European Union are small (fewer than 50 employees) and together employ about 50 percent of the employees in the non-governmental sector; these figures are approximately the same for Sweden (Eurostat, 2009).

Despite the large numbers of small companies and the great interest in small company innovation, the area is paradoxically under-researched. Most research on innovation is done on larger companies (Larsson, 2001; Moultrie et al., 2007; O'Shea & McBain, 1999). Hörte et al. (2008) conclude that innovation research in small companies is immature, heterogeneous, and lacking in cumulative knowledge creation. For example, no studies have been found that follow the process of developing product innovations in small companies. Small companies have different characteristics and contexts than large companies, which makes it doubtful whether results from innovation studies of larger companies can be directly applied to small companies (Audretsch, 2001; Rothwell & Dodgson, 1994).

There is great potential in knowledge about innovation in small companies especially concerning the question of how small established companies can be more innovative. This thesis examines the innovation and design processes in these small established companies. The word *established* is used to point out the focus on small companies that have been established in their markets for several years. These small established companies often do not have obvious potential for growth and are seldom researched. Non-established small

companies are researched in the field of entrepreneurship and studies the creation and growth of companies, the creation of the companies' products is on the whole neglected (Bessant & Tidd, 2007; Gibb & Ritchie, 1982). When the phrase *small companies* is used in this thesis, small established companies are meant.

1.1 Purpose

The overall purpose of this thesis is to deepen our knowledge of small established companies' innovation and design processes. This purpose will be more specified in three research questions in section 2.7.

2 Theoretical Framework

In this theoretical framework innovation and the process of innovation and design will be discussed. Small established companies and their context will be described as well. The design problem to be solved and novelty aspects of the innovation and design processes will also be reviewed.

2.1 What is innovation?

There is a great muddle of definitions when it comes to innovation, new product development, and design. Marxt and Hacklin (2005) state that innovation, product development, and design are terms that have evolved and adopted similar meanings. This makes it tricky to grasp the field and make distinctions among the concepts. For the present researcher these complex concepts have changed meaning several times, which is somewhat reflected in the appended papers in this thesis. But when we consider process, we must distinguish among the innovation process, the new product development process and the design process. In this thesis the term new product development is not used but is seen as included in the term innovation process. Innovation is defined as the process of turning opportunity into new ideas and of putting these into widely used practice (Tidd & Bessant, 2009). The design process is seen as a subprocess of the innovation process when the actual development work and creation of the product is carried out.

There are several ways to classify different kinds of innovations, and innovations can be developed in many different contexts. This thesis deals with innovations that are developed in the organizational structure of companies.

Tidd and Bessant (2009) present four types of innovations:

- Product innovation –Changes in the things (product/services) which an organization offers;
- Process innovation –Changes in the ways things (product/services) are created and delivered;
- Position innovation –Changes in the context in which the products/services are introduced; and
- Paradigm innovation –Changes in the underlying mental models which frame what the organization does.

This thesis focuses on product innovations, but it is likely that the four types of innovation are interconnected in an organisation and if one type of innovation is achieved the other types of innovations are affected (Tidd & Bessant, 2009).

An innovation can very briefly be described as something new that is brought into practice. This raises questions about what is meant by new? A common classification is to put the degree of newness, or *novelty*, on a scale from incremental to radical innovations (European Union, 2005; O'Shea & McBain, 1999; Tidd et al., 2005). Incremental innovations are minor improvements to existing products with a lower level of newness, while radical innovations are totally new products with higher levels of novelty (Bessant & Tidd, 2007). A typical incremental innovation is an improved product targeting an existing market that uses already existing technology (Reid & de Brentani, 2004). Incremental innovations are more common than radical innovations (Tidd et al., 2005; Veryzer, 1998). Incremental innovations are sometimes called evolutionary or continuous innovations; radical innovations are sometimes called disruptive, breakthrough, revolutionary, or really new innovations (Veryzer, 1998).

When discussing newness and novelty one question is: new to whom? From which perspective is this novelty perceived? Three different concepts for this are: new to the company, new to the market, and new to the world (European Union, 2005). New to the company is the lowest level, when the particular innovation is perceived as new for a particular company but not necessarily new for other companies, markets, or the world. New to the market is when a company first introduces a certain innovation to a specific market. New to the world is when a certain company is the first to introduce a certain innovation to all markets and industries. This thesis, in accordance with European Union (2005), uses the lowest level of novelty, new to the company, as the unit that perceives the newness and novelty for a certain innovation. This is further elaborated below in terms of relative novelty.

2.2 Innovation processes

One approach in innovation research is to compare the state before and after an innovation process takes place. The actual process and its activities are neglected and only the input and output are compared and examined (Edwards et al., 2005). This thesis deals mainly with the process between input and output in innovation, the innovation process, and less with the input and output to the process. Academic theory often refers to "the" innovation process as if there were only one description of innovation processes, but it is

likely that there are different kind of innovation processes due to different prerequisites and contexts (Clarkson & Eckert, 2005; Karlson, 1994). A common approach to make innovation process models simpler and more general is to make them abstract and generic, but this approach also makes the models less practical to use in real-life situations (Clarkson & Eckert, 2005; Singley & Andersson, 1989).

Before presenting some different innovation process models and choosing a model for frame of reference, concepts such as incremental and radical innovation processes, design problems, and relative novelty will be discussed.

2.2.1 Incremental and radical innovation processes

There is no single best way to manage and organize innovation processes due to the way different industries differ in sources of innovation, technological and market opportunities, and organization (Tidd & Bodley, 2002). Two opposites among innovation processes are incremental and radical innovation processes (O'Shea & McBain, 1999; European Union, 2005; Tidd et al., 2005). Engwall (2004) makes a similar division between innovation processes with low and high uncertainty. Lawson (1997) sees these different processes as different philosophies about how to solve problems, where incremental innovation processes represent a problem-oriented approach and radical innovation processes represent a solution-oriented approach. Radical innovation processes can, but do not need to, end up with a radical product. Conversely, incremental innovation processes can result in radical products.

Incremental innovation processes have a more linear structure and are more problem oriented, aiming to first analyze the problem before trying to solve it. A radical innovation process has a more cyclical structure and is solution oriented, where a solution is initially created and then tested to gain new knowledge allowing the creation of a new solution to test, and so on. Incremental innovation processes build upon existing knowledge and experience and may therefore represent less novelty, risk, uncertainty, and ambiguity. The product to be created in incremental innovation processes often has known characteristics and properties that make it suitable for more linear innovation processes that can be planned better in advance and be carried out in project form. The resulting product's characteristics and properties are better known in advance because the product is similar to something already existing (Engwall, 2004; Lynn & Akgün, 1998; Lynn et al., 1996; O'Shea & McBain, 1999).

Radical innovation processes are more novel, with higher risks and higher levels of uncertainty and ambiguity, and they must usually be based on experiments and learning (Peters, 2006). What is to be done, the goal, the new product, are all fuzzier in radical innovation processes than in incremental innovation processes. Radical innovation processes are usually not linear but have a more cyclic character, due to experimental loops of probing and learning (Engwall, 2004; Lynn & Akgün, 1998; Lynn et al., 1996; O'Shea & McBain, 1999). There is less time spent on analyzing but more on synthesizing learning experiments (Engwall, 2004; Lynn & Akgün, 1998; Lynn et al., 1996). Early versions of the product are tested against customers, users, or other actors to gain feedback and new knowledge about the product, its usage, its market, customers, and users (Veryzer, 1998). This new knowledge yields somewhat reduced uncertainty and ambiguity and is then used in new refined experiments with the same approach of probing and learning (Engwall, 2004; Lynn & Akgün, 1998; Lynn et al., 1996). The experiments also give direction to the developing efforts (Engwall, 2004). These successive approximations strive to gain as much knowledge and reduction in uncertainty as possible and create the final solution manifested in the new product.

Higher uncertainty in radical innovation processes also means an increased need for flexibility to cope with unforeseen difficulties (Tidd & Bodley, 2002). This leads to difficulties in applying structured development processes. Engwall (2004), Herstatt and Verworn (2001) and Lynn et al. (1996) state that a linear and formalized innovation process might be counterproductive and unsuitable if high uncertainty is present, as is most often the case in radical innovation processes.

2.2.2 The design problem in innovation

Innovation processes can be seen as problem-solving processes centering on the design problem to be solved. The solution to the design problem is the finished product at the end of the innovation process. The character of the design problem affects the innovation process. Cross (2008) and Ullman (2002) state that all design problems are ill-defined, which means that information needed for solving the problem is initially missing and must be filled in to understand the problem. Many different solutions to the design problem exist and the challenge is to find the most optimal solution. A design problem can be vague, messy, fuzzy, incomplete, inconsistent, and even imaginary (Cross, 2008; Jonassen, 2000) and must be explored and defined more clearly before it can be solved.

Jonassen (2000) states that problems vary in terms of their structuredness, complexity, and abstractness. Design problems are among the most ill-structured and complex kinds of problem experienced in practice (ibid.). Some characteristics of ill-structured problems are that they possess many unknown elements, are vaguely defined, and permit many different solutions. Because different design problems vary in structuredness, different design models are needed involving different problem-solving skills. Differences in a problem's structuredness are also related to how incremental or radical the innovation process is. If the design problem is highly ill-structured, it probably needs a radical innovation process to be solved. Well-structured design problems suit incremental innovation processes better. Problem complexity is about the number of issues, functions, or variables involved in the problem and the degree of connectivity between these properties and the stability of these connections over time. Highly complex problems are more difficult to solve due to both the high number of different sub-problems and the limitation in cognitive operation in the working memory of the human brain. Abstractness is about how much the problem is embedded in a special context or domain. There are some general differences between different kinds of product categories when it comes to the design problem. If design problems in physical artifacts and in software are compared, software has better structured and less ill-defined design problems due to the constraints of language and systems (ibid.). Design problems in software development are also relatively free from issues relating to purchasing, production, materials, logistics, and distribution, all of which are normally much more important in the design processes of physical artifacts.

Many formal systematic methods exist to solve problems in innovation and design processes (Jones, 1992); these methods are commonly known as design methods (Cross, 2008). These methods are usually said to be heuristic and domain independent, able to be used in many different situations. Examples of these systematic methods are those that organize and structure the complex innovation and design process, methods that facilitate creativity or support the collection of needs and demands from customers and users, as well as methods that create and evaluate concepts. Research by Singley and Andersson (1989) shows that problem solvers who use domain-independent heuristic approaches generally do not perform better than those who do not use them. One underlying message is that domain independence achieves through abstraction, which has a negative influence on the practical use. Singley & Andersson (1989) also concludes that those who use less abstract domain-specific approaches are better problem solvers. Jonassen (2000) concludes that problem-solving activities are domain- and context-

dependent and that especially the more common ill-structured problems need domain-specific methods. Well-structured types of problems, as in software design, suit general domain-independence abstract methods better (Jonassen, 2000).

2.2.3 The relative novelty

The design problem to be solved in an innovation process is connected to the degree of newness of the product to be developed; this novelty is perceived differently by different actors (Tidd & Bodley, 2002). In accordance with European Union (2005) this study uses "new to the company" as the lowest unit perceiving the newness in an innovation. The novelty of the innovation should be determined in relation to the company developing the innovation, i.e. the ones working in the company developing the new product. This is in line with Tidd and Bodley (2002) when they introduce the concept of *relative novelty*, which is the novelty of the product to develop in the innovation process experienced by the designers and others involved in developing the product. Tidd and Bodley (2002) found that companies had different innovation processes within the same company, and used different methods and tools depending on the relative novelty of the development project for the company. Increased experience designing a certain product will decrease the relative novelty for that kind of product, and what can be highly novel for one company can be routine for another company due to more experience and knowledge (ibid.).

If the relative novelty of the product to develop is high it becomes hard to rationally plan the developing process due to the uncertainty and lack of experience of similar developing processes and the lack of knowledge about the product's final characteristics and properties (Herstatt & Verworn, 2001; Karlson, 1994; Lynn & Akgün, 1998; O'Shea & McBain, 1999).

High relative novelty demands high interaction with customers, users, and other external actors to get input and feedback on the development process (Tidd & Bodley, 2002). Olson et al. (1995) found that the higher relative novelty the more a non-bureaucratic organizational form was needed. The newer the project was for the company and less experience, the more difficulties were found in the process. In addition, the more difficulties found, the more interdependence was seen between different functional areas and the more information flowed across the different functional departments. As more information flowed between the functional boundaries, the need for informal, non-bureaucratic ways of handling things arose. The need for an informal and non-

bureaucratic organization in developing processes with a high relative novelty was also found by Veryzer (1998).

Innovation processes where it is likely that the product being developed has low relative novelty are incremental ones. Examples of these processes are redesign projects, extensions of existing product families, small improvements to a product, addition of simpler functionality to existing products, product customization, or a combination of these. If the product to develop is similar to one the company previously developed, the process becomes less novel, because the company already has much of the needed experience and knowledge in house. A large part of the design problem for the particular product has previously been solved and the process does not need to be started from scratch every time (Karlson, 1994). Ullman (2002) refers to this as development work that has become routine when the domain for the particular product is well understood.

Innovation processes are risky, highly complex, and difficult (Tidd & Bodley, 2002), and for a new and inexperienced designer they can be hard to manage and execute. Developing a product with a high relative novelty and an abstract, ill-defined, and complex design problem also will presumably increase the relative novelty for the design process of the same product. In other words, there is a kind of relative novelty for design processes also. There is a similar conception done by Engwall (2004) that uses product and process uncertainty instead of relative novelty of the product to develop and relative novelty to design processes. It is reasonable to expect the relative novelty of design processes to decrease with increased knowledge and experience of design processes.

2.2.4 Innovation and design process models

There are many different innovation and design process models in the literature. Rothwell (1994) looked into the development of innovation process models and drew some conclusions about their evolution. The first innovation process models were technology push linear models with different stages. In the next kind of innovation process models the demand side, or market needs, was gaining more attention and was incorporated in need pull linear models. These technology push and need pull process models were later merged into the same model and the first iterative loops appeared, which meant that the process was not always linear. Different perspectives on the innovation process, for example management, project factors, and key individuals were also gaining increased attention. Concurrent models with parallel activities and integrated disciplines were then

introduced that mainly had a time compressing logic to be able to speed up the innovation process.

Innovation process models are usually divided into activities or stages (Clarkson & Eckert, 2005). Tidd and Bodley (2002) conclude that most current innovation process models are linear and often fail to catch the common iterative feedback loops present in innovation. The models can be abstract, describing the innovation process on a generic level. The models can also be less abstract, procedural, and prescriptive, and more suitable for use in practical situations (Clarkson & Eckert, 2005).

Most innovation process models target physical artifacts, but there are also innovation process models especially aiming at service innovation, see for example Edvardsson (2000). There are many similarities between developing services and goods. On a generic level the innovation process is the same (Bessant & Tidd, 2007), but on a more practical level the more specific characteristics of services must be taken into consideration. Examples of these specific characteristics are the higher level of abstraction, heterogeneity, as well as the fact that services are harder to store and often consumed at the same time they are produced (Edvardsson, 2000). Many products consist of both goods and services.

Most innovation process models fit incremental innovation work best; there is a great lack of innovation process models for radical innovation processes. The only exception found is a model by Veryzer (1998) that is unexpectedly linear and has prototyping as a main activity. In general, radical innovation processes seem to be hard to capture in a single framework (Kahn et al., 2006).
It is common that innovation process models leave out the innovation process context and only look at the activities performed, even though the innovation process is affected by its context (Clarkson & Eckert, 2005; Karlson, 1994). Examples of innovation process models that take the context into consideration include those by Bessant and Tidd (2007) and Goffin and Mitchell (2005). The innovation process model by Bessant and Tidd (2007) is depicted in Figure 1 below.

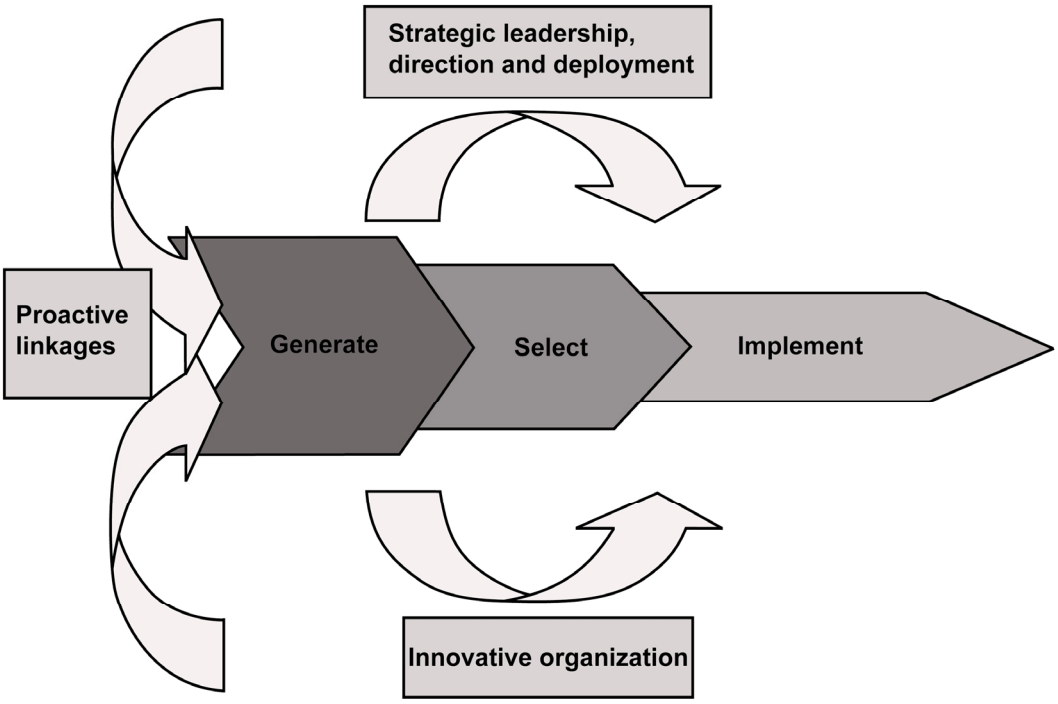

Figure 1. Model of the innovation process (Bessant & Tidd, 2007).

The model consists of three generic phases: generating, selecting, and implementing inputs for change. The context is divided into three different interacting factors. The first contextual factor, Strategic leadership, direction, and deployment, is about balancing risk in a strategic way with a clear direction, leadership, and committed resources. The second contextual factor, Innovative organization, describes the structure and climate appropriate for innovation, which should enable and facilitate creativity and communication. The third contextual factor, Proactive linkages, concerns the links to external and internal actors that are part of the innovation process, such as customers, users, suppliers, and sources of finance within or outside an organization.

To map findings in this thesis I selected the innovation process model by Bessant and Tidd (2007) as an abstract model of reference. There are several reasons for this choice of model: it is easy to understand, has a generic and abstract nature that will enhance the probability that it will suit different innovation processes, it includes context, and it clearly distinguishes between different phases, especially the idea phase and the implementing phase.

Bessant and Tidd's (2007) innovation process model can be criticized in some areas. The output of the process, the product, is not present in the model, although the product to

develop affects the innovation process (Clarkson & Eckert, 2005; Karlson, 1994; Tidd & Bodley, 2002). Only three contextual factors are present in the model, even though the wider context probably influences the innovation process. Examples on this wider context are the innovating organization's market and social context. This wider context is, for example, different for large and small companies. The model is abstract and captures activities in the innovation process on a high level. Especially in the implementing phase of the model, the model is seen as too simple for mapping findings. A more detailed implementing phase is needed.

The design process occurs inside the implementing phase of Bessant and Tidd's (2007) model. This way of seeing the whole process from initial generation of ideas to market introduction as the innovation process and the implementation phase of actual development work as the design process is supported by Marxt and Hacklin (2005). This study sees the design process as the process when such activities as exploration of the design problem, generation of possible solutions, evaluation of the solutions, and communication of the result are performed. This is in accordance with Cross's (2008) description of the design process. There exist several different models of design processes (Cross, 2008; Hubka & Eder, 1996; Otto & Wood, 2001; Pahl et al., 2007; Pugh, 1990; Roozenburg & Eekels, 1996; Ullman, 2002; Ulrich & Eppinger, 1995). All these models and theories have in common the basic activities of investigating the design problem, generating solutions to the design problem, evaluating the solutions, and communicating the solution further in the development process. It is further likely that these basic activities are the core of the design process and must in some way or other be present in all completed design processes. One design process model that suits this line of reasoning is the four-stage design process model by Cross (2008), depicted in Figure 2 below.

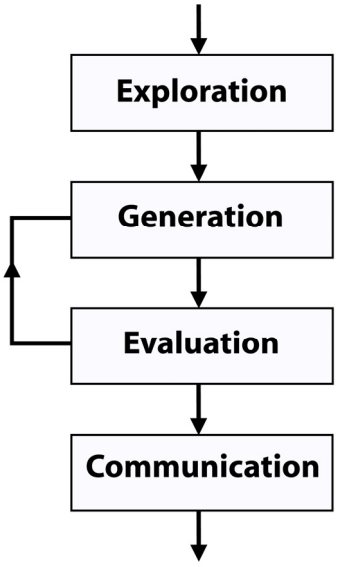

Figure 2. A four-stage model of the design process (Cross 2008)

Note the iteration feedback loop between the evaluation and generation stages. Cross's (2008) design process model provides the more detailed implementing phase needed in Bessant and Tidd's (2007) innovation process model.

2.3 Characteristics of small established companies

The focus in this study is on small established companies. They are established in their markets, develop their own products, and do most innovation and design work in house without extensive risk-funding. Most are family-owned and family-controlled small companies with an owner who is also the manager (Hadjimanolis, 2000), hence the term "owner-manager" is used when discussing the managers of these small companies.

In this thesis, a company is defined as small if it has fewer than 50 employees[1]. This figure of 50 employees was chosen not only because it agrees with other definitions of small companies, for example by the European Union (2005), but also because it is an approximate limit at which the owner-manager of a company must delegate much power and control of the company, and doing this usually demands a different leadership and management (Larsson, 2001; Storey, 1994). When a company grows to over 50 employees, it becomes hard for only one person to manage and control most activities and processes in the company and there is an increasing need to formalize the structures of different processes.

[1] In Paper A, one examined company actually had 70 employees. Since the study in Paper A was done this company has downsized to only 5 employees and then increased again to 50 employees.

Small companies have broadly similar characteristics across sectors (Bessant & Tidd, 2007). If a comparison is done between small companies and large companies, there are generally great differences in several areas. Small companies have mainly behavioral advantages, but not the material advantages that larger companies have (Rothwell & Dodgson, 1994). This means that small companies generally have scarce resources (Ghobadian & Gallear, 1996; Rothwell, 1989; Rothwell & Dodgson, 1994; Welsh & White, 1981; Zontanos & Anderson, 2004) but are more flexible, with a low level of bureaucracy and rapid internal communication and decision making (Adams, 1982; Cannon, 1985; Vossen, 1998). Large companies have greater resources but are generally stiffer and more bureaucratic (Rothwell & Dodgson, 1994). Pilemalm (2002) concludes that employees' roles are fuzzy in small companies. Separate departments are often missing and employees have multifunctional roles, working in many different situations (Bodin, 2000; Pilemalm, 2002). Informality is a central theme in small companies and most processes are informal (Pilemalm, 2002; Tidd & Bessant, 2009). Small companies' organizational strength, ease of communication, speed of decision making, degree of employee commitment, and receptiveness to new situations obviate the need for the formal strategies that are used in large companies to ensure communication and coordination (Tidd et al., 2005). Integration of different functions is of less central importance in small companies, because functions are less specialized and less likely to be separated by physical and organizational distance (ibid.). Freel (2000) concludes that small companies lack expertise in several areas and perform certain tasks with less expertise. Scott et al. (1996) found that small companies often are tied in to existing levels of technology.

The owner of a small company is often the manager with responsibility both for the company and the employees (Guimarães et al., 1996; Larsson, 2001). Small company owner-managers are often forced to be generalists to be able to handle a lot of different managerial tasks and are involved in almost all processes in the company (Verhees, 2005; Welsh & White, 1981). Hyvärinen (1995) and Verhees (2005) state that there is a close relationship between the goals and strategies of the small company and the personal values and goals of the owner-manager. Owners-managers of small companies usually do not like to delegate authority and responsibility, because they like to control most things regarding the company (Adams, 1982; Cannon, 1985).

Small companies are working in a turbulent organization (Moultrie et al., 2007), within a highly uncertain and turbulent environment (Ratcliffe-Martin & Sackett, 2001; Welsh &

White, 1981) and have little control over this environment (Carson, 1995). One reason for this high external uncertainty is lack of power in the marketplace and the fact that it is common that small companies are dependent on a large customer (Westhead & Storey, 1996). This high external uncertainty and lack of control and power in the marketplace makes the time horizon shorter in small companies, which in turn makes long-term strategies less useful and short-term returns more favourable than long-term returns (ibid.). Dalley and Hamilton (2000) state that dealing with problems as they arise is a common approach in small companies. Carson (1990) found that small companies have a constant time pressure due to day-to-day problems that need to be solved and scarcity of available time. Small companies are usually very sensitive to any disturbance in the cash flow through the company; a constant cash flow is necessary for the company's existence (Welsh & White, 1981).

