Thesis for the degree of Doctor of Philosophy

A revised perspective on Disruptive Innovation

– Exploring Value, Networks and Business models

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A REVISED PERSPECTIVE ON DISRUPTIVE INNOVATION

– EXPLORING VALUE, NETWORKS AND BUSINESS MODELS

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Abstract

The concept of disruptive innovation has received much attention in recent years. These innovations can be defined as offering an initially lower performance while at the same time bringing some new attributes to the market. This thesis aims to develop and extend existing theory on disruptive innovation with an emphasis on business models and value networks.

Previous work in this area has shown that incumbents are often toppled by entrants when disruptive innovations are introduced since these technologies are not initially demanded by the established firms' customers. Much attention has been devoted to how disruptive innovations emerge in low-end segments and in new markets. However, more knowledge is needed about whether and how they can prosper inside an incumbent firm's established market segment. Moreover, the challenges related to these innovations have increasingly been framed as related to the business model of firms, but little is known regarding how and why this is the case.

Drawing upon data from several case studies, the empirical findings in this dissertation suggest that disruptive innovations may prosper in a segment where incumbents are already present. They do so by compensating the lower traditional performance with some new ways of creating value, for instance by removing labor or changing activities inside the customer's organization. These findings in turn suggest that this theory needs to focus more on how different performance dimensions create value. Additionally, it is argued that a more nuanced conceptualization of customers and networks is needed. When regarding customers as a collection of actors with different competencies and incentives, it becomes clear that disruptive innovations are problematic even when a firm's existing customers demand them. These innovations may be incompatible with the different activities and incentives of some actors, which may result in a barrier to adoption. Disruptive innovation can therefore be regarded as a business model challenge in the sense that the new value creation and distribution distorts the firm's surrounding constellation of actors. Firms need to change their network, but struggle to do so since business models transcend their boundaries and they are therefore forced to act under conditions of interdependence.

Keywords: Disruptive innovation, discontinuous, business model, network, value, Hasselblad, Facit.

Appended papers

The thesis is based on the following papers, referred to by Roman numerals in the text.

Paper I

Sandström, C., Magnusson, M., and Jörnmark, J. (2009) Exploring factors influencing incumbents' response to disruptive innovation, *Creativity and Innovation Management*, Vol 18(1), pp. 8-15.

Paper II

Sandström, C. (2010). Hasselblad and the shift to digital imaging, forthcoming in *Annals of the History of Computing.*

Paper III

Sandström, C. (2010). High-end disruptive technologies with an inferior performance, forthcoming in *International Journal of Technology Management*.

Paper IV

Sandström, C., Magnusson, M. (2010). Value, Actors and Networks - A revised perspective on disruptive innovation, presented at the DIME conference *'Organizing for networked innovation'* in Milan, 14-16 April. Under review for publication in a special issue of *Industry & Innovation*.

Paper V

Sandström, C., Osborne, R. (2010). Managing business model renewal, forthcoming in *International Journal of Business and Systems Research*.

Paper VI

Magnusson, M., Sandström, C. (2010). Disruptive innovation as a business model challenge, *IMIT working paper 2010:142*. Submitted to Long Range Planning.

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Christian G. Sandström

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Contents

1. Introduction

"Individual innovations imply, by virtue of their nature, a "big" step and a "big" change. A railroad through new country, i.e., country not yet served by railroads, as soon as it gets into working order upsets all conditions of location, all cost calculations, all production functions within its radius of influence; and hardly any "ways of doing things" which have been optimal before remain so afterward."

Joseph Schumpeter (*1939, p. 101*)

Few people today dispute that innovation lies at the heart of economic development. Ever since Schumpeter wrote his book *The Theory of Economic Development* (1912, 1936), scholars have emphasized the importance of innovation as a driver of structural change and economic growth. Schumpeter (1942) argued that economic growth in a capitalist regime happens through *creative destruction*, a process where the old is continuously being destroyed and thereby freeing resources for the new.

The process of creative destruction has often caused insurmountable problems for established firms (Gilfillan, 1935). This phenomenon is almost as old as capitalism itself and there are many historical examples of how established firms encounter problems under conditions of discontinuous change. Few of the typewriter manufacturers survived the shift to personal computers, the shift from sailing ships to steam ships put incumbent firms in great trouble and the companies operating in the ice industry went out of business with the rise of fridges (Utterback, 1994). The shift from vacuum tube radios to transistor radios entailed great difficulties for established firms like RCA and created an innovative opportunity for entrants like Sony (Henderson and Clark, 1990). When minimill technology for steel production emerged in Northern Italy in the 1960s the large integrated steel mill manufacturers in France, Germany and Belgium encountered severe difficulties (Jörnmark, 1993).

Needless to say, there are many more examples of this pattern. Though technological discontinuities have had a great impact on changes in industrial leadership, discontinuities in general seem to cause problems for incumbents. Also, changes in the regulatory environment or the emergence of new business models have toppled former industry leaders (Chesbrough, 2003; Markides, 2006).

Many scholars have addressed this dilemma which is sometimes referred to as the "incumbent's curse" (Foster, 1986). For instance, Tushman and Anderson (1986) argued that discontinuities which render existing competencies obsolete tend to overthrow established firms. Henderson and Clark (1990) pointed at organizational impediments in order to explain changes in the competitive landscape.