Small companies are usually close to their customers and users (Rothwell & Dodgson, 1994). This means shorter lines of communication and easier contact between the company and its customers. Carson (1995) states that it is common that small company managers know their customers personally and the close relationship and interaction leads to benefits including customer loyalty and higher levels of customer satisfaction. Small companies are flexible in responding to customer inquiries, which further increases customer satisfaction (ibid.). Small companies have easy access to accurate and inexpensive market information due to their closeness to customers, users, and markets and thus can make better informed marketing decisions (Dallago, 2000). The main marketing technique is relationship marketing with current customers (Zontanos & Anderson, 2004). Relationship marketing suits small companies because it is cheap, has low risks, allows direct contact with the targeted market, and is highly flexible, which suits small companies and their turbulent environments (ibid.). Formal marketing knowledge in small companies is scarce (Adams, 1982; Cannon, 1985; Moultrie et al., 2007).

Table 1 provides a summary of the above-mentioned characteristics.

Table 1. Characteristics of Small Established Companies

Limited resources

- Scarce resources (Ghobadian & Gallear, 1996; Welsh & White, 1981; Zontanos & Anderson, 2004; Rothwell, 1989; Rothwell & Dodgson, 1994)
- Sensitive to disturbance in cash flow (Welsh & White, 1981)
- Constant time pressure (Carson, 1990)
- Limited opportunities to develop new technology by themselves (Scott et al., 1996)

Short-term strategies

- No formal strategies (Tidd et al., 2005)
- Family owned and controlled (Hadjimanolis, 2000)
- Short time horizon; long-term strategies are less useful (Westhead & Storey, 1996)
- Close relationship between the goals and strategies of the small company and the personal values and goals of the owner-manager (Hyvärinen, 1995; Verhees, 2005)

Flexible organization and management

- Flexible organization (Adams, 1982; Cannon, 1985; Vossen, 1998)
- Informal processes (Pilemalm, 2002; Tidd & Bessant, 2009)
- Owners-managers reluctant to delegate (Adams, 1982; Cannon, 1985)
- Loose and flat organization (Bodin, 2000; Pilemalm, 2002)
- Low levels of bureaucracy (Adams, 1982; Cannon, 1985; Rothwell & Dodgson, 1994; Vossen, 1998)
- Rapid decision making (Adams, 1982; Cannon, 1985; Vossen, 1998)
- Rapid internal communication (Adams, 1982; Cannon, 1985; Vossen, 1998)

General rather than specific knowledge and skills

- Fuzzy and multifunctional roles of employees (Bodin, 2000; Pilemalm, 2002)
- Many generalists but lack of expertise (Freel, 2000)

Close to customers and market

- Closeness to customers (Rothwell & Dodgson, 1994)
- Relationship marketing with high reliance on current customers (Zontanos & Anderson, 2004)

Uncertain context

- High external uncertainty, ambiguity, and turbulence (Ratcliffe-Martin & Sackett, 2001; Welsh & White,1981)
- Lack of power in the marketplace (Westhead & Storey, 1996)

2.4 Innovation characteristics of small companies

Innovation in small established companies has different characteristics in comparison to that in larger companies, due to different technological and economical environments (Audretsch, 2001). Small companies' beneficial characteristics in innovation are flexibility, agility in reacting and responding to changed market conditions, and rapid communication and decision making within the organization (Adams, 1982; Cannon, 1985; Vossen, 1998). Limited access to finance (Freel, 2000; Zontanos & Anderson, 2004) and scarce resources (Ghobadian & Gallear, 1996; Rothwell, 1989; Welsh & White, 1981; Zontanos & Anderson, 2004) are among the predominant characteristics that hinder innovation (Rothwell & Dodgson, 1994). This often leads to viable ideas being shelved (Adams, 1982). Small companies have scale-related disadvantages and often need to find extra resources externally for innovation (ibid.).

Adams & Walbank (1983) conclude that most small company innovations are incremental variants of already existing products. New-to-the-world, radical product innovations are rare. Dallago (2000) and Mosey (2005) conclude that small companies innovate with less novel technology or use known technology in new novel ways. There is an inability to spread risks within small companies' innovation activities with techniques such as portfolio management (Moultrie et al., 2006; Pilemalm, 2002). Innovation seems to be most successful if existing customers are targeted (Adams & Walbank, 1983). Schmidt-Kretschmer et al. (2007) conclude that most innovation in small companies is driven by market or customers, and that small companies have good contact with their customers' needs.

Most small companies are family owned and controlled; it is important to note, however, that more innovative small companies tend to have lower family involvement in the business (Hadjimanolis, 2000). A supportive manager is important for innovation to occur (Cannon, 1985), and a small company with an owner-manager who delegates power and knowledge among the employees is considered more innovative (ibid.). A highly centralizing, autocratic management style with all decisions and information flows involving the owner-manager, which is common in small companies, does not create a creative environment within the company, ultimately decreasing innovation (Adams, 1982; Cannon, 1985). Larsson (2001) states that information in innovation activities will naturally spread in the small company without the use of methods and tools, due to the employees working in close proximity.

Bodin (2000) and Pilemalm (2002) describe how it is hard to separate innovation activities from other daily activities in small companies, because the employees involved have multifunctional roles and are also responsible for day-to-day activities. Innovation processes must work and be executed at the same time as ordinary activities in the company such as sales, manufacturing, production, marketing, logistics, etc., and usually by the same people. In an environment of time pressures and uncertainty, innovation competes for resources. Woodcock et al. (2000) found deprioritized innovation activities when small companies were faced with short time pressure.

Small companies frequently involve some form of external linkages with external actors in innovation and are embedded in local networks (Bessant & Tidd, 2007). Both customers and competitors are perceived as important sources for ideas suitable for innovation (Hartman et al., 1994). Lots of contact with the market enhances innovation within small companies and innovative small companies are more proactive in engaging with the external environment and much more efficient in utilizing external relationships and knowledge to develop new products (Adams, 1982). Low et al. (2007) found that some small companies only innovate at customer request. Adams (1982) concludes that the most innovative small companies have a strong market orientation. Cannon (1985) states that support from existing customers is a success factor in small company innovation. Without this customer support, innovation often fails. Small companies seem to have better opportunities for market pull innovations, since they are close to their customers (Rothwell & Dodgson, 1994; Schmidt-Kretschmer et al., 2007).

Table 2 summarizes some of the characteristics of innovation in small companies.

Table 2. Some Characteristics of Innovation in Small Companies

Characteristics of small company innovation

- New variants of existing products are the most common product innovation. New-to-the-world product innovations are rare (Adams & Walbank, 1983)
- Customers and competitors are important sources for ideas suitable for innovation (Hartman et al., 1994)
- Innovation with less novel technology or using existing technology in new ways (Dallago, 2000; Mosey, 2005)
- Inability to separate innovation activities from day-to-day activities (Bodin, 2000; Pilemalm, 2002)

Factors supporting innovation processes in small companies

- Flexibility, agility in reacting and responding to changed market conditions, rapid internal communication, coordination, and decision-making (Adams, 1982; Cannon, 1985; Vossen, 1998)
- Customer support (Adams & Walbank, 1983; Cannon, 1985)
- A supportive manager (Cannon, 1985)
- Delegation of power and knowledge among employees (Cannon, 1985)
- Low involvement of family issues in the business (Hadjimanolis, 2000)
- External linkages (Bessant & Tidd, 2007)
- Proactive behavior to the environment (Adams, 1982)

Factors hindering innovation in small companies

- Scarce resources (Adams, 1982; Rothwell & Dodgson, 1994)
- Inability to spread risks in innovation (Moultrie et al., 2006; Pilemalm, 2002)

2.5 Small companies' innovation and design processes

No studies found followed innovation and design as a process over time within small companies. Instead, they have examined the innovation and design processes in small companies as snapshots, using interviews or surveys. O'Shea and McBain (1999) conclude that there is a lack of theory and models of small companies' innovation processes. Larsson (2001) studied four small companies and found the innovation processes in these small companies to be a learning process when motivation and craftsmanship lie in the hands of one or a few key persons and the owner-manager is involved. Much of the innovation work involves these key persons gaining an understanding of the company's competence and matching it with needs and problems within the company's market to develop new products with the use of external relations (ibid.).

Janhager et al. (2002), as well as Pilemalm (2002), found that innovation processes in small companies are informal. There are no studies found that link product success with formal innovation processes in small companies (Ledwith & O'Dwyer, 2008). Franke et al. (2003) found that small companies lack the qualifications and resources for a methodologically systematic design process. Meyer (2002) made an extensive survey of the use of methods and found low usage of formal methods in the innovation processes in small companies, regardless of industry. Small companies seem not to be so interested in supporting techniques as systematic methods (Scozzi et al., 2005).

No specific innovation process models for small companies were found, but for medium-sized companies, Berglund (2007) created a model that is similar to the abstract innovation process model of reference by Bessant and Tidd (2007).

Innovation processes in small companies can be seen as a continuous process with unclear start or stop points and unclear phases (Bodin, 2000; Cannon, 1985). Problems within the process are predominantly found in marketing activities and in the early parts of the innovation process (Adams, 1982). O´Shea & McBain (1999) found that small companies have problems dealing with unforeseen difficulties in the innovation process due to a lack of slack that can absorb and handle these difficulties. This lack of slack is directly caused by the small company's lack of resources.

The design process part of the innovation process in small companies is an even more poorly researched area than the innovation process because most studies done are on a managerial level and do not usually look at design activities (Larsson, 2001; Moultrie et al., 2006; Moultrie et al., 2007). Exceptions to this are studies done by Guimarães et al. (1996) and Larsson (2001). They found that the design processes in small companies were informal and used own-developed, informal design methods. Prototyping and sketching were common approaches. The owner-manager was usually involved together with other employees and was the creative engine. The use of external expertise was scarce and knowledge needed in the process was mainly gained from suppliers or other small company owner-managers. The small companies were close to their customers and external feedback from customer during the design processes was extensive. Previous experience and common sense were used in the design processes; lack of knowledge and resources necessitated improvising and creativity in how to use existing knowledge and resources in the best ways. The design processes were highly search-oriented, dynamic, and iterative with cyclical loops. Larsson (2001) alone found concurrent design activities when early attention was paid to economic, manufacturing, and marketing aspects. Commitment to design activities was often combined with marketing activities (ibid.).

The known characteristics of small established companies' innovation and design processes are listed below in Table 3.

Table 3. Characteristics of the Innovation and Design Processes of Small Companies

- Innovation and design processes in small companies are highly search-oriented, dynamic processes with iterative cyclical loops (Guimarães et al., 1996; Larsson, 2001)
- The processes are informal, with unclear start and stop point and unclear phases (Bodin, 2000; Cannon, 1985)
- Few persons are involved, often the owner-manager (Larsson, 2001)
- Formal systematic methods are rarely used (Meyer, 2002)
- Prototyping and sketching are common approaches (Guimarães et al., 1996; Larsson, 2001)
- Feedback from customers is common and extensive during the processes (Guimarães et al., 1996; Larsson, 2001)

2.6 Theory gap summary

Detailed studies of small established companies' innovation and design processes are lacking; no studies have been found that follow innovation and design processes over time. There is research about general characteristics of small established companies and their context, yet how these characteristics influence innovation and design processes in small companies have been examined only to a limited extent. A more holistic picture of small established companies' innovation and design processes that take the context into consideration is missing in the academic literature. In addition, novelty aspects in innovation and design processes in small established companies have apparently not been researched. There is a great potential in this area because of the possibility to gain new knowledge on how small established companies can be more innovative.

2.7 Research questions

From the literature review three research questions (RQs) crystallized:

RQ 1: How do small established companies carry out their innovation and design processes?

RQ 2: How does the context affect innovation and design processes in small established companies? This context consists of the three contextual factors: (a) Strategic leadership, direction, and deployment, (b) Innovative organization, and (c) Proactive linkages, present in the innovation process model by Bessant & Tidd (2007).

RQ 3: How do product and process novelty affect innovation and design processes in small established companies?

2.8 Thesis outline

This thesis is built on three research papers dealing with innovation and design processes and their contexts in small established companies in different areas and on different levels. The matrix in Table 4 below shows which research paper deals with each research question.

Table 4. The coverage of the research questions (RQs) in the three appended papers

	RQ 1	RQ 2	RQ 3
Paper A	●		
Paper B		●	
Paper C	●		●

Research question 1 is covered in both papers A and C but from different perspectives. Somewhat simplified, Paper A examines the use of formal systematic methods in the innovation processes, while Paper C examines the informal way of working in the small companies' implementing part, the design process, of the innovation process. Papers A and C also used a different mix of research methods. Mapping the research questions where they belong in the quite modified innovation process model of reference by Bessant and Tidd (2007) yields the picture in Figure 3 below.

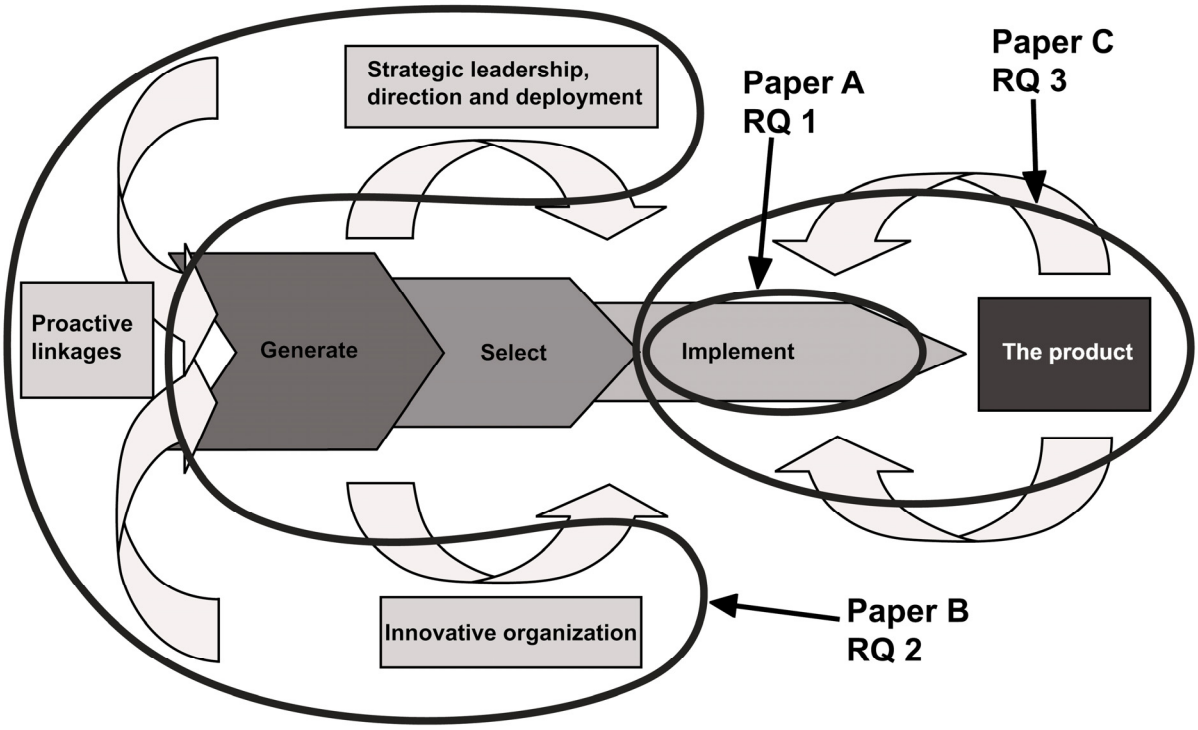

Figure 3. Illustration of the studied areas of small companies' innovation processes.

The product to be developed is also put into the model to illustrate that its future properties and characteristics (i.e., the relative novelty) affect the innovation process and in particular the design process that lies inside the implementing part. In the illustration in Figure 3 above we can see that the generation and selection of innovation ideas suitable for development is not a part of this study and will be the subject of future research.

3 Research Methods

This thesis reports on the findings from three research studies. This chapter aims to describe and discuss the methodology used for answering the research questions but also to discuss the specific circumstances of doing research on small established companies.

3.1 Scientific approach

3.1.1 A case study approach

A case study approach is qualitative research that is good at answering such explorative research questions as "how" and "why" (Voss et al., 2002; Yin, 2003). Case study methodology is appropriate when the units of study are not fully understood (Voss et al., 2002), complex and hard to isolate from real-life context (Yin, 2003). Case studies will show peculiarities and different characteristics. Although they intend to test theory, they usually cannot show how common a certain phenomenon is (Yin, 2003). This study has mainly exploratory research questions and examines innovation and design processes that are complex, with unclear boundaries (Cross, 2008; Tidd & Bodley, 2002) that are affected by and dependent on their contexts (Bessant & Tidd, 2007; Goffin & Mitchell, 2005; Karlson, 1994). Thus, case study methodology suits this study well.

3.1.2 Case selection and units of analysis

It is important to choose cases that will result in an optimal contribution to theory and help to solve the research questions (Yin, 2003). The unit of analysis differs in the appended papers. Paper A was a holistic multi-case study (ibid.) and the unit of analysis was 18 different small established companies' innovation activities. Paper B was also a holistic multi-case study, of three established companies' prerequisites for innovation. Paper C was an embedded multi-case study (ibid.) with three established companies as cases and embedded units of different design processes. Papers B and C had the same three companies as cases, but in Paper B the analysis was on the organizational level and in Paper C the analysis was on the process level.

In Paper A, small companies were recruited that had their own, or wanted to have their own, innovation processes. 29 companies were contacted mainly by e-mail to invite them to participate in the study; 18 accepted. The companies represented manufacturers of mechanical or electronic products, as well as service companies providing, for instance, software or education. 11 of the companies were manufacturers of goods and 7 were service companies. For the studies done in papers B and C, companies 1 and 2, which also

took part in the first study, were asked to participate in a deeper case study. They were chosen because they had their own products and innovation and design processes that were run in house with their own resources. Both companies claimed and were believed to have problems within their innovation and design processes and need advice. Company 1 manufactures goods, while Company 2 produces software. This was a deliberate choice because it would enable comparing and drawing conclusions about the differences in innovation and design processes that do not depend on the product to be developed. Later a third company, Company 3, was recruited to provide a contrast with the findings from the former two companies. This was a manufacturing company that was identified by the researcher to be exceptionally efficient in its innovation and design processes despite its smallness. This conclusion was mainly based on the company's extensive public written material and website. Some characteristics of the three small companies in papers B and C are given in Table 5 below.

Table 5. Some characteristics of the three companies in the studies in papers B and C

	Company 1	**Company 2**	**Company 3**
Type	Manufacturer B2B	Software B2B	Manufacturer B2B and B2C
Products	Technical floors	Booking systems for the tourism industry	Small wood refinement machines
Employees	23	9	25
Number of New or Improved Products Launched per Year	Approximately one small improvement	Several improvements	Several new or improved products
Customers	One big, many small	Many small	Many small
People Involved in the Innovation Processes at the Company	5	6	3

3.2 Research process

This section aims to give the reader an understanding of the execution of the research and the methods used to collect data.

3.2.1 Sources of data

All methods have their advantages and disadvantages and in this thesis several different methods were used to answer the research questions. In case study research it is advantageous to use many different methods and sources to collect data to be able to cross-check and validate findings that strengthen the study (Yin, 2003). Using several different methods to study the same phenomenon is called triangulation (Voss et al., 2002).

According to Yin (2003), there are six different main sources to collect data in case studies. These sources are documentation, archival records, interviews, direct observation, participant observation, and physical artifacts. Different methods suit different situations; in the research in this thesis all these sources were used in different situations. The participating companies were studied in different ways not only to cross-check and validate findings but also due to practical limitations and that the studied phenomenon proved to be hard to understand and every possible clue was needed.

All data was summarized and a first analysis was done within a 24-hour period. All data, early conclusions, questions, and ideas were documented in the field dairies during the data collection period at the companies to not forget anything and to be able to track the research process.

Table 6 summarizes the different sources of data used in the different companies.

Table 6. The different sources of data used in the different companies

	The 18 Companies in Paper A	**Company 1 in Papers B and C**	**Company 2 in Papers B and C**	**Company 3 in Papers B and C**
Documentation	Not much, mainly the company websites	Yes, but not much, mainly the company website, brochures, and manuals	Yes, but not much, mainly the company website, brochures, and manuals	Yes, study of extensive web-site, articles, manuals, brochures, the company's newspaper and Master's theses about the company
Archival records	No	Yes, information about a former innovation process	Yes, information from former customer meetings	No
Interviews	Yes, semi-structured interviews with people involved in innovation, 1-2 hours per company	Yes, semi-structured interviews with people involved in innovation, 1-2 hours per person, 5 interviews	Yes, semi-structured interviews with people involved in innovation, 1-2 hours per person, 6 interviews	Yes, semi-structured, 2.5-hour interview with the product development manager and 15 minutes with owner-manager
Direct Observations	No, but visited the companies	Yes, 2 days a week over 5 months	Yes, 2 days a week over 5 months	No, but visited the company
Participant Observations	No	Yes, on some occasions	Yes, on some occasions	No
Physical artifacts	No	Yes	Yes	Yes

3.2.2 The studies at the companies

The research started with the study presented in Paper A, when semi-structured interviews were carried out at 18 small companies. The interviews were mainly done with the owner-manager and/or the one responsible for innovation and design at the companies. The purpose was to get a basic understanding of small companies and their innovation and design processes and problems and needs within the companies.

After this initial study, companies 1 and 2 were studied. The way of working in companies 1 and 2 was hectic. The employees usually had multifunctional roles and many different working tasks and different processes were combined. At both companies there were a turbulent working environment with a continuous stream of urgent issues that arose, meaning plans had to be changed on a daily basis. Examples of this turbulence are changed customer requirements, urgent problems with the products at customers' locations that had to be fixed, and problems in production and sales. There was always more to do than there were resources and there were usually no extra buffers to deal with these unexpected urgent issues. There was always creativity about how to use existing scarce resources in the most efficient way and it was always important to sell and keep up the cash flow. When things arose that threatened the cash flow, most other activities were put aside to get resources to fix it. People were constantly in a hurry and it was common that planned interviews with employees had to be postponed not once but several times due to urgent issues that required handling right away. It was easy to deprioritize the needs of a researcher, but this must be seen as natural because of the importance of keeping the cash flow up. The researcher dealt with this in different ways; either observed the emergent issues that arose or waited and did other tasks until people were available. It also happened that people had less to do through changing circumstances and the researcher could quickly take advantage of these moments, for example to do interviews.

In companies 1 and 2 it was not possible to isolate innovation and design processes from other operational processes, so it was not possible to find and study the innovation and design processes at one special place or at a special time or time span. Bits of these processes could be found in different locations, situations, and times. Pauses in the processes were common, due to other more acute things that arose. To be able to identify, study, and catch these scattered parts required 5 months of direct observation, participant observation, semi-structured interviews, informal talk with people, studies of documents, archival records and physical artifacts.

The semi-structured interview was chosen as one method, since it may provide high-quality and detailed data about the respondents' thoughts, values, and attitudes towards various ideas and concepts – all in a relatively short interview situation (Silverman, 2006). It also caught historical events that would have been hard to catch with other methods. In Company 1, interviews were done with the general manager, the product development manager, salespeople and others involved in the innovation and design processes. In Company 2, interviews were done with the owner-manager, the strategic manager, a marketing person, a support person and others involved in innovation and design. A set of basic questions about innovation and design were used, but the interviews turned out in different ways depending on the interviewee. Examples of questions asked are:

- What do innovation and design mean to you?
- Describe the way new products are realized in the company.
- What is your knowledge and experience of innovation and design?
- How are the innovation and design processes affected by the fact that the company is small and family-owned?
- Who is involved in the processes and when?
- What are the special difficulties and problems that used to occur in the processes?
- What are the common sources for ideas suitable for innovation?
- Is there a strategy behind the innovation activities?
- What characteristics do your customers and users have?

Knowledge gained and particular interesting areas that arose in interviews were incorporated in later interviews. Questions that were missed in early interviews were asked later. In addition to these more formal semi-structured interviews, many innovation and design subjects were discussed informally with the persons interviewed and others at the companies or in the companies' contexts.

The participant observations were done mainly at the place where innovation and design activities occurred answering questions and giving advice. Direct observation was done mainly through following different people as they went about their working activities. Participation in different meetings was also done mainly as observant at companies 1 and 2. It is difficult to distinguish between direct and participating observation, but in the direct observations the interference was lower. It was generally hard not to interfere with what was studied in the small companies. It was not possible to hide and the researcher

had to interact and participate to be accepted and get access. Most of this interaction consisted of informal discussions: answering questions, asking questions and giving advice in different situations. Occasionally it was hard to balance interference with neutrality to what was studied, but the researcher was always aware of this issue.

Observation made it possible to study innovation and design processes when they naturally occurred in the natural environment. In this way *tacit knowledge* (Polanyi, 1967), knowledge that persons are not aware they possess, could be captured. This knowledge could not be articulated at the interviews done but could be observed in real working situations. Examples of tacit knowledge captured are synergy effects when innovation and other processes are mixed, and the way unfinished design processes were executed. During the observation time it was possible to cross-check findings with different sources. There was not always conformity between what was said in interviews and the observations. The people interviewed were not conscious of this but had certain beliefs expressed in the interviews that were not in accordance with the observations. An example of this was the belief that certain processes were not present or were highly inefficient.

To observe two different small companies with different products and innovation processes was shown to be advantageous. It was possible to compare the companies in many areas and see similarities and differences that probably would not have been noticed if only one company had been observed. An example of this was the differences in abstract thinking in the design processes between the companies. Company 2 had a more abstract product, software, which demanded a higher level of abstract thinking in the design processes.

The companies' products were studied because they are the results of innovation and design processes done and gave clues about these processes. All findings were later compiled and checked with the companies in special seminars to validate that the researcher had understood the findings right.

After the studies at companies 1 and 2, the researcher had two good and extensive cases but felt that one more case of a small established company with recognized efficient innovation and design processes that produces novel products was needed to contrast the findings from the two cases. An extensive search for this kind of small company began and one company that fulfils these characteristics was found. The company, Company 3,

launched several new products and products improvements per year and had extensive written material about the company and its innovation and design processes. This was unexpected, because secondary data from small companies is often rare or unavailable (Davis et al., 1985) which was the case with companies 1 and 2. It was not possible in practice for the researcher to study Company 3 in the same way as companies 1 and 2. The company was contacted and a visit made to the company's premises. A 2.5-hour semi-structured interview with the product development manager and a 15-minute informal talk with the founder/owner were done with a guide round the premises. The fact that companies 1 and 2 were studied before Company 3, and important new knowledge was gained through these cases, made it possible to fine-tune questions and focus them on the most relevant parts of small company innovation and design. The fact that the company also had extensive written material about itself and its innovation and design processes also allowed for a pre-understanding that facilitated the interview. After the interview, some additional questions arose that were asked and answered by e-mail by the product development manager. The findings were also checked for accurateness by e-mail and phone with the product development manager.

Analysis of the data took place concurrently with the observation time at companies 1 and 2. After the interviews at Company 3, all findings from the three case studies were cross-case-analyzed with each other, compiled, coded and abstracted, and related to existing literature in the subject.

3.3 Research quality

According to Yin (2003) there are four conditions related to quality in case study research: construct validity, internal validity, external validity, and reliability. These are discussed below.

3.3.1 Validity

Construct validity is about establishing the correct operational measures for the studied phenomenon (Yin, 2003). Three ways to increase the construct validity are to use multiple sources of evidence, to establish a chain of evidence, and to have key informants review findings and conclusions (ibid.). Multiple sources of evidence and key informants reviewing findings were used in this research to increase the construct validity. Much of the studied phenomenon's context has also been studied, which will decrease the probability that parts of the studied phenomenon have been missed.

Internal validity is about establishing the casual relationships between certain events that lead to other events (Yin, 2003). This kind of validity is mainly an issue in explanatory case studies. Some explanatory claims are made in this thesis, mainly causal relationships between the kind of design processes found and the context, but the strength of these relationships must be judged by the readers.

External validity deals with the question of whether findings and conclusions from the study are generalizable beyond the actual case study (ibid.). A case study is generalizable to theoretical propositions and to broader theory, but not to other populations, and the goal is to expand and generalize theories, not to show how common certain phenomena are in a statistical view (ibid.). Case studies allow analytical generalization; external validity is increased if the findings and conclusions can be used in other contexts or situations in other studies with the same results. The use of multiple cases in this research strengthens external validity more than single case studies would. Also, findings have been related to existing theory in the field (ibid.).

As a way for readers to do their own estimation about the validity of the studies done, the research process is extensively presented in section 3.2. Firestone (1993) talks about validation and generalization and how a richly detailed description of the case and the case context help the reader.

Small companies have broadly similar characteristics across sectors (Bessant & Tidd, 2007); one underlying assumption is that small companies are exposed to approximately the same external and internal difficulties in their innovation and design efforts, independent of industry and country. This assumption can affect the validity but may also enable comparisons with studies in different contexts, for example different industries and/or countries.

3.3.2 Reliability

Reliability is about how it is possible to do the same study again and reach the same findings and conclusions (Yin, 2003). Although exactly the same study cannot be done again, because it is impossible to find the same research objects again and the objects are affected by the research done, still reliability is increased in this study by the use of field diaries that document the studies.

3.4 Methodology reflections

The research done and described in this thesis was not executed in a straightforward way. The research questions have evolved over time and were at one occasion completely reformulated. This section aims at discussing the special circumstances and difficulties in doing research on small companies.

3.4.1 The initial research question

Paper A's purpose was to give the researcher a basic understanding of small companies, their innovation and design processes, and problems and needs within them. The researcher had at this point little prior knowledge of small companies and their innovation and design processes and expected similarities with larger companies but somehow on a smaller scale. What was not known then is that most processes in small companies are informal, so the questions asked in the interviews did not catch this informal way of working. Many questions aimed at the use of formal working procedures as formal systematic methods and tools. What could be concluded was that the small companies seldom used formal approaches in their innovation and design processes and that innovation and design processes were problematic mainly due to scarce resources and lack of knowledge in different areas. After the initial study, I believed that theory, methods, and tools from academia derived from research on larger companies would also be suitable for small companies. I saw the formal systematic methods as the answer and the solution to the problems the small established companies had in innovation and design.

The study that resulted in papers B and C was initially planned as an action research study in several steps, with active participation by the researcher. The idea was to test different formal systematic methods and tools in real innovation projects in small companies. Companies 1 and 2 were contacted for participation because they had shown interest and believed they had problems with their innovation and design processes. First the companies' current innovation and design processes had to be mapped. From this current situation each company was to determine a new goal for their innovation and design processes. To accomplish this new goal, innovation projects were to start, where different systematic methods could be introduced and tested. In these innovation projects I was to participate as the expert in these systematic methods. The projects were then to be evaluated and followed up. The initial research question was: How can efficient systematic methods suitable for innovation and design be implemented in small established companies?

When the initial research approach was started, the researcher thought that current ways of working in the innovation and design processes in companies 1 and 2 would be easy to map and understand, but this was not the case. What was supposed to take about 3-4 weeks took 5 months.

Within this period of 5 months I discovered that the studied small companies did not suffer from the problems that many existing formal methods aim to solve. These problems are more common in larger organizations, for example communication, coordination, and customer interaction problems. In addition, the constant need for cash flow at the small companies and their hectic and turbulent working environment prevented the small companies from starting a common innovation project with the researcher. It was also perceived as a great risk of harm to the companies if the researcher did major interference through action research with the current processes in the companies. The innovation and design processes found were also considered to be fairly appropriate and efficient with respect to the small companies' contexts. The problems that the small companies had in innovation and design were mainly due to scarce resources and a turbulent environment, factors that probably cannot be changed but must be dealt with. The probability that the first research approach would work was estimated as low. With this in mind the research questions were completely revised. The implementing idea of formal systematic methods was abandoned and never carried out. The research questions was redefined and become more exploratory of small established companies' innovation and design processes.

3.4.2 Small companies' identity

Before this research, I mainly knew about large companies and their innovation and design processes and used large companies as a reference in innovation and design. The innovation and design processes were initially very hard to grasp and understand in companies 1 and 2. To be able to understand these processes, I read a lot of academic literature in the field, but could not confine myself to studies of the innovation and design processes in small companies because so little has been written on the topic. The strategy was to look at the context of innovation and design in small companies to get knowledge and clues that would help to understand the studied phenomenon. These literature studies were done in parallel and after the observations at companies 1 and 2. General small company literature told me what a small established company is and its general characteristics and properties and what context they are working in. More specialized study of the innovation and design processes in small companies revealed them to be highly context dependent. With the extensive literature study done it was easier to grasp

and understand the studied small companies and their processes, organization, and culture.

It is particularly interesting to note that not only the researcher had large companies as an ideal and reference, but also the people at the studied small companies saw large companies and their characteristics as the ideal, model company. As a consequence of this the people at the small companies believed themselves and the company to be less great in different areas and some even felt guilt that they do not do as large companies do. This picture was proven later not to be valid, because they benchmarked themselves against large companies and not against other small companies with which they had much more in common. A general, common and healthy picture of small companies' and their characteristics seems to be missing, not only in academia but also at the small companies themselves. Small companies have broadly similar characteristics across sectors (Bessant & Tidd, 2007), so explaining this phenomenon from the delusion that small companies are so different from each other is not possible. Why this is the case can only be speculated on. But let us speculate. A possible explanation from an academic view is the fact, that most research on established companies is done on large companies (Edwards et al., 2005; Tidd et al., 2005) and as a consequence most knowledge in this field has originates with large companies, something that is not always realized. As a natural consequence this knowledge is also what mainly is communicated externally and taught in courses in this field at universities. It is odd that small companies are neglected, when 99 percent of all companies are small and employ 50 percent of those employed in the non-governmental sector (Eurostat, 2009).

Most research actually done on small established companies consists of quantitative surveys or interviews. It almost looks like researchers feel that they must cover many small companies in the same research to compensate for the companies' small size. More focused research approaches, such as observations of innovation and design processes over longer times in small established companies are not found in the academic literature despite the great need for them (Edwards et al., 2005). In this way the research in this thesis is unique.

I believe that this phenomenon of having large companies as the reference and ideal and regarding the way large companies solve different processes and working tasks as the best method can do harm if it is practiced in small companies. Ways of working in larger companies are necessitated by the fact that the company is large, whereas working in the

same way in a small company is not a guarantee of making the small company larger or more professional but can actually make the small company less efficient, solving problems that do not exist.

3.4.3 Differences between research and small companies' practices

Another issue that affected the research relates to the differences between academia and small established companies. There is a mismatch between the short-term near-market focus of small companies and the long-term basic research interests of universities (Almeida et al., 2003; Freel, 2003; Lee et al., 2001). Benefits, from the small companies' perspective, of collaborations between academia and small companies have not been shown (Freel, 2003; Stridh & Swärdh, 2008). This mismatch was present during the observation time at companies 1 and 2. Table 7 lists some differences between my experiences as a researcher and the experiences of those who work in a small company.

Table 7. The differences experienced between doing research and working in a small company

Doing research	Working in a small company
New knowledge as goal	Profit as goal, make the business run
Theoretical	Practical, hands on
Long time horizon	Short time horizon
Formalization and systematization	Informality and flexibility
Why does it work and how?	It works! Don't touch it!
Results demand accuracy and take time	Fast results at the expense of accuracy
Practical usage of new knowledge is not always important	Practical usage of new knowledge is paramount
Uncertain results, no guarantees	Clear and confident results are preferred

With the above in mind, I am glad to report that actual benefits, from the small companies' perspective, to collaboration with academia were shown in this research approach. Companies 1 and 2 principally benefited from having the researcher in the companies for direct and participating observation. For companies 1 and 2 the most appreciated parts were the interaction with the researcher on site and on the companies' conditions. It was a knowledge exchange between the companies and the researcher in real working situations inside the companies, and this suited the small companies. The larger part of the knowledge transfer occurred during the period of collecting data at the companies and not from the academic papers that were written later on. The research did not trespass or interfere with daily activities but the employees felt that they got support, a

new perspective, and ideas from the researcher during his time there. The researcher gave alternative views of certain processes or tips that sped up some problematic processes. Since the companies did not have much to offer me for free, it was very important that this exchange occurred during my visits to the companies. Company 2 said that they invested little resources in the research and doubted that academic research could offer them anything useful, yet they got much back that they had practical use for. We found the approach to be a good way to transfer knowledge from academia to small companies and vice versa. Walker et al. (2007) found that small companies are interested in skill training as long as it is directly applicable to the current situation in the company; the approach used in the study of companies 1 and 2 achieved this. These actual benefits for the small companies were unexpected but very welcome. For the researcher, the inside perspective gained through the long observation time yielded a lot of new knowledge.

4 Summary of Appended Papers

A short summary of the three research papers and their results and conclusions is presented next.

4.1 Paper A

Title: The use of methodology for product and service development in SMEs: An explorative study of 18 small companies

Author: Lars Löfqvist

Status of publication: Published in the Proceedings of the 8th International CINet Conference, "Continuous Innovation – Opportunities and Challenges," Gothenburg, Sweden, 7-11 September 2007.

Purpose: The purpose of the study was to examine the innovation processes within small companies and their use of systematic methods within these processes.

Research method: Case study methodology was used and semi-structured interviews were done in 18 small established companies, 11 of which were manufacturers of goods and 7 service companies.

Main findings and conclusions: Main conclusions from this study are that innovation was seen as a problematic area for small companies. There were many good ideas suitable for innovation within the small companies but their realization was usually prevented by scarce resources. The use of systematic methods in the innovation processes was scarce but possible, as was shown in one company.

4.2 Paper B

Title: Prerequisites for innovation in small companies: A multiple case study

Author: Lars Löfqvist

Status of publication: Published in the Proceedings of the 9th International CINet Conference, "Radical Challenges in Innovation Management," Valencia, Spain, 5-9 September 2008.

Purpose: The purpose of this study and paper was to examine the prerequisites for innovation in small companies and to describe and analyze their effects on the small companies' innovation processes.

Research method: Case study methodology was used, with three small established companies as cases. Direct and participating observation, semi-structured interviews, studies of archival records, documents, and physical artifacts were done.

Main findings and conclusions: The study used Bessant and Tidd's (2007) model of the innovation process as reference. The contextual factors in the model were found to be

valid. The study also confirmed existing research on prerequisites for small company innovation in several areas, including management, strategy, committed resources, creative climate, and proactive behaviour. The examined small companies were close to their customers and users; these relationships were friendly and consisted of an intertwined mix of trust, give and take, support, service, sales, and innovation that all reinforce each other. Relationship marketing was the main marketing technique, which was found to be closely connected to the innovation processes. Customer support was found to be important. Knowledge needed in the innovation processes was gained through direct informal communication with external actors. Scarce resources being a known barrier for innovation in small companies was confirmed in this study. However, the study also showed five different ways that small companies can increase and use existing resources more efficiently: receive financing for innovation work from customers, have customers and users do actual innovation work for free, adopt lead-user innovations, use external experts in the small company's network as pro bono consultants, and outsource activities that usually steal a lot of resources from the innovation activities. It was found to be both common and easy to take resources from innovation activities and put them in more acute areas to enable sales and maintain cash flow.

4.3 Paper C

Title: Design processes and novelty in small companies: A multiple case study

Author: Lars Löfqvist

Status of publication: Published in the Proceedings of the 17th International Conference on Engineering Design ICED'09, Stanford University, Stanford, CA, USA, 24-27 August 2009.

Purpose: The purpose of the study was to expand knowledge of design processes in small companies. The explorative research questions were:

• How do small established companies execute their design processes within their innovation processes?

• How do the relative novelty of the product being developed and the relative novelty of design processes, to the designers and others involved, affect the design process?

Research method: Case study methodology was used with three small established companies as cases and different design processes as embedded units within the cases. Direct and participating observation, semi-structured interviews, studies of archival records, documents, and physical artifacts were done.

Main findings and conclusions: Eight different design processes were identified and examined. The findings show that small companies have different kinds of design

processes even within the same company. The design processes found were linear, systematic, and structured or cyclical, experimental, and knowledge-creating and there were both finished and unfinished design processes. A generic design process model of reference by Cross (2008) was found valid in the linear design processes. If an extra feedback loop was added it also managed to describe the cyclical design processes. The concept of relative novelty (Tidd & Bodley, 2002) was used to explain the two different kinds of design processes found. If the relative novelty of design processes and the product to be developed were low for those involved in the design processes, a linear design process worked. The same design process was found to be less suitable if both the relative novelty of the product to be developed and of design processes were high. A cyclical design process was found to work no matter the relative novelty. Intense interaction and communication with customer, users, and other external actors was seen to be needed in all examined design processes.

5 Findings and Discussion

5.1 Small companies' innovation and design processes

5.1.1 The use of methods in the innovation and design processes

In Paper A, the use of formal systematic methods in the innovation processes in small companies was examined. The use of formal systematic methods was rare among the companies with the exception of one company that had a systematic, method-supported design process. Small companies often lack the qualifications and resources for a methodologically systematic design process (Franke et al., 2003). Most processes in small companies are informal, as has been stated by Tidd and Bessant (2009) and Pilemalm (2002); the study in Paper A did not record this informal way of working. In Paper A it is concluded that formal systematic methods were seldom used; in Paper C the informal way of executing the design processes was examined.

Methods are used to solve problems (Jones, 1992) and many systematic methods available in innovation and design must be regarded as tools for large companies to solve their problems in their innovation and design processes. These problems were not present in the examined small companies. For example, the examined small companies did not have the internal and external communication and coordination problem that many systematic methods, such as cross-functional teams and formalized documentation procedures, aim to solve. Easy communication and coordination are common characteristics in small companies, which has been found by Adams (1982), Cannon (1985) and Vossen (1998). Integration of different functions is futhermore of less importance in small companies, because functions are less specialized and less likely to be separated by physical and organizational distance (Tidd et al., 2005), which was also shown in the companies examined in papers B and C. Systematic methods for market, customer and user interaction, and communication, as for example focus groups and customer surveys, were also found to be less needed because of the close, natural, and intense interaction and communication found between the examined small companies and their customers and users. Proximity to customers and users in small companies were also found in studies by Carson (1995) and Rothwell and Dodgson (1994). Using systematic methods to find ideas suitable for innovation seems unnecessary because of the abundance of good ideas suitable for innovation originating in the interaction with customers and users. Finding good ideas was not a problem, obtaining resources to

develop them was. This abundance of good ideas suitable for innovation in small companies was also found in a study by Dalrymple (2007).

Systematic methods are often formal (Cross, 2008) and this property probably contributes to their unsuitability with the informal processes common in small companies. Another reason for informality in the small companies examined is that an informal relationship with customers and users was found to be a large part of their innovation and design processes. This was particularly found in companies 2 and 3.

The rare usage of formal systematic methods can also be explained from the perspective and fact that small companies have scarce resources (Ghobadian & Gallear, 1996; Rothwell, 1989; Rothwell & Dodgson, 1994; Welsh & White, 1981; Zontanos & Anderson, 2004) and must use them efficiently. Although formal and systematic methods are claimed to work in many different specific situations (Cross, 2008), Jonassen (2000) states that it is more efficient to use domain-specific methods than abstract and generic domain-independent methods. This makes domain-specific ways to solve problems in innovation and design more suitable for small companies because they are always forced to be as efficient as possible. Companies 2 and 3 displayed informal design processes with their own domain-specific methods developed to suit the companies, the design processes, and the context. Examples of these domain-specific methods used are the integration of customers and users in the design work and the use of prototyping and mock-ups to gain feedback. The combination of processes to maximize resources and to coordinate the innovation and design processes with other processes in the companies is another informal domain-specific method that was practiced. Other examples are the use of overall constraints in the design work to obtain consensus on the design, running many design processes concurrently to be able to evaluate them properly, and striving for a simple design to facilitate lead-user[2] inventions, as occurs in Company 3. Formal, abstract, systematic methods were in fact in use in Company 2 in the development of software products with low relative novelty. Examples of these systematic methods were project planning, abstraction, and different flowcharts. This exception can be explained by the fact that design problems in software development are quite well structured, making formal methods suitable (Jonassen, 2000). Problems in software design are also quite abstract which fits abstract formal design methods better. In the study in Paper A, another

[2] Lead-users are users that face needs that will be general in a marketplace earlier than other users, and they benefit greatly if a solution to these needs is obtained. Lead-users can by themselves modify existing products to satisfy their unmet needs (von Hippel, 1988).

small company, not in software development, was found to use systematic design methods. Examples of identified methods used in this company were brainstorming (Osborn, 1953), quantitative structures (Tjalve, 1979), and design for assembly (Andreasen et al., 1983). The designers in this company had all worked with the same products in a large company before, so the relative novelty of the products to develop and the process to do so were low. They had found a process that almost always worked and were also able to explain it in a generic, abstract form. This ability to explain their process and way of working on a generic and abstract level was interpreted as the usage of formal systematic design methods. It is possible that the companies studied in Paper A were not aware that the way they were working can be seen as method supported. It is important to note that even if the companies could not always describe their innovation processes, they still developed and launched successful products. Products do not develop themselves and are too complex to be realized by chance, so there must be some kind of working process by which they are developed. Perhaps many of the companies studied in Paper A had well-functioning ways of developing new products, and the interviewees simply could not describe them. This was apparently the case with Company 2, where observations showed well-functioning innovation processes with the use of systematic methods but interviewees could not describe them properly.

To summarize the reasons why small established companies seem not to be using formal systematic methods:

- The problems the methods aim to solve are not present.
- It is more resource efficient for a company to use their own domain-dependent methods than formal, domain-independent methods.
- The methods' formality is less suitable given the informal processes common in small companies.
- The methods' formality does not fit well with the informality in the interaction with customers and users.

In spite of Jonassen's (2000) findings of efficiency in the use of domain-dependent methods, the above reasons why small established companies do not use formal systematic methods have not been found in other studies.

Paper A concluded that innovation is an area of concern for the examined small companies. The use of formal systematic methods in innovation processes was rare, and the above discussion shows how these methods are probably not the solution to small

companies' problems with their innovation processes. It was also found that scarce resources were the main reason that prevented the exploration and realization of innovative ideas, and this seems to be the primary source of the problems in the examined small companies' innovation processes. The small companies were found to have some approaches and strategies to deal with this resource scarcity in innovation and design, which will be further discussed in section 5.1.4.

5.1.2 Intertwined innovation processes

The innovation processes were found to be intertwined in other activities and processes in the examined small companies in the studies in papers B and C. Innovation apparently must be done side by side with ordinary activities and processes; the innovation processes apparently cannot be isolated in small established companies. This is due to the fact that the same employees have responsibility for both day-to-day activities and innovation activities and to the physical smallness of the companies' premises. The companies must make the best of the situation. These intertwined innovation processes had both positive and negative effects in the studied companies. The negative effect from an innovation perspective is that resources were easily taken from innovation activities to fix acute problems in daily operations. The positive effects were the synergy effects that were achieved when innovation processes were intertwined and mixed with other processes and activities. This caused existing scarce resources to be used in a more efficient way. For example, the support function in Company 2 not only supported issues in the contact with customers and users. The support was also a channel for sales, marketing, and input and feedback on innovation activities. The small size of the companies, with easy communication and coordination, and the employees' often broad knowledge and multiple functions at the companies enabled this way of working. Intertwined innovation processes are not a totally new phenomenon; for example, Clarkson and Eckert (2005) and Berger (1999) have also found this. The inability to isolate innovation activities in small companies was found in studies by Bodin (2000) and Pilemalm (2002). However, these researchers did not relate the intertwined innovation processes to the ability to gain synergy effects and the efficient use of resources, a finding unique to this thesis.

5.1.3 The important role of customers and users

To involve customers and users in innovation processes is not a new idea. One famous pioneer in the area is for example von Hippel (1988) with his lead-user theories. One important kind of proactive linkage found in the examined companies in papers B and C and at the same time a large part of the innovative organization in companies 2 and 3 are

the companies' customers and users. In Company 1 the importance of customers and users was shown in the design processes that had low customer and user involvement during the process. These design processes had difficulties due to lack of customer and user feedback to the processes. The friendly and close relations to customers and users in companies 2 and 3 meant that they become a fundamental resource in the small companies' innovation processes. The customers and users were found to finance innovation processes, provide most of the ideas suitable for innovation, participate and do innovation work for free for the companies. They also developed lead-user inventions by themselves and then gave the inventions away for free to the small companies, while continuously giving feedback and input to innovation processes as a way to steer the processes in the right direction.

For example, with the lead-user inventions done in Company 3 in Paper C, the company actively searched for a simple design for its products. Complex design and solutions presumably mean complex innovation and design processes, which can be expensive and hard to manage. The simple design of the products also meant that users could more easily modify the products on their own and make lead-user inventions, as described by von Hippel (1988). This was an efficient way to increase resources for innovation. The company not only learned of real customer and user problems, but also got the solutions to these for free, which saved a lot of effort and resources.

One exceptional thing is that intense customer and user interaction and communication took place not only in the design processes with a high relative novelty but also in the least novel design processes. This high customer and user interaction and communication in processes with low relative novelty was an unexpected finding. According to Engwall (2004) and Tidd and Bodley (2002), a high level of interaction with customers, users, and other external actors is needed in innovation processes with high uncertainty and high relative novelty, in order to get input and feedback to the development process. This indicates or is an indirect proof that the innovation processes found are affected by something external that further increases the uncertainty and the relative novelty. A qualified guess is that this external thing is the turbulent and uncertain organization and environment that the examined small companies were working in. This turbulence and uncertainty affects the whole small company, including processes such as the innovation process.

5.1.4 Efficient use of resources in the innovation processes

In section 5.1.1 we concluded that the most probable cause for problems in innovation processes in the examined small companies was scarce resources and not the lack of formal systematic methods. What was mainly found in Paper B is that the examined small companies had several approaches to increase resources or to use existing scarce resources more efficiently in their innovation processes. These approaches were receiving financing for innovation work from customers, having customers and users do innovation work for free, adopting lead-user innovations, using external experts as pro bono consultants, and outsourcing activities that steal resources from the innovation activities. In addition to those approaches, other approaches to the efficient use of resources will be discussed.

A creative and efficient use of internal and external resources has been shown to be a central theme in the examined small companies' innovation and design processes. What has not yet been discussed is how resource efficiency can be reached through the structures of the design processes. It will also be discussed how small companies lower risk and save resources through a closeness to customers, together with a fit between the product to develop, skills and knowledge, and certain small company characteristics.

Knowledge in project management was found to be important in innovation processes with low relative novelty. Low relative novelty made it easier to plan and execute design processes as projects. The design processes with high relative novelty were not executed in the form of projects. Company 1 tried executing a high novelty design process in the form of a project but failed. In the design processes with low relative novelty in Company 2, planning time and resources meant that existing resources were used in a more efficient way. But there was also another resource-saving logic used in the cyclical innovation processes. This was made possible by the small companies' special characteristics, including fast and informal communication, rapid decision making, and flexibility, together with the extensive and continuous feedback from customers, users and other external actors. Following a cyclical approach with continuous and extensive feedback, the company can quickly find out if they are working on the right things and in the right direction, which saves resources. It is hard to predict the optimal solutions, especially with the design processes with high relative novelty, and it is easy to put effort into the wrong activities or solutions. A cyclical approach caused as little as possible of the innovation work to be applied to the wrong solutions, because the customers and users continuously valued solutions and gave feedback and ideas during the whole innovation

process. The customers and users are the final judges of a product's value, and this value can be said to be optimized since these judges are part of the process creating the value. The often friendly and honest relationships with customers, users, and other external actors made feedback honest and accurate.

Although the actual selection of ideas to develop in small companies' innovation processes is outside the scope of this thesis, one common approach used by companies 1, 2, and 3 in the selection phase pertains to the efficient use of resources in later parts of the innovation process. Small companies are usually used to risk because of the uncertain and turbulent environment common in small companies (Ratcliffe-Martin & Sackett, 2001; Welsh & White, 1981). One approach to lower risk is to only begin serious amounts of design work if there is a customer that demands or needs the innovation. Low et al. (2007) also found that some small companies only innovate upon customer requests. This lowers the market uncertainty and risk and mainly leaves only technology risk and uncertainty to handle. With a customer to buy the innovation in the end and to pay for the development effort, the company can receive continuous feedback from the customer during the whole design process. The very fact that it is a customer asking for advice and feedback in the innovation process further lowers the risk that efforts are applied to the wrong solutions. Sometimes the customer also finances the design process, which in turn also lowers the risk and increases the resources further.

Cannon (1985) has found the importance of customers' support during the innovation process when he states that innovation processes without customer support often fail in small companies. Technology uncertainty and risk are handled through the fact that there are special kinds of product innovations that small established companies bring into being. Dallago (2000) and Mosey (2005) found that product innovations in small companies are not accomplished due to new technology but rather with less novel technology or by using existing technology in new ways. This use of less novel technology and reusing existing technology was shown in the studied companies' design processes. Less novel technology or existing technology increase the probability that specialists will be unnecessary in the innovation process, which suits small companies that usually have owner-managers and employees with generalist knowledge (Bodin, 2000; Pilemalm, 2002; Verhees, 2005; Welsh & White, 1981) and no employed specialists (Freel, 2000). Most likely the needed skills and knowledge to create the innovation can be found in just a few or one single person in the company, due to their generalist knowledge. This generalist knowledge is also complemented by the knowledge

possessed by customers, users and others in the company's environment that are part of the innovation and design processes. Thus, the technological uncertainty and risk are lowered, because the technology chosen matches the knowledge and skills possessed by the actors in small companies' innovation processes. External and expensive expertise is less needed, which saves resources. The reusing of known existing technology also saves development resources.

5.2 The prerequisites for innovation in small companies

For innovation to be possible in small companies, some prerequisites must exist. On a fundamental level there must be resources available for innovation. The study in Paper B primarily dealt with the prerequisites for innovation to occur in small companies. What could be concluded from that study is that if a small company has well-developed routines within the contextual factors of Bessant and Tidd's (2007) innovation process model, it may have a working innovation process. If parts of the contextual factors were missing, a working innovation process is problematic to achieve. The three contextual factors will be further discussed more deeply in the sections below.

5.2.1 Strategic leadership, direction, and deployment

Some kind of uniform strategy, vision, goal, or direction within the small companies studied seems to enhance innovation, a finding that is supported by Bessant and Tidd (2007). Example of a lack of conformity in strategy, vision, and goal were shown in Company 1, whose two leaders at the helm confused the employees. The companies in the study did not have great power or control over the marketplace, and their environment was uncertain and turbulent. These characteristics of small companies, also found by Carson (1995), Ratcliffe-Martin and Sackett (2001) and Welsh and White (1981), made planning hard and long-term strategies less useful in the examined companies. This was also indirectly shown by the fact that sales almost always had priority and production troubles had to be quickly fixed to maintain cash flow. Any plans were put aside if the cash flow was threatened. Deprioritized innovation processes when faced with short time pressure were also found by Woodcock et al. (2000). The fact that small companies are sensitive to disturbance in the cash flow was also found by Welsh and White (1981). This made the time horizon short in the examined small companies; short-term returns were favoured over long-term ones. Westhead and Storey (1996) have also found this predilection for short-term returns in small companies.

Apparently it is easy to steal resources from innovation and design processes if doing so it will not affect the company's performance in the short run. Production troubles were a resource stealer from innovation. One company, Company 3, had outsourced all production primarily because it was cheaper, but an incidental effect was that fewer resources were taken from the innovation activities. It seems that long-term strategies and goals had less importance in the small companies in this study because the future seemed to be hard for them to predict. One thing that mitigates the effects of and compensates for this uncertain and turbulent environment was that the examined small companies were flexible and had the ability to rapidly respond to future situations and could handle future difficulties when they occurred. Deal with problems as they arise is a common approach in small companies, as was also found by Dalley and Hamilton (2000).

5.2.2 Innovative organization

The need for a creative climate cannot be underestimated in the examined small companies' innovation activities. Scarce resources made creativity necessary in at least three stages: obtaining needed resources, using these resources in the best way in the innovation and design processes, and then actually creating the new product. Communication and coordination was not a large problem in the examined small companies' innovation processes due to their small size and relative easy access to different people they required within and outside the organization. The few communication problems found had their origin in interpersonal relations and not in organizational issues. To achieve a creative and constructive climate suitable for innovation, those companies that trusted their employees and had an owner-manager who delegated authority and power had this effect. Often small companies have an owner-manager who does not like to cede authority and responsibility rather to retain control over most aspects of the business (Adams 1982; Cannon 1985). Examples of this were seen in the study in Paper B, with the effect of decreasing creativity among employees.

5.2.3 Proactive linkages

This study shows that proactive linkages and external linkages in general were crucial and very important in the innovation processes in the studied small companies. These linkages were primary with customers, users, suppliers, other companies, and external specialists. Relationship marketing was found to be the primary marketing technique, which was also highlighted by Zontanos and Anderson (2004). Relationship marketing was found to be highly related to innovation activities. Through these relationships and links, ideas suitable for innovation and continuous and extensive feedback on the innovation and

design processes were gained. Without efficient linkages innovation processes were found to have difficulties due to lack of knowledge, information, and feedback. This was shown in an abandoned design process in Company 1. Different kind of links and communication channels seem to enhance communication and innovation in the examined small companies, because they increased the probability that different actors would find a communication channel that suited them best. Example of communication channels used were personal meetings, phone, mail, e-mail, customer support, and trade fairs. The small companies in papers B and C were all reactive to requests for innovations; the companies that also were proactive were more innovative and launched more new products. This importance of proactive behaviour in innovation is supported by Bessant and Tidd (2007).

5.3 Relative novelty and innovation processes

5.3.1 The impact of relative novelty

In the study in Paper C, eight different design processes were found and examined as to their relative novelty in two dimensions: the relative novelty of the product to develop, as described by Tidd and Bodley (2002), and the relative novelty of design processes in general for the designers and others involved. The results showed that the small companies studied had different design processes, with different degrees of relative novelty. The eight design processes found are depicted in Figure 4 below.

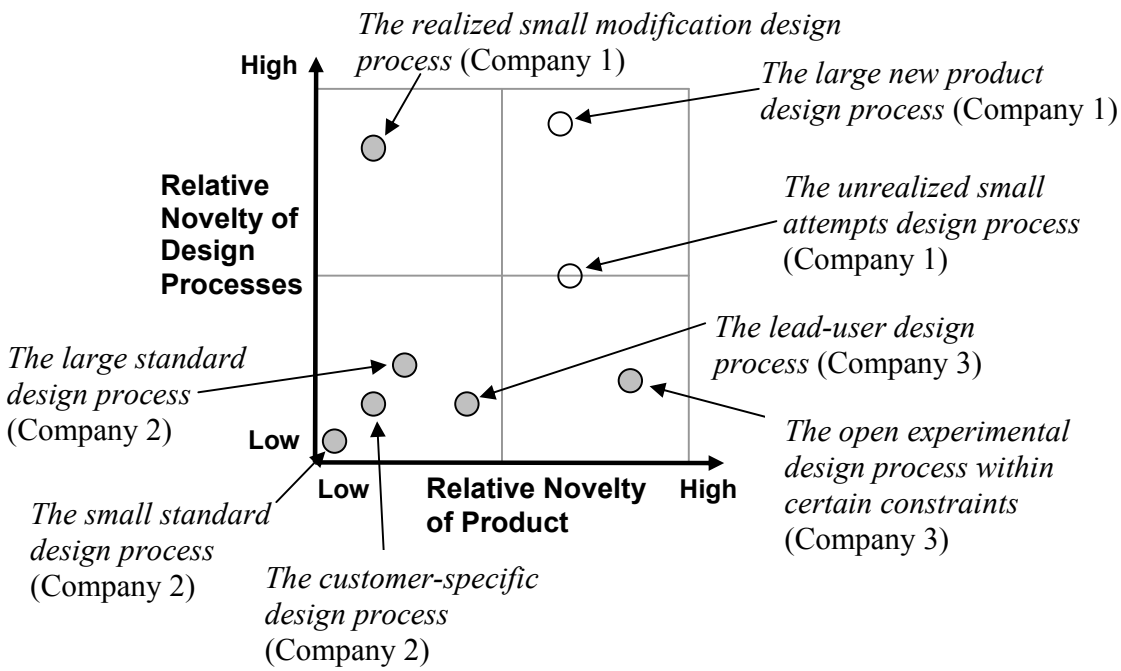

Figure 4. The eight different design processes found in relation to two different kinds and grades of relative novelty

The grey dots in Figure 4 are design processes that are usually finished and the white dots are abandoned design processes with unfinished products. Both linear and cyclical design processes were found in the examined companies; if these structures are added to the conclusive picture above the result is Figure 5, which shows the working and non-working structures of design processes within different kinds and grades of relative novelty.

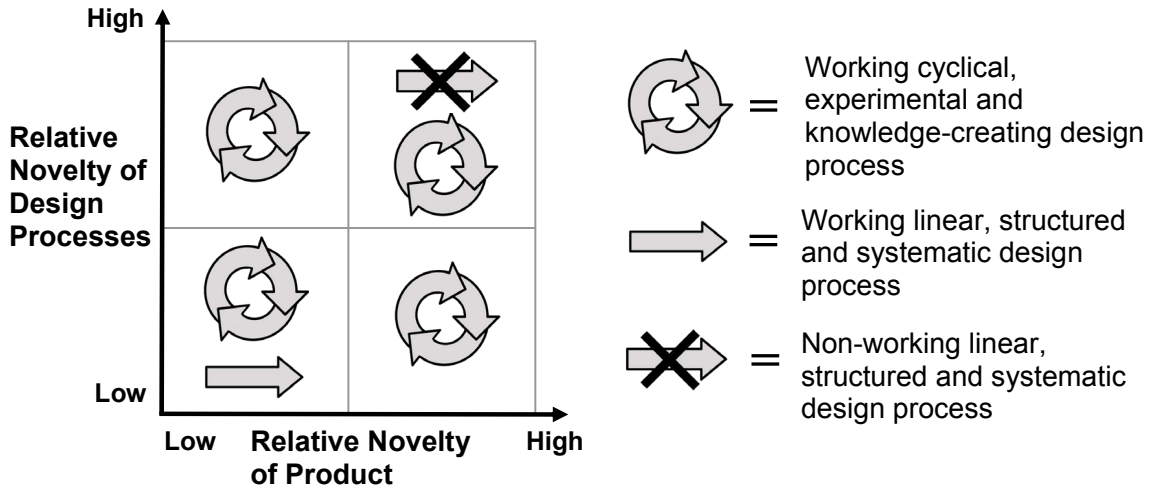

Figure 5. Working and non-working design processes in relation to different kinds and grades of relative novelty

Linear structured and systematic design processes were successfully used when there were low relative novelties of both kinds. These design processes mirrored the design process model of reference by Cross (2008). In these linear design processes most of the exploration of the design problem was done prior to the generation of possible solutions. This low relative novelty meant that these design processes could be planned accurately in advance and executed in a quite systematic linear manner. During this kind of design process there was extensive feedback and communication with customers and users.

The other kind of design process found is the cyclical, experimental, and knowledge-creating design process with extensive feedback from customer, users, and other external actors. These design processes were done in cyclical loops of exploration, generation, and evaluation. Solutions are generated and tested on the design problem to gain new knowledge to use when new possible solutions are created to test, and so on. In practice these tests of solutions were done with customers, users, and other external actors to gain feedback and new knowledge. In the cyclical design processes the exploration is done in several stages within the cyclical loops. A cyclical design process is theoretically

estimated to be working if a high relative novelty is present (Engwall, 2004; Lynn et al., 1996; O'Shea & McBain, 1999), but this approach also worked with low relative novelty of the kinds examined, which was an unexpected finding. These cyclical design processes commonly used in the examined small companies did not quite fit into the design process model of reference by Cross (2008). If Cross's (2008) design process model of reference is modified with an extra feedback loop, it manages to catch these cyclical processes too. In Figure 6 below this modified design process model with linear and cyclical design processes is shown.

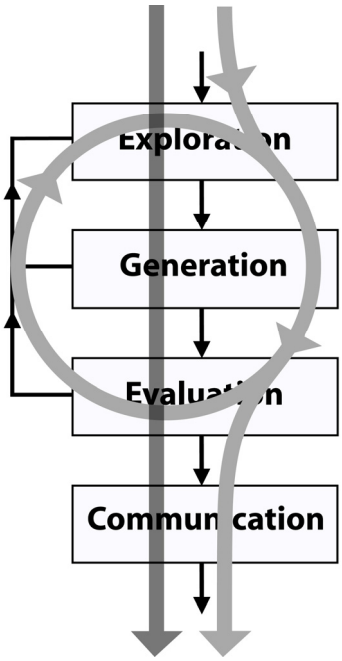

Figure 6. Modified design process model for both linear and cyclical design processes

5.3.2 Do cyclical design processes naturally suit small companies?

Five out of eight design processes found had a cyclical structure. These kinds of design processes were also found by Guimarães et al. (1996) and Larsson (2001) in small companies. This cyclical approach was also found by Engwall (2004), Lynn and Akgün (1998) and Lynn et al. (1996) to be well-functioning approaches in innovation processes under conditions of great uncertainty, as processes with high relative novelty normally are. Lynn et al. (1996) states that experimental innovation processes of probing and learning are expensive for a company, but they are probably referring to large companies in this statement. For small companies this probably does not hold true, because of their flexibility, low bureaucracy, rapid decision making and the natural and intensive interaction and communication with their market, customers, and users. Cyclical, experimental, and knowledge-creating design processes with probe and learning

approaches were used in the small companies studied, even through the final product innovations did not always appear radical to an external viewer. Large companies must create a special organization form and environment to cope with the development of radical product innovation with high uncertainty (Engwall, 2004), but small companies do not need to create this because they already have the requisite environment and therefore have the natural ability to create both incremental and radical new products in cyclical design processes. It seems that it is not only the relative novelty of the product to develop and the relative novelty of design processes in general that determine the choice of process, but also the characteristics of the organization, its size, and its environment.

6 Conclusions and Future Research

The overall purpose of this thesis, to deepen the knowledge about small established companies' innovation and design processes, has been achieved. Existing research was confirmed and new knowledge was found. The conclusions from the studies done are summarized below.

6.1 Small companies' innovation and design processes

The conclusions about small established companies' innovation and design processes are divided into different categories for a better overview below.

The use of methods in the innovation and design processes

- The use of formal systematic design methods is low in small companies.
- Formal systematic methods seem not to be efficient in small companies' innovation processes, because many of the problems they aim to solve, for example coordination, communication, and interaction problems, are not present, while for other problems domain-specific methods are more efficient.
- Formal systematic methods fit less well with the informal processes common in small companies.
- Formal systematic methods do not match the informality in the interaction with customer and users.
- One exception found, when formal, abstract, and systematic methods do suit the tasks, is in design processes for software which has more abstract characteristics resulting in a better fit between the methods and the design problem to be solved.

Overall structures of design processes

- There are different kinds of design processes used within the same small company.
- The two main structures of design processes used are cyclical and linear design processes.
- The cyclical design processes consist of learning experiments of probing and learning in cyclical loops, with extensive feedback from customers and users.
- Linear design processes follows the steps in Cross's (2008) design process model of exploration, generation, evaluation, and communication. This kind of process also includes extensive feedback from customers and users.

Intertwinement of the innovation and design processes

- The innovation and design processes were intertwined in other processes to gain synergy effects and to use existing scarce resources more efficiently.

- Innovation and design processes were found to be impossible to separate from daily activities in the examined small companies.
- It is common that problems in day-to-day activities steal resources from innovation and design processes.

The importance of customers and users in the innovation and design processes

- Customer and user interaction, communication, and feedback are crucial during the innovation and design processes in small companies.
- There are relative few employees involved in innovation processes inside small companies, but if external actors such as customers, users, and others are taken into consideration, the number involved increases.
- Small companies have the natural prerequisites to efficiently take advantage of and use lead-users and adopt lead-user inventions in their innovation activities.
- Customer and user feedback help to steer innovation and design processes in the right directions.

Approaches to increase and use existing scarce resources more efficiently

- Obtain financing for innovation from customers asking for or needing the product innovation.
- Include customers and users in the innovation and design processes, doing actual innovation work.
- Use external experts in the small company's network as pro bono consultants in the innovation and design processes.
- Intertwine the innovation and design processes in other operational processes to gain synergy effects.
- Outsource activities that might otherwise steal resources from innovation and design processes.
- Reduce formality in the innovation and design processes, making the processes more efficient.
- Use the right kind of design process structure to match relative novelty aspects and small company characteristics.
- Strive to achieve a simple design to lower the complexity of both the design process and the final product, which in turn increases the probability of lead-user inventions.
- Adopt lead-user inventions.
- Match the technology used in new products with small companies' knowledge and skills and reuse known technology and solutions.

- Only start to do serious innovation work if there is a customer asking for or needing the innovation, to be sure that the innovation efforts will be compensated.

6.2 The context's effect on innovation and design processes

Innovation and design processes in small established companies were found to be highly context dependent and hard to understand without also understanding the context. The following conclusions about the effect of the context are categorized according to the contextual factors in Bessant and Tidd´s (2007) innovation process model.

6.2.1 Strategic leadership, direction, and deployment

- Some kind of uniform strategy, vision, or goal was found to be important for innovation processes to succeed.
- Mixed family and business issues can affect innovation processes negatively.
- Delegating power and authority among the employees increases innovation.
- Committed resources to innovation were found to be crucial for innovation to occur.

6.2.2 Innovative organization

The need for a creative environment in small companies, with trusted employees and shared power and control, cannot be underestimated. Creativity is needed to gain resources, use them in the most efficient way and actually create the product.

6.2.3 Proactive linkages

- Proactive linkages to customers, users, and other external actors are crucial in small companies' innovation and design processes and many different communication channels with these actors increase innovation.
- The examined companies were all reactive in innovation but those that were also proactive were more innovative.

6.3 Product and process novelty

The characteristics of the design problem to be solved, small company characteristics and the concept of relative novelty for the product to develop and for design processes in general are found successful in explaining the use of different kinds of design processes in small established companies. The following conclusions may be drawn:

- Linear, systematic, and structured design processes worked when the relative novelties were low for both the product to be developed and for design processes

in general. The same type of design process was found unsuitable within a high relative novelty situation.

- Cyclical, experimental, and knowledge-creating design processes worked no matter the relative novelty.
- Small companies seem to have the natural prerequisites to practice cyclical design processes, mainly due to their flexible organization and close relationships with customers and users.

6.4 Future Research

The research done in this thesis focussed on the context and the implementing phase, the design phase, of the innovation process. The phases of generating and selecting ideas for input to innovation are very briefly described in papers B and C but not examined more deeply. If Bessant and Tidd´s (2007) innovation process model were used, additional knowledge about these issues would fill in all parts of the model and give a more complete overall picture of small established companies' innovation processes. All parts of an innovation process and its context interact; therefore, this thesis only provides a partial description of innovation processes within small established companies.

Carrying out a quantitative test on findings from this thesis would be interesting to see if it is possible to generalize the findings statistically. Many more interesting areas for further research exist, such as a closer examination of the concept of relative novelty and its content, to see how it influences the innovation and design processes further in small companies. To further examine the intertwinement of innovation and other processes in small established companies would also be interesting for future research.

7 References

Adams, A. (1982). Barriers to product innovation in small firms: Policy implications. *International Small Business Journal*, *1*(1), 67-86.

Adams, A. & Walbank, M. (1983). Perceived and acted out training needs in small manufacturing firms. *International Small Business Journal*, 2(1), 46-51.

Almeida, P., Dokko, G. & Rosenkopf, L. (2003). Startup size and the mechanisms of external learning: Increasing opportunity and decreasing ability? *Research Policy, 32*(2), 301-315.

Andreasen, M.M, Kähler, S. & Lund, T. (1983). *Design for assembly*. Kempston: IFS Publications.

Audretsch, D. B. (2001). Research issues relation to structure, competition and performance of small technology-based firms. *Small Business Economics*, *16*(1), 37-51.

Berger, A. (1999). Continuous improvements strategies in the manufacturing sector in Sweden. In H. Boer, A. Berger, R. Chapman, & F. Gertsen (Eds.), *CI changes. From suggestion box to organisational learning. Continuous improvement in Europe and Australia*. 51-72. Aldershot, UK: Ashgate.

Berglund, A. (2007). *Assessing the innovation process of SMEs*. Licentiate Dissertation. Luleå University of Technology, Sweden.

Bessant, J. & Tidd, J. (2007). *Innovation and entrepreneurship*. Chichester, UK: John Wiley & Sons.

Bodin, J. (2000). *Perpetual product development: A study of small technology-driven firms*. Dissertation. Umeå University, Sweden.

Cannon, T. (1985). Innovation, creativity and small firm organisation. *International Small Business Journal*, *4*(1), 34–41.

Carson, D. (1990). Some exploratory models for assessing small firms' marketing performance (A qualitative approach). *European Journal of Marketing*, *24*(11), 8-51.

Carson, D. (Ed.). (1995). *Marketing and entrepreneurship in SMEs: An innovative approach*. London: Prentice Hall.

Clarkson, J. & Eckert, C. (Eds.). (2005). *Design process improvement: A review of current practice*. London: Springer.

Cross, N. (2008). *Engineering design methods: Strategies for product design* (4th ed.). Chichester, UK: John Wiley & Sons.

Dallago, B. (2000). The organisational and productive impact of the economic system. The case of SMEs. *Small Business Economics*, *15*(4), 303–319.

Dalley, J. & Hamilton, B. (2000). Knowledge, context and learning in the small business. *International Small Business Journal*, *18*(3): 51–59.

Dalrymple, J. F. (2007). *R&D and innovation in regional SMEs: A response to globalisation?* Proceedings of the 8th International Research Conference on Quality Innovation and Knowledge Management, New Delhi, 12-14 February 2007.

Davis, C. Hills, G., & LaForge, R. (1985). The marketing/small enterprise paradox: A research agenda. *International Small Business Journal*, *3*(3), 31-42.

Edvardsson, B. (Ed.). (2000). *New service development and innovation in the new economy*. Lund: Studentlitteratur.

Edwards, T., Delbridge, R. & Munday, M. (2005). Understanding innovation in small and medium-sized enterprises: A process manifest. *Technovation, 25*(10), 1119-1127.

Engwall, M. (Ed.) (2004). *Produktutveckling bortom kunskapens gränser: Mot en osäkerhetens grammatik*. Lund: Studentlitteratur.

European Union. (2005). *Oslo Manual –Guidelines for collecting and interpreting innovation data* (3rd ed). European Commission: OECD Publishing.

European Union (2008). *SEC(2008) 2101, Comission Staff Working Document Accompanying the Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions – "Think Small First - A Small Business Act" for Europe*.

Eurostat. (2009). *Key figures on Europe, 2009 edition*. Eurostat European Commission. ISBN 978-92-79-11056-6.

Firestone, W. A. (1993). Alternative arguments for generalizing from data as applied to qualitative research. *Educational Researcher*, *22*(4), 16-23.

Franke, H. J., Löffler, S. & Deimel, M. (2003). The database "Methodos" assists an effective application of design methods. Proceedings at the 14th International Conference on Engineering Design, ICED 2003, August 19-21 2003, Stockholm.

Freel, M. S. (2000). Barriers to product innovation in small manufacturing firms. *International Small Business Journal*, *18*(2), 60-80.

Freel, M. S. (2003). Sectoral patterns of small firm innovation, networking and proximity. *Research Policy*, *32*(5), 751–770.

Ghobadian, A. & Gallear, D. N. (1996). Total quality management in SMEs. *Omega*, *24*(1), 83–106.

Gibb, A. & Ritchie, J. (1982). Understanding the process of starting small businesses. *International Small Business Journal*, *1*(1), 26–45.

Goffin, K. & Mitchell, R. (2005). *Innovation management: Strategy and implementation using the pentathlon framework*. Basingstoke, UK: Palgrave Macmillan.

Guimarães, L., Penny, J. & Stanley, M. (1996). Product design and social needs: The case of northeast Brazil. *International Journal of Technology Management*, *12*(7/8), 849–864.

Hadjimanolis, A. (2000). A resource-based view of innovativeness in small firms. *Technology Analysis and Strategic Management*, *12* (2), 263-281.

Hartman, E. A., Tower, C. B., & Sebora, T. C. (1994). Information sources and their relationship to organizational innovation in small businesses. *Journal of Small Business Management, 32*(1), 36–47.

Herstatt, C. & Verworn, B. (2001). *The "fuzzy front end" of innovation*. Working Paper No. 4. Department of Technology and Innovation Management, Technical University of Hamburg, Germany.

Hippel, E. von. (1988). *The sources of innovation*. New York: Oxford University Press.

Hubka, V. & Eder, W. E. (1996). *Design science: Introduction to the needs, scope and organization of engineering design knowledge*. London: Springer.

Hyvärinen, L. (1995). *Essays on innovativeness and its evaluation in small and medium-sized enterprises*. Dissertation. Lappeenranta University of Technology, Finland.

Hörte, S. Å., Barth, H., Chibba, A., Florén, H., Frishammar, J., Halila, F., Rundquist, J. & Tell, J. (2008). Product development in SMEs: A literature review. *International Journal of Technology Intelligence and Planning*, *4*(3), 299–325.

Janhager, J., Persson, S. & Warell, A. (2002). *Survey on product development methods, design competencies, and communication in Swedish industry*, Proceedings of the 4th International Symposium on Tools and Methods of Competitive Engineering, China.

Jonassen, D. H. (2000). Toward a design theory of problem solving. *Educational Technology, Research and Development*, *48*(4), 63–85.

Jones, J. C. (1992). *Design methods* (2nd ed.). New York: John Wiley & Sons.

Jones, O. & Tilley, F. (Eds.) (2003). *Competitive advantage in SMEs: Organizing for innovation and change*. Chichester, UK: John Wiley & Sons.

Kahn, K.B., Barczak, G. & Moss, R. (2006). Perspective: establishing an NPD best practices framework, *Journal of Product Innovation Management*, *23*(2), 106-116.

Karlson, B. (1994). *Product design: Towards a new conceptualization of the design process*. Dissertation. The Royal Institute of Technology, Stockholm.

Larsson, G. (2001). *Designprocessen i fyra småföretag: Att arbeta med känsla och intuition*. Licentiate thesis. Luleå University of Technology, Sweden.

Lawson, B. (1997). *How designers think: The design process demystified* (3rd ed.). Oxford: Architectural Press.

Ledwith, A. & O'Dwyer, M. (2008). Product launch, product advantage and market orientation in SMEs. *Journal of Small Business and Enterprise Development*, *15*(1) 96-110.

Lee, C., Lee, K. & Pennings, J. M. (2001). Internal capabilities, external networks, and performance: A study on technology-based ventures. *Strategic Management Journal*, *22*(6/7), 615–640.

Low, D., Chapman, R. & Sloan, T. (2007). "*We only innovate on customer's requests": An exploration of market orientation in Australian manufacturing SMEs*, Proceedings at the 8th International Research Conference on Quality, Innovation and Knowledge Management, 12-14 February 2007, New Delhi, India.

Lynn, G. S. & Akgün, A .E. (1998). Innovation strategies under uncertainty: A contingency approach for new product development. *Engineering Management Journal*, *10*(3), 11–17.

Lynn, G. S., Morone, J. G., & Paulson, A. S. (1996). Marketing and discontinuous innovation: The probe and learn process. *California Management Review*, *38*(3), 8–37.

Marxt, C. & Hacklin, F. (2005). Design, product development, innovation: All the same in the end? A short discussion on terminology. *Journal of Engineering Design*, *16*(4), 413-421.

Meyer, J-A. (2002). Knowledge and use of innovation methods in young SME's. *International Journal of Entrepreneurship and Innovation Management*, *2*(2/3), 246-267.

Mosey, S. (2005). Understanding new to market product development in SMEs. *International Journal of Operations & Production Management*, *25*(2), 114-130.

Moultrie, J., Clarkson, J. P. & Probert, D. (2006). A tool to evaluate design performance in SMEs. *International Journal of Productivity and Performance Management, 55*(3-4), 184-216.

Moultrie, J., Clarkson, J. P. & Probert, D. (2007). Development of a design audit tool for SMEs. *The Journal of Product Innovation Management*, *24*(4), 335–368.

Nutek. (2009). *Nutek årsbok 2009*. Nutek, the Swedish Agency for Economic and Regional Growth. ISBN 978-91-7318-412-0.

Olson, E. M., Walker, O. W. & Ruekert, R. W. (1995). Organizing for effective new product development: the moderating role of product innovativeness. *Journal of Marketing*, *59*(1) 48-62.

Osborn, A. (1953). *Applied imagination: Principles and procedures of creative thinking.* New York: Charles Scribner's Sons.

O'Shea, A. & McBain, N. (1999). The process of innovation in small manufacturing firms, *International Journal of Technology Management*, *18*(5-8), 610-626.

Otto, K. & Wood, K. (2001). *Product design: Techniques in reverse engineering and new product development*. Upper Saddle River, NJ: Prentice Hall.

Pahl, G., Beitz, W., Feldhusen, J., & Grote, K-H. (2007). *Engineering design: A systematic approach* (3rd ed.). Berlin: Springer.

Peters, L. S. (2006). Rejoinders to "Establishing an NPD Best Practices Framework." *Journal of Product Innovation Management*, *23*(2), 117-127.

PIEp. (2006). *Product Innovation Engineering Program (PIEp)*. Royal Institute of Technology, Stockholm.

Pilemalm, J. (2002). *Generating products in small and medium sized enterprises: challenges and potential improvements*. Licentiate dissertation. Royal Institute of Technology, Stockholm.

Polanyi, M. (1967). *The tacit dimension*. London: Routledge.

Pugh, S. (1990). *Total design: Integrated methods for successful product engineering*. Wokingham, UK: Addison-Wesley.

Ratcliffe-Martin, V. & Sackett, P. (2001). Information and small companies: Chaos with intent. *AI & Society, 15*(1-2), 22–39.

Reid, S.E. & de Brentani, U. (2004). The fuzzy front end of new product development for discontinuous innovations: A theoretical model. *Journal of Product Innovation Management, 21*(3), 170-184.

Roozenburg, N. F. M. & Eekels, J. (1996). *Product design: Fundamentals and methods*. Chichester, UK: John Wiley & Sons.

Rothwell, R. (1989). Small firms, innovation and industrial change. *Small Business Economics*, *1*(1), 51-64.

Rothwell, R. (1994). Towards the fifth generation innovation process. *International Marketing Review*, *11*(1), 7-31.

Rothwell, R. & Dodgson, M. (1994). Innovation and size of firm. In *The Handbook of Industrial Innovation,* 310-324. M. Dodgson & Rothwell. R. (Eds.). Vermont: Edward Elgar Publishing.

Schmidt-Kretschmer, M., Gericke, K., & Blessing, L. (2007). *Managing requirements or being managed by requirements –Results of an empirical study*. Proceedings of the 16th International Conference on Engineering Design ICED, 28-31 August 2007, Paris.

Scott, P., Jones, B., Bramley, A., & Bolton B. (1996). Enhancing technology and skills in small and medium sized manufacturing firms: Problems and prospects. *International Small Business Journal*, *14*(3), 85–99.

Scozzi, B, Garavelli, C., & Crowston, K. (2005). Methods for modelling and supporting innovation processes in SMEs. *European Journal of Innovation Management, 8*(1), 120-137.

Silverman, D. (2006). *Interpreting qualitative data* (3rd ed.). London: Sage.

Singley, M. K. & Anderson, J. R. (1989). *The transfer of cognitive skill*. Cambridge, MA: Harvard University Press.

Storey, D. J. (1994). *Understanding the small business sector*. London: Routledge.

Stridh, K. & Swärdh, M. (2008). *På spaning i tredje uppgiftens landskap –Samverkan mellan akademi och småföretag.* Report on commission by KK-stiftelsens krAftprogram, Internationell Kompetens AB. Retrieved from http://www.interkomp.se

Swedish Government. (2008). *Regeringens proposition 2008/09:50 - Ett lyft för forskning och innovation*. Proposition. The Swedish Government, Sweden.

Tidd, J. & Bessant, J. (2009). *Managing innovation: Integrating technological, market and organizational* change (4th ed.). Hoboken, NJ: John Wiley & Sons.

Tidd, J., Bessant, J., & Pavitt, K. (2005). *Managing innovation – Integrating technological, market and organizational change* (3rd ed.). Chichester, UK: John Wiley & Sons.

Tidd, J. & Bodley, K. (2002). The influence of project novelty on the new product development process, *R&D Management*, *32*(2), 127-138.

Tjalve, E. (1979). *A short course in industrial design*. London: Newnes-Butterworths.

Ullman, D. G. (2002). *The mechanical design process* (3rd ed.). New York: McGraw-Hill.

Ulrich, K. T. & Eppinger, S. D. (1995). *Product design and development*. New York: McGraw-Hill.

Verhees, F. J. (2005). *Market-oriented product innovation in small firms*. Dissertation. Wageningen University, Wageningen, The Netherlands.

Veryzer, R. W. (1998). Discontinuous innovation and the new product development process. *Journal of Product Innovation Management*, *15*(4), 304-321.

Voss, C. Tsikriktsis, N., & Frohlich, M. (2002). Case research in operations management. *International Journal of Operations & Production Management*, *22*(2), 195-219.

Vossen, R. W. (1998). Relative strengths and weaknesses of small firms in innovation. *International Small Business Journal*, *16*(3), 88-94.

Walker, E., Redmond, J., Webster, B. & Le Clus, M. (2007). Small business owners: too busy to train? *Journal of Small Business and Enterprise Development, 14*(2), 294-306.

Welsh, J. A. & White, J. F. (1981). A small business is not a little big business. *Harvard Business Review*, *59*(4), 18–32.

Westhead, P. & Storey, D. (1996). Management training and small firm performance: Why is the link so weak? *International Small Business Journa*l, *14*(4), 13-24.

Woodcock, D. J., Mosey, S. P. & Wood, T. B. W. (2000). New product development in British SMEs. *European Journal of Innovation Management*, *3*(4): 212-221.

Yin, R. K. (2003). *Case study research: Design and methods* (3rd ed.). London: Sage.

Zontanos, G. & Anderson, A. R. (2004). Relationships, marketing and small business: An exploration of links in theory and practice. *Qualitative Market Research: An International Journal*, *7*(3), 228-236.

Appended Papers

Paper A

The Use of Methodology for Product and Service Development in SMEs: An Exploratory Study of 18 Small Companies

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THE USE OF METHODOLOGY FOR PRODUCT AND SERVICE DEVELOPMENT IN SMEs: AN EXPLORATORY STUDY OF 18 SMALL COMPANIES

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ABSTRACT

This paper examines the use of systematic methods in the product and service development process within small companies. The method used was semi-structured interviews with persons involved in the product or service development process in the companies. The results show that almost all of the 18 companies examined in the study used no systematic methodology in their product or service development processes. The development processes were often ad hoc and inefficient and the companies were aware of this problem and suffered from it. They wanted to change their way of working but did not know how, yet expressed that a more systematic product or service development methodology could be a promising alternative to solve their problems. The small companies often had scarce resources for product or service development and had limited or no knowledge of systematic methods that could be used in their product and service development processes. Only one company in the study had a structured and effective product development methodology that suited the company's characteristics. This case, however, shows that a structured and effective product or service development process is possible in a small company.

Keywords: design methods, product development, service development, small companies

1. INTRODUCTION

Increased competition, more complex products and shorter lifecycles of products and services force companies to become more innovative and flexible to answer the demands from the market. This is true both for large and small companies. The ability to generate innovations is the most important factor for success for small companies (Friis et al. 2002). An innovative product or service development process within the company is a way to meet these demands. One problem for small companies is lack of resources and knowledge of systematic methods that can be used in their product and service development processes (Larsson 2001; Elfving 2004).

There are numerous systematic and efficient methods for product development processes (Pahl & Beitz 1996; Pugh 1990; Roozenburg & Eekels 1996; Ulrich & Eppinger 2005) and how it can be introduced in companies (Bessant & Francis 1997) but these methods are often designed to suit larger companies with greater resources for product development (Hoffman et al. 1998; Elfving 2004). Small and large companies are also innovative in different ways and existing methods do not respect that (Olsen et al. 2006). Elfving (2004) concludes that useable product development models for small companies are missing in the academic literature. This shows the importance of taking a closer look at smaller companies' product and service development processes and their use of systematic product or service development methods.

1.1 PURPOSE

The purpose of the study is to examine the product and service development processes in small companies and in particular the use of systematic methods in these processes. The systematic methods in this study are those that are used in the early phases of the product or service development process. Examples of these methods are methods that structure the often complex product or service development process, methods that facilitate creativity or support the collecting of needs and demands from customers and end-users, as well as methods that create and evaluate concepts. The aim is to identify the needs and challenges of adapting, implementing and using systematic and effective development methods in smaller companies.

2. METHODOLOGY

Product and service development processes are often complex, with unclear boundaries. A multi-case study approach was chosen because it allows the researcher to deeply understand the studied phenomenon and its context (Yin 2003).

2.1 SAMPLE SELECTION

A small company in this study was defined as a company with less than 70 employees. The small companies in this study had to have their own product or service development activities or to want to have their own product or service development activities.

Twenty-nine companies were contacted. These small companies were asked to participate in the study and 18 were positive. The companies had between one and 70 employees and represent manufacturers of mechanical products, electronic products and service companies providing for instance software or education. They were mainly B2B companies and all except for one were from the same small municipality in Sweden. The one company not from the municipality was considering getting established in the same municipality.

2.2 INTERVIEWS

The companies that agreed to take part in the study were visited in person and semi-structured interviews were carried out with the top managers, usually the owner of the firm, or some of those responsible and involved in product or service development within the firm. The interview questions covered the companies' product or service development process, the methodology used and the problems and needs within the process. The research method, semi-structured interviews, was chosen because it can provide high quality and deep data about the respondents' thoughts, valuation and attitudes towards different ideas and concepts, all in a relatively short interview situation (Silverman 2006).

General questions about the firm and their products and services were asked. If the company had an existing product or service development process it was discussed. Otherwise, the need for a product or service development process was discussed. Questions were asked about attitudes and thoughts about product and service development, how the process starts, disciplines and persons involved, phases and activities carried out and supporting methods and techniques. During the interview problems and needs within the firm's product or service development process were identified.

At the semi-structured interviews a rough outline of questions was used. Some of the questions that were central to the research question were asked at all interviews, while other questions were put aside when discussions and topics produced other useful information.

Field notes were used during the interviews. One problem with field notes is that the researcher cannot go back to the origin as with recordings but only to the field notes as they were written (Silverman 2005). The field notes were compiled and analysed further within 24 hours from the interviews, so as little as possible of the data was forgotten.

Important questions at issue that arose in earlier interviews were asked in later interviews. At the last interviews a theoretic saturation was experienced when no much new data arose around the most important issues.

It is possible that quantitative methods could have been used in this study instead of the qualitative method of the semi-structured interview, because the study is mostly about the methods used in the small companies' product and service development process. But this could be misleading because of the fact that one company used several methods without knowing the method's name and that the methods were prescribed in academic literature. This use of product development methods could probably easily be missed if the company, for example, had to fill in a quantitative survey when they mark the methods used in the product or service development.

3. FINDINGS

The semi-structured interviews gave information about the use of systematic methodology in the product and service development process in smaller companies but other useful information about the same process also arose.

3.1 THE USE OF PRODUCT AND SERVICE DEVELOPMENT METHODOLOGY

To structure the findings some classification was performed. Product and service development methods were divided into three categories. The categories were methods used for analysis of the development problem, methods to support creativity and methods for evaluation of ideas and concepts. These are common classifications of product development methods and have equivalence in Ulrich & Eppinger (2005).The three categories and the firm's theoretical knowledge of product and service development and its methods, as well as the company's will to change their existing way of working in the product or development process are summarized in Table 1 below.

Product or service firm	Number of Employees	Got develop-ment process	Methods used for analysis of develop-ment problem	Methods to support creativity	Evaluation methods	Theoretical knowledge of product and service development and its methods	Want change in way of working
Service	1	●					●
Product	3	●	●	●	●		
Service	6	●				●	●
Product	20	●					●
Product	1	●					●
Service	9	●		●		●	●
Product	70	●					
Service	2	●					●
Service	20	●					●
Service	1	●					●
Product	3						●
Product	3	●					●
Product	25						●
Product	5						
Product	2	●					
Product	1	●					●
Service	10	●					
Product	11	●		●		●	●

Table 1. The use of product or service development methodology

The findings showed that many, 12 out of 15, of the companies who have their own product or service development process, worked without the use of systematic methods in their development of products and services in the early phases of the development process. The companies mostly worked in an ad hoc way. One of the vice presidents at one company described the development process as this: they developed something in some way and if they were lucky it became some kind of product in the end.

The most common method was the creativity-supporting method of brainstorming (Osborn 1953), which was used by all the three companies that used product or service development methods.

The analysis of the product or service development problem to be solved was often scarce among most of the companies and they usually skipped the analysis phase and directly tried to solve the product or service development problem without much

knowledge about it. The results of this way of working were that the product or service development process often became unstructured and inefficient and not very innovative. Only one company used some method for analysis of the development problem.

Two companies were quite happy with their way of working and did not see why they should change it even though they often worked inefficiently and in an unstructured manner, without the use of systematic product and service development methods.

As an exception, a company with only three employees used methods in all three categories. This methodology was well suited for the company and its resources. They used several methods without knowing their names or that they were scientifically developed methods. Examples of methods used for analysis of the development problem were the use of requirement specifications that were developed in collaboration with the customer. Examples of creativity-supporting methods used are brainstorming, the theory of quantitative structures (Tjalve 1979), sketching, and several design–for-property methods, for example design for assembly (Andreasen 1983). One evaluation method used, which was also a way to increase the customer value, was that the company often invited the customer and let him or her do all of the tests of the new product. This more often than not gave the customer a deep trust in the performance of the product and in the company. They also integrated industrial design aspects in their design to gain a more user-friendly and neat product. The company developed almost all of their products using the same methods. The company worked closely with its customers.

In relation to previous research the study shows that 11 out of 15 of the companies with a development process, were conscious of the structural problems and inefficiency in their development process and said that they suffered from it and want to change it. These companies explicitly wanted to work more in a more structured way in their development process and expressed that a more systematic product or service development methodology could be a promising alternative to solve their problems. These companies wished to have more knowledge about the product or service development process and its methods.

Three companies had employees with theoretical knowledge of product development and its methods. One of the vice presidents of a company in the study, who was familiar with product development methods from his education, said that they did not use any product development methods, except for brainstorming, at the company and one reason was that the methods were too many and it was hard to pick the right one in the right stage of the development process. Brainstorming was sometimes used because it was easy to accomplish and had a noticeable effect. He also mentioned that he did not consider himself to have the time to use other product development methods because many of his company's product development projects were so urgent.

3.2 OTHER FINDINGS RELATED TO PRODUCT AND SERVICE DEVELOPMENT

Some other useful information about the product and service development process arose during the semi-structured interviews that was not directly related to methodology issues. Two factors, resources and knowledge, were almost always lacking for the small companies.

3.2.1 RESOURCES

Lack of resources was a main theme for the companies when it comes to product and service development. The firms often worked with acute problems and short-term money-makers and said they lack the resources to carry out product or service development as they wish. It was almost always a problem to finance larger development projects due to lack of resources. Some of the companies were very active in fundraising from different foundations and organisations when they planned larger product or service development projects. The companies were not satisfied with the venture capital available on the market, as the venture capitalists seldom supported smaller companies in their experience.

There was no lack of ideas for product or service development projects among the companies. Many of the companies had a lot of ideas about what could be developed but scarce resources often prevented their realization.

3.2.2 KNOWLEDGE

Knowledge about different subjects was often lacking in the product and service development processes in the small companies. There were some supporting organisations to get help from but the companies often experienced the help as too theoretical and not useful in reality. The companies wanted more practical help from the supporting organisations. Knowledge of economic, marketing and law were often lacking in the product and service development process. The companies said that often it was too expensive to buy these competencies on a consulting basis. It was also hard for the companies to get resources for benchmarking and further education for the employees.

3.2.3 SERVICE DEVELOPMENT METHODOLOGY

Some of the service-providing firms asked for methods and tools to manage new service ideas and concepts. One major problem they had experienced was difficulty in communicating their ideas of new services to supporting organisations and investors. They had experienced that ideas and concepts of physical products were easier to communicate to others. They thought that the immaterial aspects of services were hard for most people to grasp. Methods to develop, measure and value services were requested. The experience of purchasing services among companies was estimated as low by some companies. This resulted in, according to the companies, too much time being placed on finding out what the customers actually want to buy. This time was often unpaid and that was a problem.

3.2.4 MISCELLANEOUS

The planning of the product or service development processes was mostly scarce among the companies and therefore so was the strategic dimension of product and service development.

Many of the small companies were fast and flexible to react to their customers' demands but often this caused a problem when too many resources were applied, as they saw it, to late changes in the design or customers that did not know or realize what they want. The companies had a strong will to identify these changing demands earlier in the product or service development process.

Most of the companies were familiar with each other. The municipality was quite small comparatively speaking. One repeated statement was that the most creative companies, the ones with the most ideas for business, also were the ones that other companies often thought were odd and non-serious.

Industrial design in the product development process is said to be problematic for the small companies. The companies say it is difficult to purchase because it is hard to know what you get if you hire an industrial design consultant. It is also experienced as very expensive and the companies see it mostly as a cost and not an investment.

Some of the companies were sometimes visited by inventors who wanted help with their inventions. Even if the inventions were good and suited the company's business the company could seldom help the inventors due to lack of resources.

Several of the companies were members of both externally constructed networks of companies and spontaneously constructed networks of companies. They said that spontaneous constructed networks or alliances often worked better because of the fact that they usually were built around a real win-win situation for the participating companies. This win-win situation was often a product development project when the companies needed each other's knowledge to manage the project. Alliances were seen as a way to compete with larger firms, a phenomenon that Miles et al. (1999) confirm.

4. DISCUSSION

Lack of resources was a main theme for the companies, and not only in product and service development. This is in accordance with Ghobadian & Gallear (1996), who reported that small and medium enterprises (SMEs) have comparatively limited resources. Planning of resources and time in the product or service development process and the use of product and service development methods can be a way for the small companies to use resources more efficiently.

The companies had a strong will to identify changing demands early in the product or service development process, which can be done by using some suitable development methods.

The fact that several companies in the study said that they did not have the resources to conduct product or service development as they wished and also said that they suffered from lack of knowledge about the product or service development process and its methods matches Larsson's (2001) and Elfving's (2004) findings about smaller companies' lack of resources and knowledge of systematic methods that can be used in their product and service development processes.

The vice president of one company said that they do not use product development methods, except for brainstorming, because many of his company's product development projects were so urgent. This is a conception that contradicts the common comprehension that systematic development methods save time in the product or service development process.

The most creative companies in the study were often seen as odd and non-serious. This can indicate that it is only accepted to be creative in small amounts and in a restricted area. This contradicts the creativity literature that prescribes a lot of wild and crazy

ideas to be sure to find the most promising ideas. One mantra often heard in creativity literature is "Quantity gives quality" (Osborn 1953).

5. CONCLUSIONS AND FURTHER RESEARCH

The study shows that almost all of the 18 companies examined in the study used no systematic methodology in their product or service development processes. Product and service development is hard for smaller firms to manage and some of the reasons are lack of resources and knowledge. The companies suffered from their often unstructured and inefficient product or service development processes and wants to change them. They saw product and service development methodology as a promising alternative to help them in their product and service development processes.

The case reveals some important challenges for future research. One challenge is to examine what mix of methods could support smaller companies' early phases of the product or service development process. Another challenge is to examine how to implement and establish systematic and efficient methods in smaller companies and examine their effects with regards to efficiency and innovation. The company in the study that had a smoothly operating product development methodology shows that a structured and efficient way of developing products is possible even in a small company.

REFERENCE

Andreasen, M. 1983. *Design for assembly*. IFS Publications, Ltd., London.

Bessant, J. and Francis, D. 1997. Implementing the new product development process. *Technovation*, 17(4), 189-223.

Elfving, S. 2004. Managing collaborative product development in small companies. Licentiate thesis. Mälardalen University, Sweden.

Friis, C., Paulsson, T., Karlsson, C. 2002. Entrepreneurship and economic growth – A critical review of empirical and theoretical research. Institutet för tillväxtpolitiska studier, International Business School, Jönköping, Sweden.

Ghobadian, A. and Gallear, D. 1996. Total quality management in SMEs. *Omega*, 24(1), 83–106.

Hoffman, K., Parejo, M., Bessant, J. Perren, L. 1998. Small firms, R&D, technology and innovation in the UK: A literature review. *Technovation*, 18(1), 39-55.

Larsson, G. 2001. Designprocessen i fyra småföretag. Licentiate thesis. Luleå University of Technology, Sweden.

Miles, G., Preece, S. and Baetz, M. 1999. Dangers of dependence: The impact of strategic alliance use by small firms. *Journal of Small Business Management*, 37, 20–29.

Olsen, J., Lee, B.-C., Hodgkinson, A. 2006, Innovation in small and medium-sized enterprises: A study of business in New South Wales, Australia. University of Wollongong Economics working paper series. Available at: http://www.uow.edu.au/commerce/econ/wpapers.html

Osborn, A. 1953. Applied imagination: The principles and procedures of creative thinking. Charles Scribner's Sons, New York.

Pahl, G. and Beitz, W. 1996. *Engineering design – A systematic approach* (2nd ed.). Springer-Verlag, London.

Pugh, S. 1990. *Total design: Integrated methods for successful product engineering*. Addison-Wesley Publishing Company, Wokingham, UK.

Roozenburg, N. F. M. and Eekels, J. 1996. *Product design: Fundamentals and methods*. John Wiley & Sons Ltd., Chichester, UK.

Silverman, D. 2006. *Interpreting qualitative research*. SAGE Publications, London.

Tjalve, E. 1979. *A short course in industrial design*. Newnes-Butterworths, London.

Ulrich, S. & Eppinger, K. 2005. *Product design and development*. McGraw-Hill Education, New York.

Yin, R. K. 2003. *Case study research: Design and methods* (3rd ed.). SAGE Publications Ltd., London.

Paper B

Prerequisites for Innovation in Small Companies: A Multiple Case Study

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PREREQUISITES FOR INNOVATION IN SMALL COMPANIES: A MULTIPLE CASE STUDY

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ABSTRACT

This paper examines the prerequisites for innovation in three different small companies. The method used is an examination of the case studies with observations during a period of five months and interviews with persons involved in the innovation activities within those companies. A generic innovation process model was used as a reference when the case studies were analysed; the model was found to be valid in describing prerequisites for small company innovation. The findings confirm previous research on prerequisites for small company innovation in several areas such as leadership, strategy, creative climate, innovative organization, and contextual linkages. The unique value of this study is that relationship marketing - with intense communication with customers and users - can be a major source for input and feedback to the innovation activities within the small companies. Scarce resources is a known barrier for innovation in smaller companies, which the study confirms; it also shows five different ways that small companies can increase and use existing resources more efficiently.

Keywords: innovation, new product development, small companies, relationship marketing, resources

1. INTRODUCTION

Increased competition, more complex products, and shorter product lifecycles force companies to become more innovative and flexible in order to meet market demand. This is true for both large and small companies. Friis et al. (2002) note the most important factor for success for small companies is the ability to generate innovation. Some researchers also note that small and large companies are innovative in different ways, which existing models and methods do not take into consideration (Olsen et al. 2006). Bessant et al. (2005) conclude that not much is known in academic literature in the area of innovation and small companies, with the exception of research on small fast-growing high-tech firms. An innovative product development process within the small company is a way to meet these demands for innovation. This process is not an isolated part of an organization, and is dependent upon several prerequisites.

1.1 PURPOSE

The purpose of this study is to examine the prerequisites for innovation in small companies, and to describe and analyse their effects on the innovation process. This is achieved by exploring the innovation processes of three separate small companies.

1.2 DEFINITIONS

Innovation, product development, and design are terms that have evolved and have all adopted a similar meaning (Marxt & Hacklin 2005). This study also makes no distinction between the terms. The focus here is the process within companies of developing product innovations, such as introducing new or improving existing goods and/or services (Francis & Bessant 2005). The term *product* is, hence, used both for physical goods and/or services.

A small company is defined as *a company that has less than 50 employees and can be controlled by one owner and/or manager*.

1.3 PREVIOUS RESEARCH WITHIN SMALL COMPANY INNOVATION

As mentioned in the introduction, Bessant et al. (2005) conclude that not much is known in academia in the area of innovation and small non high-tech companies. What is known, however, is that smaller companies have different characteristics in comparison to larger companies when it pertains to innovation due to different technological and economical environments (Audretsch 2001). While many of these characteristics hinder innovation, some are advantageous. Some of the beneficial characteristics are: flexibility, agility to react and respond to changed market conditions, and rapid communication and decision-making within the organization (Adams 1982; Cannon 1985; Vossen 1998). Limited access to finance (Freel 2000) and scarce resources (Rothwell 1989; Welsh & White 1981) are among the predominant characteristics that hinder innovation, as is lack of managerial skills and marketing knowledge (Adams 1982). External uncertainty is generally higher among small firms; one reason for this is the lack of power in the marketplace and the fact that many small firms are dependent upon a large customer (Westhead & Storey 1996). This also results in a shorter time horizon in small firms. This means long term strategies are less useful, and that shorter time returns are more favourable than longer ones.

Innovation processes in small firms are often seen as a continuous process with no distinct starting point and blurred and unclear phases (Cannon 1985), which seem to be most successful if existing customers are targeted (Adams & Walbank 1983). Problems within the process are predominantly found in marketing activities and in the early parts of the innovation process. The most innovative small firms have strong market orientation (Adams 1982). Support from existing customers is a success factor in small company innovation and without this customer support, innovation often fails (Cannon 1985). Adams & Walbank (1983) conclude that most small company innovation is incremental. Radical innovations are very rare. A small company with an owner/managing director that delegates power and knowledge among its employees is considered more innovative (Cannon 1985). Many small companies are family-owned and controlled businesses; it is important to note, however, that more innovative small companies tend to have lower family involvement in the business (Hadjimanolis 2000). Some innovation process models exist for smaller companies (Berglund 2007; Verhees 2005). Although these models are comprehensive throughout several phases, they lack in content detail or are too narrow in scope and are, therefore, considered less useful in helping small companies with their development efforts. A recent study by Löfqvist (2007) concludes that innovation is an area of concern for smaller companies.

1.4 MODEL OF REFERENCE

In this study, the innovation process is described and visualized by a generic innovation process model by Bessant et al. (2007) as depicted in figure 1:

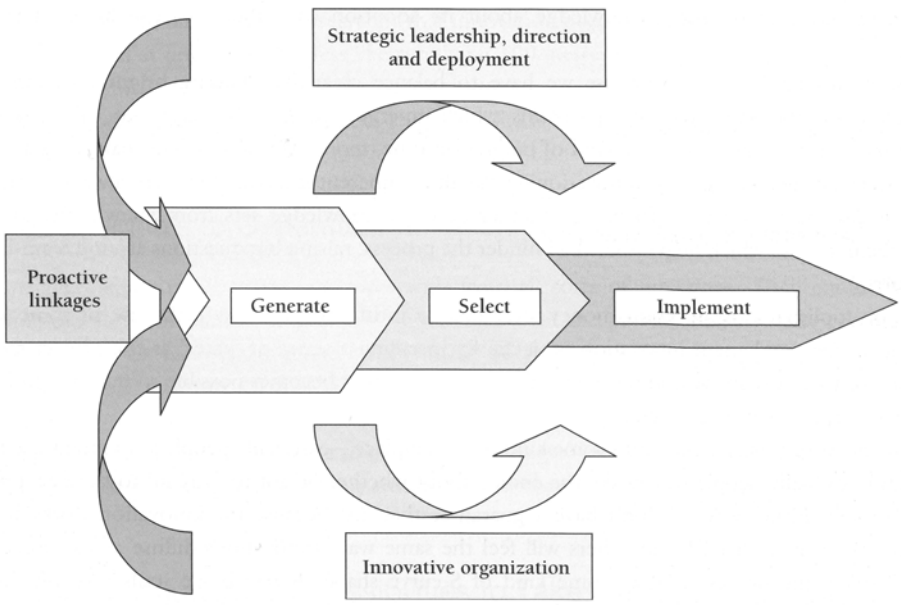

Figure 1. Model for Managing Innovation (Bessant et al. 2007)

The model consists of three generic phases: generating, selecting, and implementing inputs for change. Bessant et al. (2007) claim that the model is valid to all organizations independent of size.

In an organization, however, it is the context that determines whether or not most of the prerequisites for the innovation process will occur. In the above model, the context is divided into three different factors that interact. It is within these contextual factors where the prerequisites in this study can be found. The first factor - Strategic Leadership, Direction, and Deployment - is about balancing risk in a strategic way with a clear direction, leadership and committed resources. The second factor - Innovative Organization - describes the structure and climate appropriate for innovation, which should enable and facilitate creativity and communication. The third factor - Proactive Linkages – concerns the links to external and internal actors that are part of the innovation process. Examples of these actors are: users, customers, suppliers, source of finance, and other actors within or outside an organization.

2. METHODOLOGY

Innovation processes are often complex and have unclear boundaries. A qualitative multi-case study approach has been chosen because it allows the researcher to understand more deeply the studied phenomenon and its context (Yin 2003).

2.1 SAMPLE SELECTION

Three small companies – with their respective products and innovation activities - were studied. These companies were chosen due to their differing grade of systematic innovation processes, their varying interaction intensity within their markets, and the difference in the number of new or improved products launched. A systematic innovation process means that the company has developed certain routines in order to

execute the process. Table 1 displays some of the characteristics of the three companies in the study:

Table 1. Some Characteristics of the Three Companies in the Study

Characteristics	Company 1	Company 2	Company 3
Firm Type	Manufacturer B2B	Software B2B	Manufacturer B2B and B2C
Systematic Innovation Process	No	Yes	Yes
Interaction With Market	Low	High	Very High
Amount of New or Improved Products Launched	Approximately One Small Improvement of an Existing Product per Year	Several Improvements of an Existing Product per Year	Several New or Improved Products per Year
Employees	23	9	25
Customers	One Big, Many Small	Many Small	Many Small
Market	Sweden and the World	Sweden	Sweden and the World
People Involved in the Innovation Process at the Company	5	6	3

2.2 INTERVIEWS AND OBSERVATIONS

Semi-structured interviews were carried out with persons involved in the innovation activities within the firms. This research method was chosen since it may provide high quality and detailed data about the respondents' thoughts, values, and attitudes towards various ideas and concepts - all in a relatively short interview situation (Silverman 2006).

Field notes were used during the interviews with one difficulty being noted: the researcher cannot go back to the origin of the field notes as he/she can with recordings, yet can only refer to them as they were written (Silverman 2006). During the writing of field notes, analyses are simultaneously done in the interview situation. The field notes were compiled and then, in an attempt to remember as much as possible, the data was analysed again within a 24-hour period. Important questions and issues that may have arisen in earlier were asked again in later interviews. In the final interviews, a theoretic saturation was experienced when no much new data arose regarding the most important issues.

The innovation activities of company 1 and 2 were also observed two days a week in each company during a period of five months. The companies´ activities (particularly the innovation activities) were observed. These observations provided the opportunity to cross check answers that had been given in the interviews in order to determine if the interviewees actually did what they claimed to do.

Company 3 was studied in a different way. This company had a substantial amount of secondary data available about the company and its innovation process. This was not the case with Company 1 or 2. Secondary data from small companies is often rare and unavailable (Davis et al. 1985). This secondary data from Company 3 made it possible to get a good understanding of its innovation processes. The studies of Companies 1 and 2 were made prior to that of Company 3. The findings from the first studies made it possible to fine-tune the questions and to focus more upon the most relevant and interesting areas in small company innovation. This culminated in a visit at Company 3 with a two-and-a-half hour semi-structured interview with the product development manager,

3. RESULTS OF THE CASE STUDIES

Each case study is described below.

3.1 COMPANY 1

Company 1 is a manufacturing firm with relatively low technical products for a special segment of a market. The competitors are few, and the company's unique selling proposition is fast delivery of ordered products. It has been more than 20 years since the company developed entirely new products. Although the company has many ideas about innovation and makes small attempts to innovate on its own, it usually does not lead anywhere. Innovation that is requested by the largest customer is treated seriously with some innovation being achieved; however, these realized innovations are few and are merely incremental variants of existing products. Recently, upon request from the larger customer, the company attempted to develop a completely new variant of an existing product. This project, however, failed in many areas such as teamwork, planning, and communication. Working routines in the innovation activities were absent. The market in which it acts has a relatively low rate of change; the market pull is the dominant demand factor for new or improved products. There are scarce resources for innovation.

3.1.1 STRATEGIC LEADERSHIP, DIRECTION, AND DEPLOYMENT IN COMPANY 1

A managing director runs the company alongside the owner on the board of directors. The owner has the ability to interfere in the daily operation of the firm. This results in two leaders at the helm, which can be confusing for the employees. Goals are not clearly defined and can change arbitrarily. Much of the conditions for the firm are dictated by the largest customer. Innovation is said to be the highest priority yet, in practice, few resources or support is allocated. Sales are always prioritized and order-specific design and adjustments of the products are most often taking resources from the innovation activities. Production trouble is common and in order to rectify any problems, many resources are taken from other activities, such as innovation. Family members and friends work at the company; therefore, business and family issues are often intertwined, and underlying conflicts complicate communication and work efficiency. The company believes strongly in the well-being of its employees and their families and, therefore, gives them several benefits that are not regulated in their official employment contract. Innovation is also not supported by all at the company.

3.1.2 THE INNOVATIVE ORGANIZATION IN COMPANY 1

Five persons are more or less involved in the innovation activities of the company; however, most of the work is done by one or perhaps two of the employees. Those

involved have many roles at the company; hence, it is common that they work with completely different tasks than what they are supposed to be doing. Cross-functional teams are not present and there is lack of knowledge in several areas in the innovation activities. The creative climate is low due to the owner not delegating much power and control; the owner's personal traits, therefore, affect the entire company. The effect is that employees do not always feel trusted with their work. When employees present their ideas, they are not given the appropriate attention and non-constructive criticism is a common result. This inevitably decreases creativity. Many of the employees are not accustomed to taking their own initiative; they want someone to direct them in new situations. There is no knowledge about creativity, nor about how to create a creative climate. There is also a great lack of communication. Everyone involved in the innovation activities are located relatively close to each other, which should enhance communication yet, at this company, it does not. One explanation is that many of the employees are taciturn. External consultants are hired (for example, to work in design). Specialists in the company's external network are, at times, invited to discuss various innovation ideas. While they do exist, lead users (Von Hippel 1988) that modify the company's products on its own are not common. Moreover, its innovations are not given the appropriate attention. Those involved in innovation have little understanding of project work and little knowledge in theoretical and practical innovation work.

3.1.3 Proactive Linkages in Company 1

This company is not proactive in the area of innovation. Instead, it is reactive to innovation and responds mainly to the requests from its largest customer. There is no active search for input, ideas, and challenges with innovation even though many innovative ideas exist. Marketing activities aimed at new customers are low with some industry magazines and some trade fairs. No formal marketing research is done. Most of the marketing activities are relationship marketing, built upon relationships with known customers; it is precisely within these relationships that most of the ideas for innovation occur. Relationship marketing is defined by Gummesson (2002) as marketing based upon interaction within networks of relationships. The contacts are mainly with the buyers and not with the users of the products. There is no natural contact between the ones involved in innovation and the customers and users. The company has a few competitors but its activities are not challenged. The change rate in the market is low, and the demand for product development is also relatively low. The largest customers see cheaper products as more important than innovative products. Customers that need support receive help, yet no official support function exists for the company's products.

3.2 *Company 2*

Company 2 is a software development firm with a product for a special segment of a market. The company has a few competitors; the company's unique selling proposition is its ability to easily customize the software to exactly fit the customers' business. The company's product is an innovation done by the owner/managing director in the mid 1990s that has since evolved, and a new functionality been added. Its innovations are incremental modifications of the existing products, new modules, or functionality. The sources for innovation are mostly market pull, yet there is also technology push. The market for Company 2 changes moderately, yet the underlying technology for the product changes fast. The company has scarce resources for innovation, yet gains extra resources for larger customer-specific innovation projects through direct financing of the development work by the buying customer. Product maintenance and smaller

innovation projects are financed by the company itself and are launched to the customers who pay for software upgrades.

3.2.1 Strategic Leadership, Direction, and Deployment in Company 2

In Company 2, innovation is given priority since it generates money and work through customer financing of the development work for most of the larger innovation projects. Innovation is natural for the employees and is seen as a way to stay competitive, to gain competence, and to serve customers. Sales and customer-financed innovation are always prioritized because they are seen as important in order to constantly generate money. Urgent issues that appear and are related to sales can take resources from the innovation activities that are not financed by customers. The company has strategies for both the long and short term, and has clear goals and resources that are committed to innovation. The owner/manager director considers that the company should work as a football team toward a common goal. Authority and responsibility are delegated to the employees and the need for direct leadership is relatively low. Family members work in the company, yet family issues are not present in the business. The company continuously review itself and discusses questions such as who they are, what they do, and why.

3.2.2 The Innovative Organization in Company 2

People in the company work with what they are supposed to do, and have broad skills to *cover for others* when they are needed. The creative climate is high due to the owner/managing director delegating power and control; communication is informal and intensive. All employees work together at close proximity, which enhances and facilitates communication. Visualization is used as a form of communication in complex issues. Some employees have knowledge of creativity, creativity methods and tools, and how to create a creative climate. Ideas from employees are given due attention, and even unconventional ideas are welcomed. Any criticism that is given when presenting ideas is constructive. Cross-functional teams are not used; communication with different professions is done directly or at coffee breaks when all employees meet. They possess almost all of the in-house knowledge, yet must engage at times external consultants when using new technology. Lead users are not common, yet they do exist. Annual customer and user meetings are held in order to receive input and feedback on innovation. The company has working innovation routines and is skilled at project work, and does most of the larger innovation activities such as formal projects with customers and users involved in the project organization. Through involving customers and users, the company increases its resources and innovative organization; input and feedback is continuously given on each project. This way of working often produces efficient work, satisfied customers, and high quality products.

3.2.3 Proactive Linkages in Company 2

The company is proactive in the area of innovation. The company is also reactive to innovation, responding according to requests from customers and competitor activities. The company always strives to get support and financing from existing customers involved in larger innovation projects. Marketing activities aimed at new customers are moderate with some advertisement in industry magazines, circulars, and trade fairs. No formal marketing research is done. Most of the marketing activities are done through relationship marketing, which is built upon relationships with known existing customers. Through this intensive contact and communication with customers and users, most of the input and feedback to innovation occurs. The company has some problems in

communication with its customer and users due to the fact that its employees can easily get too technical, which makes them less easily understood. The relationship with its customers is more of a friendly one where company and customers help each other with various tasks. There is no active search for input to innovation; still, there are more good ideas for innovation than there are resources to explore them. Competitors are monitored in an informal way - and often by Company 2´s customers. The customers also help Company 2 to sell its products to new customers. The intensive contact with existing customers and users is not only good since some customers are interrupting. There is often problems when projects are done with customers who do not understand project work.

The company actively strives to only employ social people since all employees must be able to interact with each other in the company, within the market, and with customers and users. The ones working in the innovation activities meet the customers and users in their natural environment when visiting them in different innovation projects. The company is relatively open to the environment, with communication through a variety of channels mostly with customers and users, and sometimes also through academia, other companies, and organizations. The external communication channels are informal meetings, trade fairs, education, support, and user-meetings. The customers expect the product to develop over time and launch new versions every year. Much of the contact with customer and users are through the support, which gives continual feedback in the form of ideas and problems to use as input to innovation. The support is also a way to serve and keep contact with customers: a channel for sale and marketing and a business concept for which customers pay.

3.3 COMPANY 3

Company 3 is a manufacturer firm with technical products for a particular segment of a market. The company has some large competitors. Its products are innovations mainly conceived by the owner/managing director and his family. They have many ideas for innovation, and innovate on their own from identified customer and user problems, or lead user ideas. These innovations are new products and incremental improvements of existing products. There is a relatively low rate of change in its market and market pull is the dominant demand source for innovations. The company finances its own innovation activities itself, has a good reputation, and is a well-known brand on the market.

3.3.1 STRATEGIC LEADERSHIP, DIRECTION AND DEPLOYMENT IN COMPANY 3

Innovation is prioritized and it appears to be a natural part of the company's activities. Innovation is considered to give the company a competitive edge and to satisfy its customers. The company has strategies, clear goals, and commits its resources to innovation. Family members and friends work in the company, yet family issues and business are separated. The company works mostly without present leadership because authority and responsibility are delegated to its employees.

3.3.2 THE INNOVATIVE ORGANIZATION IN COMPANY 3

The entire company is built around innovation and marketing activities. The company has outsourced all production and almost all assembling to its suppliers. One probable exceptional thing for this kind of company is that it has employed specialists to work in marketing, web publishing, and linguistics. The employees have clearly defined roles with an obvious interface acting between them. The creative climate is high due to the

owner/managing director delegating power and control; communication is plentiful and informal. Ideas from employees are given due attention, and even unconventional ideas are welcome; criticism is constructive. The company has no special knowledge in creativity or creativity methods and tools, yet manages to create a highly creativity climate anyway. Visualization is used in communication. Cross-functional teams are not used in innovation, yet communication with various professions is done directly or at coffee breaks when all employees meet. Everybody involved in the innovation activities work in relatively close proximity to each other, which enhances communication. Almost all necessary knowledge, is available in-house, and the company seldom engages external consultants. The company understands project work, yet does not arrange innovation activities as formal projects. The company has working innovation routines, and works on projects that have identified needs in the market and on which are fun to work. This way of working is said to result in good innovation. The company often works on several innovation ideas concurrently as a way to prove which ideas are strong enough to survive.

Company 3 increases its resources and expands its innovative organization through using its many lead users that modify the company's products and give the innovations to the company for free. This works because of the company's friendly and intensive relationships with its customers and users. Moreover, the products are relatively low-tech and are easy to modify. One additional thing that probably increases lead user activities is the strong and positive emotional bonds that the customers and users have to some of the company's products. One thing that makes the lead user innovations extra useful is that they most often have their origin in real customer and user problems. A lot of work is saved by the company because they not only have real customer and user problems served, but there are also working solutions to eliminate the problems.

3.3.3 PROACTIVE LINKAGES IN COMPANY 3

The company is proactive in the area of innovation. They are also reactive in innovation and react to competitors' activities and requests, and needs from customers and users. There is little change in the marketplace; however, customers and users expect new or improved products since they are so accustomed to it.

The company has an extremely open working environment; anyone is welcome to visit the company, which is often the case with customers and users. The company is proud and honest of what it does, and considers that it has nothing to hide from its customer and users. The relationships with customers and users are more of a friendly relationship, and the customers and users also help Company 3 to sell its products. The company actively strives to employ social people since all of its employees must be able to interact with the market, the customers, and the users. The internet is its primary platform for communication with customers and users around the world. Mostly everything the company does, or interesting things that customers or users do, is published on the home page and in its own customer newspaper. Marketing activities are done in several ways. Most of the marketing activities are relationship marketing with both new and existing customers and users. The communication channels with customers and users are: the company homepage, informal meetings, trade fairs, education, support, user-meetings, retailer-meetings, and its own customer newspaper. Through this intensive contact and communication with customers and users, most of the input and feedback to innovation occurs. There is no active search for input for innovation. There are more good ideas and problems suitable for innovation than there are resources to explore them. The company's interaction with its environment is not

only with customers and users. Interaction with academia, other companies, and organizations is also common. Competitor analysis is usually conducted at bigger trade fairs that give input to innovation in two different ways. Analysis sees what the competitors have that the company must match, and also what the competitors do not have. What the competitors do not have can later be matched with identified customer and user problems and needs, and become entirely new products. Much of the contact with customer and users are through the support. The support gives continual feedback in the form of ideas and problems that can be used as input to innovation. Support is also a way to serve and keep contact with the customers and users, and a channel for sale and marketing. All involved in the innovation activities understand their customers and users, and speak their *language* by meeting customers and users in their natural environment. It is common for the company finance suppliers to be involved in the innovation process. Otherwise, the innovation project could not occur. This is an efficient way to manage and rule the company's suppliers in order to support the company's innovation activities.

4. DISCUSSION

The findings below are divided into the three contextual factors presented in Bessant et al. (2007) innovation process model and prerequisites for innovation are discussed.

4.1 PREREQUISITES IN STRATEGIC LEADERSHIP, DIRECTION, AND DEPLOYMENT

There is a clear difference between Company 1, and Companies 2 and 3 together, when it comes to leadership, strategy, clear goals, and committed resources. Leadership is unclear in Company 1, which makes it difficult for the employees to know to whom they should listen. This is not the case in the other two companies when strategy, direction, and goals are clearer and understood. Leadership plays a minor role in these two companies, where authority and responsibility are delegated to the employees. Delegated authority and responsibility is not often the case in smaller companies when owner/managers like to have control of most things, which ultimately decreases innovation (Adams 1982; Cannon 1985). Strategy, directions, and goals are often unclear in Company 1, and can change from time to time. This makes it hard for the employees to build a team and work in the right direction toward a common goal.

Committed resources to innovation are important if there is going to be any innovation in the end. Innovations do not develop themselves. Scarce resources for innovation are common in small companies (Rothwell 1989; Welsh & White 1981); this is the case in Companies 1 and 2. Company 3 seems to have relatively more resources dedicated to innovation, which probably can be explained in that Company 3´s core businesses are innovation and marketing. In Company 1, innovation is said to be prioritized, yet not much resources are committed to it. This makes the innovation rate very low and the few resources given are easily redirected to more urgent needs which must be taken care of. This is also the case in Company 2 when urgent needs can take resources away from innovation that is not financed by customers. In most cases, these urgent needs threaten the flow of capital into the company. In Company 1, sales always comes first and production problems must be quickly fixed in order to enable sales. In Company 2, sales also come first, which could put innovation aside until a later date. This can probably be explained in that small companies are generally very sensitive to disturbance in the capital flow (Welsh and White 1981). Innovation is often a highly uncertain activity and has long time returns. Small companies often work in great external uncertainty, which makes long time strategies less useful and short time returns

more favourable than long ones (Westhead & Storey 1996). The small company probably favours short time returns if the uncertainty in the innovation work and/or external uncertainty become too high. It also seems that it is easy to take resources from innovation activities since they do not have an effect on the company performance in the short run.

Company 3 had no frequent or urgent needs that took resources from innovation activities. One explanation to this can be that it has a larger resource buffer than the other two companies, and that it had outsourced all production to suppliers. Moreover, the company took of unforeseen occurences in the production that may have needed extra resources.

A great difference between Company 1, and Companies 2 and 3 together, is the involvement of family issues in the business. For Company 1, this involvement affects the innovation activities negatively. This finding matches Hadjimanolis (2000), which states: more professionally run small companies are more innovative.

4.2 Prerequisites for an Innovative Organization

There is a clear difference between Company 1, and Companies 2 and 3 together when it comes to innovative organizations that support creativity and communication. Company 1 practices several things that is known to decrease creativity and innovation. Authority and responsibility are not delegated, which is not good for creativity (Cannon 1985). The employees are not used to taking their own initiatives in new situations, and feel they are not being trusted. This decreases their own initiatives even further. Non-constructive criticism is common when discussing ideas which also decreases creativity (Osborn 1953). The internal communication is low and working innovation routines are absent. This makes innovation activities even less efficient. Innovation is often carried out as projects, and Company 1 is unfamiliar with project work. This also contributes to innovation inefficiency. Companies 2 and 3 do not have the aforementioned obstacles in their innovation activities. The employees are trusted and communication is intensive and informal; therefore, the creativity climate high. They also have working innovation routines and understand project work. Cross-functional teams are not used by the companies; however, when needed, external input to the innovation activities is achieved by informal talk with others in the company or consulting external experts in the companies´ network.

Companies 2 and 3 had certain ways to increase resources and/or use existing resources more efficiently. Company 2 let customers finance innovation projects and used customers and users in the innovation work, actually doing development work and feeding the project continuously with input and feedback. Company 3 increased its resources by taking advantage of its many lead users and their modifications of the company's products. Involving customers and users in innovation activities enhanced the quality and the adoption of the innovation developed (Andersson & Rollenhagen 2003; Von Hippel 1988). Company 3 also secured its resources for innovation by outsourcing activities that could easily steal innovation resources for production.

4.3 Prerequisites for Proactive Linkages

Companies 2 and 3, which have proactive behaviour and react to future situations, are more innovative. This finding is supported by Bessant et al. 2007. All three companies are reactive to market request for innovation. There is no active search of input for innovation. No formal marketing research is done, which is a finding that matches

Cannon (1985). Still, they had more ideas, customer problems and needs than they had the resources to explore them. This abundance of good ideas in small companies is also found by Dalrymple (2006) and Löfqvist (2007). All companies practice relationship marketing (Gummesson 2002), which appears to be closely connected to the innovation activities. It is in these relationships with customers and users that most input and feedback to innovation occurs. The relationships with customers and users seem to be an intertwined mix of trust, of giving and taking, and of support, service, sales, innovation, and marketing that reinforce each other. These relationships give a continuously stream of input, ideas, and feedback to innovation activities, which can be seen as part of a market orientation by the small companies. This concurs with Low et al. (2007) who found that market orientation and the innovation process interacts in small and middle-sized enterprises, and that market orientation is positively correlated with firm innovativeness (Erdil et al. 2004; Low et al. 2007b).

Close relationships with customers are not only good; sometimes customers can be annoying, and cause problems in project work due to low skills in project management. A variety of different communication channels in the market seem to enhance innovation. This matches findings by Cannon (1985).

It seems to be important to have customers who are supportive of innovation. This finding is also supported by Cannon (1985). This support can take different forms. The customer can co-develop the innovation with the company and also finance the innovation development work and, ultimately, buy the innovation in the end. Another way for indirect support by customers is the clear identification of customer problems or needs in the market that the innovation will solve. Company 3 seemed to have more resources and capital, in comparison to the other two companies. That made it possible to manage its suppliers in an efficient way to enable innovation. Through financing suppliers' parts of the innovation process, some innovation projects became possible that, without financing, would not otherwise have been.

5. CONCLUSIONS

This study confirms that the contextual factors in the Bessant et al. (2007) model of the innovation process are valid for small companies. Existing research on prerequisites for small company innovation are confirmed in several areas:

- A more professional way to manage the small company seems to enhance the innovation activities;
- Family issues and business in not a preferable mix when it comes to innovation;
- Trusted employees with delegated authority and responsibility are good for innovation;
- Intensive communication through a variety of channels in the market, with customers, users, other actors, and organizations seems to enhance innovation; and,
- Supporting customers in innovation activities seems to increase innovation success.

What is claimed to be new findings is that relationship marketing with its intense and extensive communication with customers and users is a major source for input, ideas, and feedback to the innovation activities in small companies. These relationships can be the primary source of the abundance of good and innovative ideas in small companies.

Resources to innovation are a crucial prerequisite for innovation to occur. The resources are often scarce and are often transferred to other more acute areas. This study also shows that small companies practice several ways to increase and use existing resources in a more efficient way, such as:

- Receiving financing for innovation development work by ordering customers;
- Including customers and users in the actual innovation work;
- Adopting lead user innovations;
- Using external experts in the small company's network as *pro bono* consultants in the innovation activities; and,
- Outsourcing activities that usually steal a lot of resources from innovation activities.

REFERENCE

Adams, A. (1982). Barriers to product innovation in small firms: Policy implications. *International Small Business Journal*, 1(1), 67-86.

Adams, A., Walbank, M. (1983). Perceived and acted out training needs in small manufacturing firms. *International Small Business Journal*, 2(1), 46-51.

Andersson, E. R. & Rollenhagen, C. (2003). *Systemgrupper och innovativ problemlösning*. Lund: Studentlitteratur

Audretsch, D. B. (2001). Research issues relation to structure, competition and performance of small technology-based firms, *Small Business Economics* 16 (1), 37-51

Berglund, A. (2007). *Assessing the Innovation Process of SMEs*. Licentiate Dissertation. Luleå University of Technology. Luleå , Sweden.

Bessant, J., Pavitt, K. & Tidd, J. (2005). *Managing Innovation – Integrating Technological, Market and Organizational Change (3rd ed.)*. John Wiley & Sons Ltd, England

Bessant, J. and Tidd, J. (2007). *Innovation and Entrepreneurship*. John Wiley & Sons Ltd, England

Cannon, T. (1985). Innovation, creativity and small firm organisation. *International Small Business Journal*, 4(1): 33–41.

Dalrymple, John F. (2007). *R&D and Innovation in Regional SMEs A Response to Globalisation?*. Research Paper Presented at The Eighth International Research Conference on Quality Innovation and Knowledge Management, India Habitat Centre New Delhi, 12-14 February

Davis, C. Hills, G. & LaForge, R. (1985). The marketing/ Small Enterprise Paradox: A research agenda. *International Small Business Journal*, 3, 31.

Erdil, S., Erdil, O. and Keskin, H. (2004). The Relationships between market orientation, firm innovativeness and innovation performance, *Journal of Global Business and Technology*, 1 (1), 1-11

Francis, D. & Bessant, J. (2005). Targeting innovation and implications for capability development, *Technovation*, 25(3), 171-183.

Freel, M. S. (2000). Barriers to product innovation in small manufacturing firms, *International Small Business Journal* 18 (2), 60

Friis, C., Paulsson, T., Karlsson, C. (2002). *Entrepreneurship and Economic Growth – A Critical Review of Empirical and Theoretical Research*. Institutet för tillväxtpolitiska studier, International Business School, Jönköping, Sweden.

Gummesson, E. (2002). *Total Relationship Marketing: Marketing Strategy Moving From the 4Ps - Product, Price, Promotion, Place - of Traditional Marketing Management to the 30Rs - the Thirty Relationships of a New Marketing Paradigm. 2. ed*. Oxford: Butterworth-Heinemann

Hadjimanolis, A. (2000). A Resource-based view of innovativeness in small firms. *Technology Analysis and Strategic Management* 12 (2), 263-281.

Hippel, E von (1988). *The Sources of innovation*. New York: Oxford U.P.

Low, D., Chapman, R., Sloan, T. (2007). *"We Only Innovate on Customer's Requests": An Exploration of Market Orientation in Australian Manufacturing SMEs*, Paper Presented at 8th International Research Conference on Quality, Innovation and Knowledge Management, New Delhi, India, 12-14 February.

Low, D., Chapman, R., Sloan, T. (2007b). Inter-relationships between innovation and market orientation in SMEs, *Management Research News*, 30 (12), 878-891

Löfqvist, L. (2007). *The Use of Methodology for Product and Service Development in SMEs: An Exploratory Study of 18 Small Companies*. Research Paper Presented at the 8th International CINet Conference, Continuous Innovation - Opportunities and Challenges. Gothenburg, Sweden, 7-11 September 2007.

Marxt, C. and Hacklin, F. (2005). Design, product development, innovation: all the same in the end? A short discussion on terminology. *Journal of Engineering Design* 16 (4), 413-421.

Olsen, J., Lee, B.-C., Hodgkinson, A. (2006). *Innovation in Small and Medium-Sized Enterprises: A Study of Business in New South Wales, Australia*. University of Wollongong Economics Working Paper Series. Available at: http://www.uow.edu.au/commerce/econ/wpapers.html

Osborn, A. 1953. *Applied Imagination: The Principles and Procedures of Creative Thinking*. Charles Scribner's Sons, New York.

Rotwell, R. (1989). Small firms, innovation and industrial change. *Small Business Economics*, 1. 51-64.

Silverman, D. (2006). *Interpreting Qualitative Research*. SAGE Publications, London.

Verhees, F. J. (2005). *Market-Oriented Product Innovation in Small Firms*. Dissertation. Wageningen University, Wageningen, The Netherlands.

Vossen, R. W. (1998). Relative strengths and weaknesses of small firms in innovation, *International Small Business Journal*, 16, 3, 88-94.

Welsh, J. A. and White, J. F. (1981) A Small Business is not a Little Big Business, *Harvard Business Review*, 59(4): 18–32.

Westhead, P., Storey, D. (1996). Management training and small firm performance: Why is the link so weak?, *International Small Business Journa*l 14 (4), 13

Yin, R. K. (2003). *Case Study Research: Design and Methods (3rd ed.)*. SAGE Publications Ltd., London.

Paper C

Design Processes and Novelty in Small Companies: A Multiple Case Study

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DESIGN PROCESSES AND NOVELTY IN SMALL COMPANIES: A MULTIPLE CASE STUDY

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ABSTRACT
This study explores the design processes in small established companies and investigates how these design processes are executed. How two different kinds of novelty influence the design processes is further examined: the relative novelty of the product being developed and the relative novelty of design processes. The relative novelty of the product is high if it is a radically new product to develop. High relative novelty for design processes typically means no experience or knowledge about design processes. Based on an embedded multiple case study of three small established companies in Sweden, eight different design processes are described and analyzed. The results show that the design processes differ, even within the same company. The results also show that relative novelty affects the design process. If the relative novelty of both the product to be developed and of design processes is low, a linear, structured, and systematic design process was found to work. A design process that is cyclical, experimental, and knowledge-creating seems to work no matter the relative novelty.

Keywords: Design process, small companies, novelty, product innovation engineering

1 INTRODUCTION
Most literature in new product development and design is derived from research on large companies [1, 2, 3] and its relevance for smaller companies is doubtful due to small and large companies' different economic and technical environments [4]. Design processes are a poorly researched area in small established companies [1, 5, 6], as is the impact of novelty aspects on the same design processes. This lack of knowledge justifies this explorative study on small established companies´ design processes.

1.1 Purpose
The purpose of this study is to expand knowledge of design processes in small established companies by empirically analyzing them within the companies' new product development processes. The explorative research questions are:

- *How do small established companies execute their design processes within their new product development activities?*
- *How do the relative novelty of the product being developed and the relative novelty of design processes to the designers and others involved affect the design process?*

2 FRAME OF REFERENCE

2.1 Some characteristics of design processes and design process models
This study sees the design process as a part of the new product development process and uses a generic design process model by Cross [7] as model of reference. The model is depicted in Figure 1 below.

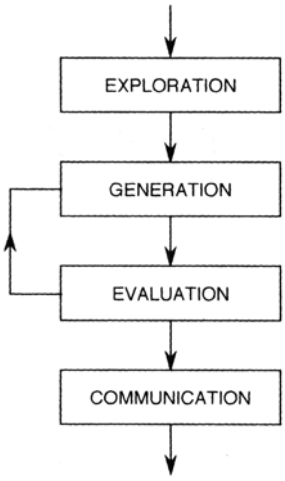

Figure 1. A four-stage model of the design process [7].

The design process model by Cross [7] has four stages. Stage one consists of exploring the design problem. A design problem can be vague, messy, fuzzy, incomplete, inconsistent, and even imaginary in places [7, 8], and must be explored and defined more clearly before it can be solved. Stage two consists of the generation of possible solutions to the design problem, when different solutions are created and the solution space is explored. In stage three the evaluation of the solutions is conducted, aimed at finding the best overall solution that solves the design problem. The final and fourth stage is about the description of the final design for communication of the result, to incorpoate it in the later parts of the new product development process. Iteration is common in design processes; an iteration loop is present between the evaluation and generation stage. The design process model is quite linear because all exploration of the design problem is completed before the generation and evaluation of different solutions to the design problem.

A point that distinguishes different models of the design process is that the models can be linear or cyclical [2] with iterative loops of learning experiments. In more linear design process models, most of the analysis of the design problem is done prior to the generation and evaluation of different solutions. In more cyclical design process models, the analysis is not completed prior to the generation and evaluation of solutions; rather analysis, generation, and evaluation are done after each other in cyclical loops. Linear design process models are suitable if the product to develop is incremental, the design problem to solve is well-defined, and the product's characteristics and properties are well-known in advance. Cyclical models are suitable if the product to be developed is radically new, with an ill-defined design problem and more unknown characteristics and properties [2]. The cyclical part is a knowledge-creating process in which different solutions are generated and tested on the largely unknown design problem to gain more knowledge of the product to be realized. Linear and formalized design processes can be counterproductive and unsuitable due to the need for flexibility when high uncertainty is present, as the case normally is in the development of radically new products [9, 10].

Tidd and Bodley [11] examined how project novelty (i.e., the novelty of the product to be developed) influenced the new product development process. The novelty is the relative novelty, in practice the novelty experienced by the designers and others involved in the new product development process. Tidd and Bodley [11] found that companies had different new product development processes within the same companies, and used different methods and tools depending on the relative novelty of the development project. For projects with high relative novelty, some methods and approaches were seen as more useful and more commonly used, such as focus groups; customer cooperation, involvement, and development; market experimentation; prototyping; heavy-weight project managers and cross-functional teams; marketing; and R&D involvement. Most of these methods and approaches are used to facilitate and increase interaction and communication with the market, customers, and users. Indirectly this means that good contact and communication with the market, customer and users are needed in more radical new product development activities. If the relative novelty of the product to develop is high, it becomes hard to rationally plan the design process in a linear manner, because the goal of the process, the product, is so ill-defined and fuzzy [2, 12, 9]. What can be perceived as highly

novel for one company can be routine for another company; with increased experience developing a certain product the relative novelty will decrease [11]. High relative novelty of the product to be developed can mean no experience or knowledge of similar products or the context the product will work in, abstract and ill-defined properties and characteristics, and a highly complex and large design problem. The relative novelty of the product is probably the highest the first time a certain product is designed by a company.

Although not investigated by Tidd and Bodley, it seems interesting to examine whether the novelty of design processes to the designers and others involved has an impact on the design process. Design processes are risky, highly complex, and difficult [11], and for a new and inexperienced designer they can be hard to manage and execute. It is probable that the relative novelty of the product and the relative novelty of the design process are connected. Designing an ill-defined and complex product with a large design problem probably represents an extensive and complex design process, which will probably increase the relative novelty for that process. It is reasonable to expect the relative novelty of design processes to decrease with increased experience and knowledge about design processes.

2.2 Small companies and design processes

This study looks at small established companies in non-high-tech businesses with less than 50 employees. What is meant with the word *established* is that the companies are not in their start-up process, have been established within their markets for several years, and have developed their own products that they sell. The companies also have their own new product development and design activities that are mainly run in house, with the companies' own resources. These small companies often have scarce resources [13-15], flat organization and are often working in a turbulent organization [6] within a highly uncertain environment [16, 17]. Other common characteristics are flexibility, fast, and informal communication, low bureaucracy, and rapid decision-making [18-20]. Small companies are often close to their customers and users [14, 21].

Design processes in small companies are a poorly researched area; studies have mostly been done on a managerial level [1, 5, 6]. Exceptions to this are studies done by Guimarães et al. [22] and Larsson [1]. Both found that the design processes in small companies were informal, unstructured, and without formal control. The small companies used their own informal design methods and their use of formal methods was limited, with the exception of prototyping and sketching. The owner/manager was usually involved, together with other employees, and often the owner/manager was the creative engine. The use of external expertise was rare; knowledge needed in the process was mainly gained from suppliers or other small company owners/managers. The small companies were close to their customers and feedback from customer and users during the design processes and afterward was common and extensive. Previous experience and common sense were used in the design processes; lack of knowledge and resources necessitated improvising and creativity in the use of existing knowledge and resources. The design processes were highly search-oriented, dynamic, and iterative, with cyclical loops. Larsson [1] alone found concurrent design activities with early attention paid to economic, manufacturing, and marketing aspects. Commitment to design activities was often combined with marketing activities. Tacit knowledge and intuition were also found to be important in the design processes. Small companies often lack the qualifications and resources for a methodologically systematic design process [23].

3 METHODOLOGY

Design processes are often complex and have unclear boundaries [7]. A qualitative, embedded multi-case study approach was chosen because it allows the researcher to understand the studied phenomenon and its context in more depth [24].

3.1 Sample Selection

Small established companies with their own products and design activities were recruited for this study. Three small established companies in Sweden that fulfill these criteria were studied. These companies were chosen to represent the range in the number of new or improved products launched. The number of new or improved products launched presumably indicates the existence of a working design process that fosters new products. One of the companies, a software developing company, can

be considered a technology-based service company, which may be seen as an odd one to include when design is frequently equated with engineering [25], which traditionally deals with the design of physical artifacts. But research into design processes in service development firms shows that service companies' design processes are quite similar both in content and theory [26–28]. Moultrie et al. [6] claim that design processes can be applied to all kinds of creative processes, and Ullman [29] explicitly states that design methodology is directly applicable to software design processes. Some differences between design problems do appear when considering design in software and in physical artifacts. Ullman [29] states that all design problems are ill-defined, which means that the information needed for solving the problem is initially missing and must be filled in to understand the problem. Design problems in software design are better structured and defined than most other design problems due to the constraints of language and systems [8]. Design problems in software development are also relatively free from issues relating to purchasing, production, materials, logistics, and distribution, all of which are normally much more important in the design of physical artifacts. Table 1 displays some of the characteristics of the three companies in the study.

Table 1. Some Characteristics of the Three Companies in the Study

Characteristics	**Company 1**	**Company 2**	**Company 3**
Firm Type	B2B Manufacturer	B2B Software	B2B and B2C Manufacturer
Products	Technical floors	Booking systems for tourism industry	Small wood refinement machines
Number of New or Improved Products Launched per Year	Approximately one small improvement of an existing product	Several improvements of an existing product	Several new or improved products
Employees	23	9	25
Customers	One big, many small	Many small	Many small
People Executing the Design Processes	2	6	3
Leadership, Strategy and Resources Committed to New Product Development	Unclear leadership and strategy. Few resources for NPD	Clear leadership and strategy. Resources committed to NPD	Clear leadership and strategy. Many resources committed to NPD
Organization that Suits and Supports NPD	Poor delegation of power, low communication and creative climate	Delegation of power and authority. Intense internal communication and highly creative climate	Delegation of power and authority. Intense internal communication and highly creative climate
Proactive Linkages between NPD Activities and Internal and External Actors	No, only reactive to customer requests. Poor linkages between NPD activities and other actors	Proactive and reactive. Many different linkages to internal and external actors, with intense communication	Proactive and reactive. Many different linkages to internal and external actors, with intense communication

3.2 Observations and interviews

The design activities and their context were observed in companies 1 and 2 four days a week over a period of five months and documented in field diaries. Usually many activities were going on simultaneously at the companies, so design activities were often put aside for more urgent business. A lot of the research time at the companies consisted of waiting for the design activities to occur, but this waiting approach made it possible to study design activities when they occurred naturally in their natural environment. Tacit knowledge [30] of the design processes could be captured with this approach.

Semi-structured interviews were also carried out with persons involved in or related to the design activities within companies 1 and 2. In Company 1 five interviews were conducted, in Company 2, six interviews. In addition to these interviews many new product development and design subjects were discussed informally with the persons interviewed and others at the companies or in the companies'

contexts. Field notes were used during the interviews. In an attempt to recollect as much as possible, the data was analyzed within a 24-hour period. Important questions and issues that arose in earlier interviews were asked in later interviews. The answers given during the interviews were cross-checked in the observations done.

Company 3 had a substantial amount of secondary data available about the company and its design activities. Examples of these secondary data were brochures, newspaper articles, the company's own newspaper, extensive website information and different manuals. Neither Company 1 nor 2 had much secondary data. Secondary data from small companies is often rare or unavailable [31]. This secondary data from Company 3 made it possible to get a good understanding of their design processes. The studies of companies 1 and 2 were performed prior to the study of Company 3. Later a visit was paid to Company 3 with a two-and-a-half-hour semi-structured interview with the product development manager, a 15-minute informal meeting with the manager/owner/founder of the company, and a short guided walk around the company premises. The findings from the studies already conducted of companies 1 and 2 made it possible to fine-tune questions and to focus more upon the most relevant and interesting areas in small company design processes.

4 FINDINGS

Each case study is described below with the design processes found.

4.1 The design processes in Company 1

The development and design of new products is rare in Company 1, although they have plenty of good ideas for new product development. New products launched are merely incremental variants of existing products that are requested by the largest customer. There are doubts about how to execute design processes in the company. Three different design processes could be observed: the *realized small modification design process*, the *unrealized small attempts design process*, and the *large new product design process*.

4.1.1 The realized small modification design process

This design process is informal and done by the product development manager. In this design process smaller modifications are made to the company's existing products. It is a kind of trial and error approach, where existing designs are manipulated with experience in mind and then tested to see whether they still work. The relatively novelty of the product is low when seen from the designers' point of view, but the relative novelty for design processes is high due to the product development manager's limited experience and knowledge about design processes. Usually the design problem to be solved is somewhat fuzzy and ill-defined but not so complex. To examine the design problem sketches are done and needed knowledge is collected informally with contacts within the company and with the customer. Geometry, assembly, and strength studies of existing designs and informal sketches of some new design proposals are then done, and a first virtual proposal is designed in a 3D CAD program, with the help of an external consultant. Rendered pictures of the new design are then shown to the customer at a fine-tuning meeting. If the customer is pleased with the design and thinks it will work, design drawings are done and a prototype is built and tested in an external research institute. If the customer is not pleased, a new proposal is designed, and so on in a cyclical manner. If a customer-approved prototype passes the test, the new product is manufactured and assembled and later sent and installed at the customer's location. If the design does not pass the test, it is modified and tested again in a cyclical manner. In relation to the design process model of reference by Cross [7], exploration, generation, and evaluation are done in a cyclical way when the parts contain different contents, activities, and actors. The communication stage is present when a working prototype is finished.

4.1.2 The unrealized small attempts design process

Company 1 sometimes makes smaller attempts to develop new products that usually do not go through the whole design process and become realized. These small attempts consist of informal sessions when the actors, such as the product development manager, other managers, employees and external experts in the company's external network, meet and discuss different development ideas. This work can be described as a cyclic and iterative process of analysis, synthesis, and evaluation, aiming at understanding the design problem and finding different solutions to the problem. Informal sketching is

common in this design process. The product ideas to develop usually have a high relative novelty, but the design process has a medium relative novelty and the way of working is quite natural for the participants. Difficulties arise when finishing the design process. These attempts often become shelved or abandoned due to scarce resources, difficulties in getting the right information, technical difficulties and uncertainties, and/or disturbance from other more urgent activities in the company. There is not always a customer to buy the potential new product in the end and that can contribute to a decrease in motivation to finish the design process if difficulties and uncertainties occur. In relation to Cross's generic design process model [7], this design process is more cyclic when exploration, generation, and evaluation are done in cyclical loops. The communication stage is not present because the ideas are usually not realized.

4.1.3 The large new product design process

Upon request from the largest customer, Company 1 tried to develop a completely new version of one of their existing products. A specification of the new product was done by the customer but it was poor and ill-defined in several areas and unrealistic in others. To execute this design process the company tried a systematic, linear approach that they had never tried before. A formal project plan of the design work was created and time, resources, goals, and activities were specified and planned in time, but in reality this plan was never followed and the way of executing the design process slipped over to a more cyclical approach. Resources allotted to the project were scarce and day-to-day activities in the company stole time and resources from the project. The relative novelty of the product to develop was high and the relative novelty of a systematic, linear design process to those involved was also high, because there was no history, experience, or deeper knowledge of systematic design work in the company. Internal communication and external communication with the customer were also low during the process. The design problem to be solved was never analyzed properly and the work was quickly reduced to finding a solution to a design problem only partially known. Jonassen [8] concludes that the most important key to problem solving is to construct the design problem, which was not done. Alternative solutions were not investigated properly and one solution inspired by a competitor product was developed and designed in detail. This solution was later criticized and abandoned because it was not more flexible and not cheaper than their current product. No more design work was done on the project and the result was wasted time and resources and unsatisfied team members. The initial planned, systematic, and linear design process was quite similar to Cross's generic design process model [7], but that changed to a way of working that consisted of exploration, generation, and evaluation in a more cyclic way that was more natural for those involved. The communication stage was not present because the project was abandoned.

4.2 The design processes in Company 2

Company 2 practices both formal and their own informal methods to execute their design processes. The company is well skilled in project management and planning. The design problems to be solved by the company are quite limited and structured. This, together with their familiarity with the domain, experience with similar design problems, and extensive knowledge about and communication with their customers and users, all contribute to the company planning the design work and executing it in a systematic and linear way. They can accurately determine in advance the final product's characteristics and properties, which make the novelty low for the products being designed. Those executing the design processes are also well skilled and educated in systematic approaches. The company's extensive experience in design processes makes the relative novelty of design processes low. The company has three different design processes: the *small standard design process*, the *customer-specific design process*, and the *large standard design process*.

4.2.1 The small standard design process

In the *small standard design process* the relative novelty is low both for design processes and for the product to be developed. The products are usually small, relatively uncomplicated upgrades to the main software product. The design problems are well defined, structured and not so complex, and they do not need extensive analysis. The exploration of the design problem is done by informal talk with others in the company and/or phone contact with customers and users that experienced the problem to be solved. The generation, in this case the programming, is done more directly and the code often becomes untidy. The new code is evaluated by the company before it is communicated and

implemented in the main software product. This design process is usually done by one or maybe two employees. The design process is similar to Cross's generic design process model [7] and is quite linear, with some iteration between the evaluation and generation stages.

4.2.2 The customer-specific design process

The *customer-specific design process* is used for larger development projects that aim at solving a specific customer's problem or need. The design process starts with a formal analysis phase. This analysis phase is usually done in close interaction with the customer to get the right specifications for the project. It is common that this work is done at the customer's location with the customer in the real environment for the new product. Design work can even be done by the customer. Later all requirements for the new product are gathered in a specification and a project document with planned activities that all involved must approve. The synthesis starts with an abstract analysis of the design problem, where the overall structure and function and sub-functions are investigated and the connections are analyzed and described. Visualization and abstraction are commonly used methods. This work is later followed by detailed programming of the sub-functions that solve the abstract design problem. Interface and usability aspects are handled in an ad hoc way during the programming. Prototypes and mock-ups are commonly used for testing concepts and solutions and to get feedback and ideas from others at the company, as well as the customer and users. The product developed is later tested in several steps. The code is tested by the company and the functions are tested both by the company and the ordering customer. When satisfactory, the product is delivered to the customer. The design process is similar to Cross's generic design process model [7] and is quite linear, with some iteration between the evaluation and generation stages.

4.2.3 The large standard design process

The *large standard design process* is used for large development projects that can take several years. One design process of this kind aims at improving the interface of the main software product. Extensive planning and specification activities and some synthesis activities have been done in this project so far. Annual customer and user meetings are held to get feedback and ideas about the project. Overall this design process includes all activities, aspects, and characteristics of the *customer-specific design process*, with the exception of its size and time horizon. The design process is similar to Cross's generic design process model [7] and is quite linear, with some iteration between the evaluation and generation stages until the design problem is solved.

4.3 The design processes in Company 3

Company 3 has an official description of how they work with their design processes, but no distinct design process model. Most activities in Company 3 concern marketing and new product development; all production and almost all assembly are outsourced. The company has a strong tradition of, and applies considerable resources to, new product development and design. The relative novelty of design processes is low due to the designers' great experience with designing products. The relative novelty for the products to be developed is usually high because the final properties and characteristics of the products often are fuzzy and unclear. The design activities are not formally planned and several design processes are usually executed concurrently in a somewhat chaotic manner within certain frames and constraints. These frames and constraints can be seen as a general and abstract specification of properties and characteristics that all products developed by the company should fulfill, but that can be questioned if good reasons exist. The company's contact with customers and users is intense, friendly, and close. Two different design processes could be identified: the *open experimental design process within certain constraints* and the *lead user design process.*

4.3.1 The open experimental design process within certain constraints

Most of the work with this design process is done by the new product development manager and one engineer. Sometimes the owner/manager also contributes. The design process is open; customers, users, employees, external experts, manufacturers, and others are free to take a look and contribute ideas and feedback on the design process, and they do take advantage of this freedom. The company actively searches for feedback during the design process, because they value the different knowledge and way of thinking each person brings. Marketing, in this case *relation marketing* [32] with existing customers and users, is closely related to this design process. The company finds it hard to evaluate

their ideas without developing them further. The usual approach is to run many design projects concurrently and develop the projects as far as is feasible in order to evaluate them properly. Approximately one-fourth of all projects survives and become new products.

This design process usually has a fuzzy and unclear starting point. It typically starts with sessions of sketching to externalize the ideas and to communicate and examine the design problem and possible solutions. This is usually done by the product development manager. Function and form are concurrently developed during these sessions. The solutions are a mix of rough overall solutions and more detailed sub-solutions. There is early consideration of production, economic, logistics, and marketing issues. Between the sessions there is an incubation time, when totally different work is performed. Paper models, mock-ups and simple prototypes are built to evaluate ideas and solutions. Later a working prototype is built to see if the final concept works. The working prototype is the basis for the later stages of the new product development process.

In relation to Cross's generic design process model [7], this design process is cyclic with iterative loops of exploration, generation, and evaluation. Different solutions are tested on the ill-defined design problem and evaluated with customer and user feedback to gain new knowledge about the problem in order to generate more solutions to test, and so on. This approach brings the overall design process forward, due to the design problem and solution space being explored. The communication stage is present when a working prototype is finished. The company does not want to work in a more structured manner because it would decrease their flexibility. A more linear, structured, and systematic way of working would also not fit with their close, unstructured, and flexible customer and user interaction. Extensive external feedback, past knowledge, new knowledge, constraints and intuition all keep the design processes on track in the right directions.

4.3.2 The lead user design process

The company has many lead users [33] that modify and develop the company's products on their own. The customer and users are free to come and visit the company whenever they want to; they do so and show their inventions to the company and give them away for free. How the lead users execute their design processes when developing their inventions is not covered in this study but if the company believes in the lead user invention they adopt it, which gives them the solution for an identified user problem for free and saves design work. The company usually cannot adopt a lead user invention directly without modifying or adjusting it so it will fit within the company's frames and constraints. In relation to Cross's generic design process model [7], the design processes done by customers and users are unknown, but if the company adopts a lead user invention a cyclical design process starts that is similar to the *open experimental design process within certain constraints*. The communication stage is present when a working prototype is finished.

5 DISCUSSION

5.1 The design processes on a generic level

The design processes examined differ considerably due to the different products and contexts. On a generic level, the model of reference, Cross's generic design process model [7], mirrored the more linear design processes of Company 2. The processes were more linear because most exploration and analysis of the design problem was done before the generation and evaluation of different solutions. Companies 1 and 3 had more cyclical design processes similar to the small company design processes described in the studies by Guimarães et al. [22] and Larsson [1]. Most of the analysis of the design problem was not done before the generation of solutions but rather in several steps in the cyclical iterative loops of exploration, generation and evaluation. This cyclical process would be more accurately captured by Cross's design process model [7] if an extra feedback loop were added between the evaluation and exploration parts, as depicted in the left part of Figure 2 below.

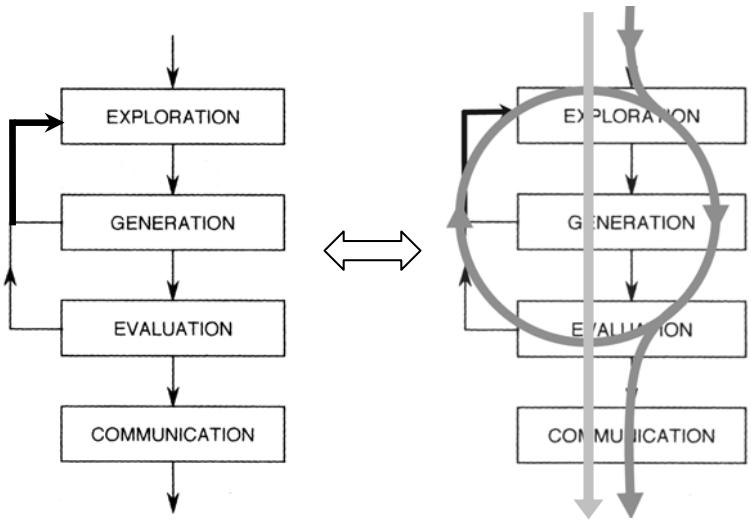

Figure 2. A modified four-stage model of the design process.

The modified generic design process model above manages to mirror all design processes in this study on a generic level, because design processes can be both linear and cyclical in the model, as shown in the right part of Figure 2.

5.2 The relative novelty of the design processes

Tidd and Bodley [11] concluded that (a) the project novelty (i.e., the novelty of the product to be developed) influenced the new product development process and (b) increased market, customer, and user communication were more important when the relative project novelty was high. Both of these conclusions were the case in this study too, but an unexpected finding was that extensive market, customer, and user interaction were also present in design processes when there was low relative novelty. The examined companies' natural and close relations with their customers and users, as well as the turbulent and uncertain environment, could be the explaining factors for this. A turbulent and uncertain environment is common for small companies [16, 17]. It is possible that this extra uncertainty affects the design process and adds extra relative novelty to the design processes, making closer contact and communication with the market, customer, and users needed in the design processes with the least relative novelty as well.

The relative novelty of design processes was also examined in this study. The matrix in Figure 3 shows the different design processes mapped against the relative novelty of the product to be developed and the relative novelty of design processes. Unfinished design processes are marked with a white dot and realized design processes with a grey dot.

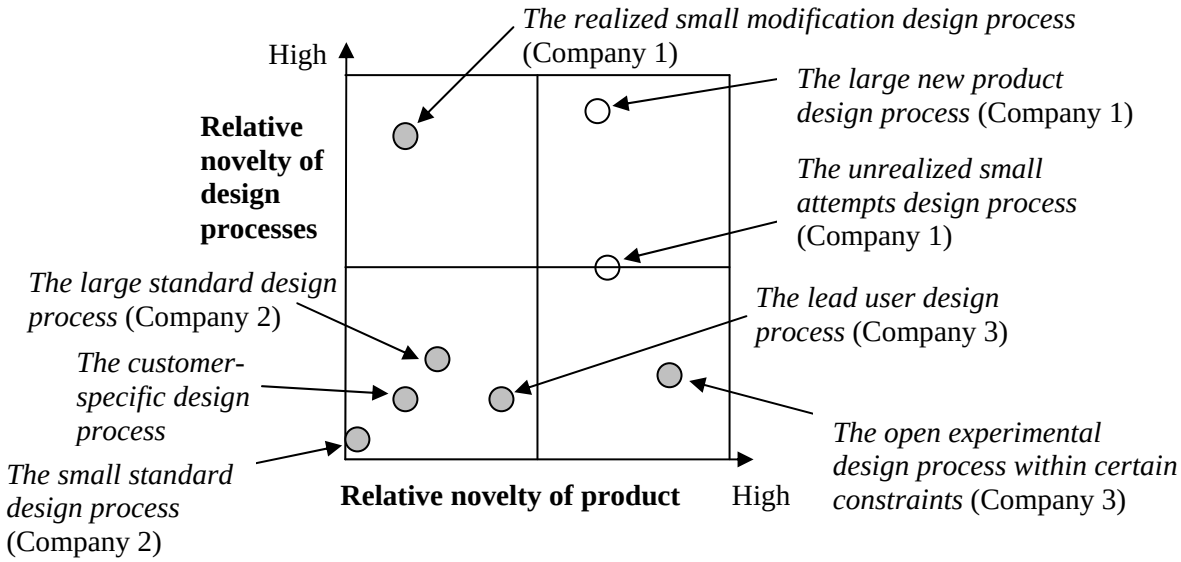

Figure 3. The relative novelty of the product and design processes.

Note that the three examined companies have design processes in all fields of the matrix and that in the most novel part of the matrix the design processes were discontinued. This indicates the difficulty of managing and executing design processes with high relative novelty. A more cyclical, experimental, and knowledge-creating design process was used when either (or both) the relative novelty of the product to develop or the relative novelty for design processes was high. If the relative novelty of both kinds was low, both cyclical, experimental, and knowledge-creating design processes and linear, systematic, and structured design processes were used.

Companies 2 and 3, which execute many design processes, were also best at performing their design processes, in the sense of launching the most new products. They had experience and knowledge about design processes that lowered their relative novelty. In Company 1 there were doubts about how to execute design processes and the relative novelty for design processes was high. Only in the products that were least novel to develop were the design processes finished (the *realized small modification design process*). Company 1 seems to lack the experience and knowledge needed to manage to design new products with a high relative novelty; they probably need to train and learn more to accomplish that. To clarify, all design processes and products being designed at Company 2 were low in relative novelty. The relative novelty only increased with the size of the design problem. Company 3 manages to design highly novel products because of their great experience and knowledge about design processes. In the *lead user design process* the relatively novelty of the product to be developed is lower than in the *open experimental design process within certain constraints*, because when the lead users present their inventions for the company the company will see and understand most of the characteristics and properties of the product to be developed. In other words, they will know with high certainty what the product will be in the end, and that lowers the relative novelty.

5.3 Structured, systematic, and formal design processes and small companies

According to Larsson [1] there is an upper limit of about 25 employees before a manufacturing company must begin to add structure to different processes. With increased company size it becomes more difficult to coordinate, communicate, control, and manage different activities and processes within the company. Companies 1 and 3 are manufacturing companies with about 25 employees each, at Larsson's [1] limit for increased structure. In Company 3 the informal structure of the design processes consists of the overall constraints and frames that all the companies' products should fulfil. Company 3 does not want more structure within their design processes because of a perceived decrease in needed flexibility. Company 3's customers and users are an important and fairly large constituent in the design processes, and the interaction with them is informal, unstructured, and uncoordinated. If Company 3 tried to formalize and structure the design work more, it would be unrealistic to expect them to formalize and add structure to the interaction with their market, customers, and users. The forces controlling the design processes in Company 3 are the extensive external feedback from the market, customers and users in combination with the employees' great experience and knowledge of design processes. In Company 2 the same mechanisms control the design processes in addition to the project planning. An extensive push for external feedback from the market, customers, and users during the design processes in small companies was found by Larsson [1], Guimarães et al. [22] and Moultrie et al. [5] and seems to be an efficient way to gain extra resources and to steer and control the design processes in small companies. It is reasonable to assume that Company 3 has found a good balance between control, coordination, formality, experimentation, and flexibility in their design processes.

It may be harder to say something about the structure need for Company 1 design processes, because of their lack of experience and knowledge of design processes. In the *large new product design process*, it is clear that when a formal, linear, systematic, and structured design process was tried, it was less successful. A more flexible, informal, cyclical design process turned out to be more natural for those involved. Although the result of this process was unsatisfactory, the first formal, linear, and structured approach cannot be blamed alone; even Herstatt and Verworn [9] state that a linear and formalized design approach might be counterproductive and unsuitable if high uncertainty is present, which was the case when the relative novelty was high. The scarce and insufficient resources for the project are another explanation, as was the poor communication and feedback from the market, customers, and users during the project. It is also possible that the frequent lack of structure and

coordination in Company 1's other activities and processes created difficulties for interaction with a structured and systematic design process. That design processes in small companies interact with other processes in the company is common [3, 34, 35]. In Company 1's *realized small modification design process*, a cyclical, informal, experimental, and knowledge-creating approach was used that was more successful and natural for those involved. The relative novelty of the product to develop was low due to a modest and limited design problem. The relative novelty of design processes was higher but could be managed because of the limited design problem. There was some contact with the customer during this design process and the feedback contributed to the successful result. The *unrealized small attempts design process* in Company 1 was also executed in a cyclic, experimental, and knowledge-creating way by employees at the company and other invited external experts, but the design processes were usually not finished.

Company 2's linear, structured and systematic design approach did not work well in Company 1's large new product design process. What distinguishes Company 2's design processes from *the large new product design process* in Company 1 is that the design problems were well structured and better defined, as is typical in software design [8], and the relative novelty was low both for the products to be developed and for the design processes. What can be said from the *realized small modification design process* in Company 1 and Company 3's design processes is that a cyclic, experimental, and knowledge-creating design process worked and was quite natural for the employees involved if there was contact, communication, interaction, and feedback from customers and users. From examining Company 2's design processes we can conclude that a linear, structured, and systematic design process is working if the relative novelty is low for both the product to develop and design processes and when there is contact, communication, interaction, and feedback from the market, customers, and users.

Combining these observations, this study shows that contact, communication, interaction and feedback from the market, customers and users are crucial for small companies during all their design processes. Yet it is still reasonable to assume as Tidd and Bodley [11] found that more communication is needed and the need increases as relative novelty increases. The study also shows that increased experience and knowledge about design processes decreased the relative novelty of the design process for the actors involved. Another interesting thing is that either a cyclical, experimental, and knowledge-creating design process or a linear, structured, and systematic design process can work well if the relative novelty for the product to develop and the relative novelty of design processes are both low. Modifying Figure 3 above to depict the different kinds of design processes, we obtain a picture of the approaches in the design processes of small established companies (Figure 4).

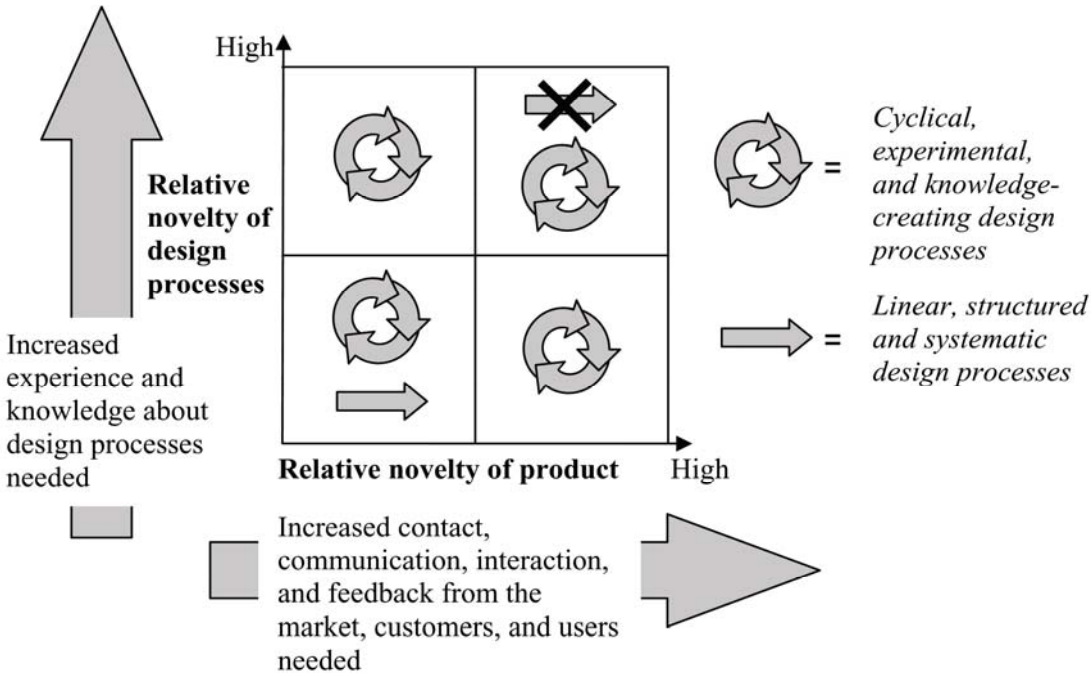

Figure 4. Design processes in small companies in relation to relative novelty.

6 CONCLUSIONS AND FURTHER RESEARCH

The findings show that small established companies have different design processes even within the same company. All design processes examined included exploration, generation, and evaluation stages, executed either in a linear or a cyclical manner. The communication stage was only present in realized design processes. The generic design process model of reference by Cross [7] was found valid in the more linear design processes. If the model of reference is slightly modified with an extra feedback loop it manages to mirror all realized design processes in the study on a generic level.

If the relative novelty of design processes and the product to be developed is low for those involved in the design processes, a linear, structured, and systematic design process was found to work. The same design process was found not to work if both examined novelties were high and there was poor external communication, interaction, and feedback from the market, customers, and users. A cyclical, experimental, and knowledge-creating design process was found to work if the relative novelty of design processes and/or the product to develop was high for those involved in the design processes, but this cyclical approach also worked when both the examined relative novelties were low.

Interaction with the market, customers, and users was found to be a crucial activity in all design processes examined. Customers and users seem to have several important functions in the small companies' design processes. They give feedback during the design processes that helps to steer and control the process, and they do actual design work either with the companies or on their own that they then give away for free to the companies.

Further research could consist of taking a closer look at the concept of relative novelty, examining its content in more detail, and determining how its details influence the design process. Another interesting topic would be to take a closer look at the formal and informal design methods that are used within the design processes described above.

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REFERENCES

[1] Larsson, G. (2001). Designprocessen i fyra småföretag: att arbeta med känsla och intuition. Licentiate thesis. Luleå University, Luleå, Sweden.
[2] O'Shea, A. & McBain, N. (1999). The process of innovation in small manufacturing firms. *International Journal of Technology Management*, 18 (5-8), 610–626.
[3] Tidd, J., Bessant, J. & Pavitt, K. (2005). *Managing Innovation – Integrating Technological, Market and Organizational Change* (3rd ed.). Chichester, UK: John Wiley & Sons Ltd.
[4] Audretsch, D. B. (2001). Research issues relation to structure, competition and performance of small technology-based firms. *Small Business Economics* 16(1): 37–51.
[5] Moultrie, J., Clarkson, J. P. & Probert, D. (2006). A tool to evaluate design performance in SMEs. *International Journal of Productivity and Performance Management*, 55(3/4): 184–216.
[6] Moultrie, J., Clarkson, J. P. & Probert, D. (2007). Development of a design audit tool for SMEs. *The Journal of Product Innovation Management*, 24(4): 335–68.
[7] Cross, N. (2008). *Engineering Design Methods: Strategies for Product Design* (4th ed.). Chichester, UK: John Wiley & Sons.
[8] Jonassen, D. H. (2000). Toward a design theory of problem solving. *Educational Technology, Research and Development*, 48(4): 63–85.
[9] Herstatt, C. & Verworn, B. (2001). *The "Fuzzy Front End" of Innovation*. Working Paper No. 4, Department of Technology and Innovation Management, Technical University of Hamburg.
[10] Lynn, G. S. & Akgun, A. E. (1998). Innovation strategies under uncertainty: A contingency approach for new product development. *Engineering Management Journal* 10(3): 11–17.
[11] Tidd, J. & Bodley, K. (2002). The influence of project novelty on the new product development process, *R&D Management* 32(2): 127–138.

[12] Karlson, B. (1994). Product design: Towards a new conceptualization of the design process. Dissertation. Stockholm: The Royal Institute of Technology.
[13] Rothwell, R (1989). Small firms, innovation and industrial change. *Small Business Economics*, 1: 51–64.
[14] Rothwell, R. & Dodgson, M. (1994). Innovation and size of firm. In Rothwell, R. & Dodgson, M. (Eds.),*The Handbook of Industrial Innovation* (pp. 310–324). Northampton, MA: Edward Elgar Publishing Limited.
[15] Welsh, J. A. & White, J. F. (1981). A small business is not a little big business. *Harvard Business Review*, 59(4): 18–32.
[16] Ratcliffe-Martin, V. & Sackett, P. (2001). Information and small companies: Chaos with intent. *AI & Society*, 15(1-2): 22–39.
[17] Westhead, P. & Storey, D. (1996). Management training and small firm performance: Why is the link so weak? *International Small Business Journal*, 14(4): 13.
[18] Adams, A. (1982). Barriers to product innovation in small firms: Policy implications. *International Small Business Journal*, 1(1): 67–86.
[19] Cannon, T. (1985). Innovation, creativity and small firm organisation. *International Small Business Journal*, 4(1): 33–41.
[20] Vossen, R. W. (1998). Relative strengths and weaknesses of small firms in innovation. *International Small Business Journal*, 16(3): 88–94.
[21] Schmidt-Kretschmer, M., Gericke, K. & Blessing, L. (2007). *Managing requirements or being managed by requirements – Results of an empirical study*. Proceedings of the International Conference on Engineering Design, ICED 2007, August 28–31, 2007, Paris.
[22] Guimarães, L., Penny, J. & Stanley, M. (1996). Product design and social needs: The case of northeast Brazil. *International Journal of Technology Management*, 12(7/8): 849–86.
[23] Franke, H. J., Löffler, S. & Deimel, M. (2003). *The Database "Methodos" Assists an Effective Application of Design Methods*. Proceedings of the International Conference on Engineering Design, ICED 2003, August 19-21, 2003, Stockholm.
[24] Yin, R. K. (2003). *Case Study Research: Design and Methods* (3rd ed.). London: SAGE Publications.
[25] Veryzer, R. (2005). The roles of marketing and industrial design in discontinuous new product development. *The Journal of Product Innovation Management*, 22: 22–41.
[26] Candi, M. (2007). The role of design in the development of technology-based services. *Design Studies*, 28(6): 559–83.
[27] Smith, A., Fischbacher, M. & Wilson, F. (2007). New service development: From panoramas to precision. *European Management Journal*, 25(5): 370–383.
[28] Berkley, B. J. (1996). Designing services with function analysis. *Hospitality Research Journal*, 20(1): 73–100.
[29] Ullman, D. G. (2002). *The Mechanical Design Process* (3rd ed.). New York: McGraw-Hill.
[30] Polanyi, M. (1967). *The Tacit Dimension.* London: Routledge.
[31] Davis, C., Hills, G. & LaForge, R. (1985). The marketing/small enterprise paradox: A research agenda. *International Small Business Journal*, 3, 31–42.
[32] Gummesson, E. (2002). *Total Relationship Marketing: Marketing Strategy Moving from the 4Ps – Product, Price, Promotion, Place – of Traditional Marketing Management to the 30Rs: The Thirty Relationships of a New Marketing Paradigm* (2nd ed.). Oxford: Butterworth-Heinemann.
[33] Hippel, E. von (1988). *The Sources of Innovation*. New York: Oxford University Press.
[34] Bodin, J. (2000). *Perpetual product development: A study of small technology-driven firms*. Dissertation. Umeå University, Umeå, Sweden.
[35] Pilemalm, J. (2002). Generating products in small and medium sized enterprises: Challenges and potential improvements. Licentiate dissertation. Stockholm: Royal Institute of Technology.

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