This dissertation focuses on the phenomenon of disruptive innovation, which can be regarded as an important sub-set of discontinuous innovation. A disruptive innovation can be defined

as a technology which initially underperforms along performance dimensions that mainstream customers have historically valued, while at the same time bringing new performance attributes to the market (Govindarajan and Kopalle, 2006a). Theory on disruptive innovation has received a lot of interest from practitioners and scholars. However, more knowledge is still needed regarding how these innovations emerge and why they are problematic to handle. The aim of this thesis is to nuance and improve existing theory related to disruptive innovation, and in particular to describe and analyze the roles played by value networks and business models. More specifically, it seeks to answer the following research questions:

Research question 1: Can a disruptive innovation emerge in an established value network and if so, how can this be explained?

Research question 2: How and why is a disruptive innovation a business model challenge?

The thesis consists of six appended articles along with this covering paper. The covering paper starts with a review of the literature on discontinuous innovation, disruptive innovation and related bodies of literature. Towards the end of this section, the two research questions above are derived and justified. Section 3 provides a sketch of the methods that have been employed and also describes the research setting more generally. The fourth section contains a summary of the appended papers whereas the subsequent sections analyze these findings and seek to develop existing theory on disruptive innovation. The conclusions are presented in the seventh section and eventually, some managerial implications are provided.

2. Theories on discontinuous and disruptive innovation

This section contains a review of existing literature on discontinuous and disruptive innovation. The first part provides a more general overview of the field and the following sections go into more detail regarding disruptive innovation, value and networks. Some areas in need of further development are identified and explicated as two research questions towards the end.

2.1 Discontinuous Innovation

It is not the owner of stage-coaches who builds railways.

Joseph Schumpeter (1936, p. 66)

It is well documented today that established firms may encounter difficulties in the face of discontinuous innovations (Cooper and Schendel, 1976; Anderson and Tushman, 1990). A discontinuous innovation can be regarded as an innovation which creates a discrete and momentous shift related to a firm's competence base or network.[1] Such a shift can be created by new technologies, business models or regulatory changes.[2] A technological discontinuity can be defined as "a major technological change resulting in the creation of a substitute technology for a particular industry's products or processes" (Hamilton and Singh, 1992). The emergence and eventual domination of digital imaging as opposed to analog photography can serve as an illustrative example of a discontinuous innovation since it implied a momentous shift in the industry, for instance with regard to its competence base and the way that value is created.

Incumbent companies are usually good at innovation under steady, stable circumstances, but when technologies shift or new business models are introduced they can all of a sudden become vulnerable. Their attempts to develop significantly new technologies are often less productive than when entrant firms try to do so (Henderson, 1993). Frequently, established

[1] *Steady-state innovations* will throughout this thesis be thought of as the opposite of discontinuous innovations (Bessant, 2008). While the term continuous innovation is in some cases considered to be the opposite of discontinuous innovation, it has a different meaning for other scholars. For instance, Boer and Gertsen (2003) define continuous innovation with regard to the firm's "*ability to combine operational effectiveness and strategic flexibility - exploitation and exploration - capabilities that have traditionally been regarded as antithetical*" (p. 805). This stream of literature thus considers continuous innovation to be a capability of a firm rather than an attribute of certain innovations. In order to avoid confusion, the term steady-state innovation is regarded as the opposite of discontinuous innovation in this thesis.

[2] Sometimes, the term radical innovation is used in order to describe similar phenomena. Throughout this thesis, a radical innovation is rather associated with a significantly enhanced performance (Leifer et al., 2001). Such an innovation does not necessarily have to be discontinuous or disruptive; it might create a much greater performance without implying any discontinuities for the firm or its surrounding network.

firms fail to cope with these changes, they lose market shares and the successful firms are found among newcomers (Utterback, 1994)[3].

Dosi (1982) introduced the concepts of technology paradigm and technology trajectories in an attempt to describe continuous and discontinuous change. He identified a parallel to Kuhnian theories of development of new science. According to Dosi, technologies tend to evolve along certain trajectories and occasionally, these trajectories are punctuated by a discontinuous change that upsets the existing paradigm. Firms which have built their competencies around an existing paradigm are therefore likely to encounter problems when a new trajectory is introduced. It has also been argued that technological change is inherently path dependent (e.g. Rosenberg, 1972). For example, Clark (1985) observed that the early decisions by engineers in the automotive industry to develop the combustion engine instead of steam or electrical engines affected the decisions by the following generations of engineers. Hence, through path dependency, established firms become increasingly reliant on one particular technology and therefore also more vulnerable to changes in the underlying technology.

Dosi's argument was nuanced by Abernathy and Clark (1985) who argued that the discontinuity's impact can be understood in terms of to what extent it changes the existing competence and to what extent it disrupts established market linkages. In more general terms, literature on discontinuous innovation can therefore be classified as related to either the supply-side and a firm's existing resources and capabilities or the demand-side and its impact on the market and the surrounding environment.

Starting with the supply-side related literature, several explanations for why established firms struggle under conditions of discontinuous change have been presented. It has for instance been suggested that established firms build organizational structures, values, and processes over time that enable them to efficiently process information within the context of an existing technological paradigm. As firms grow large they tend to become more mechanistic organizations, i.e. more structured and hierarchical (Burns and Stalker, 1961). The same authors also noted that the appropriate organizational structures and management skills depend upon the kind of innovation that a firm aims to introduce. A shift towards a mechanistic organization often results in an improved efficiency, but may at the same time

[3] While the incumbent's curse has received a lot of attention, some scholars have argued that this dilemma may in fact be a bit exaggerated. Chandy and Tellis (2000) write: "*Events in which the mighty are humbled and the little guy finishes first are likely to be more eye-catching than are those in which the mighty remain mighty.… … Our research of innovations in the consumer durables and office product categories suggests that incumbents or large firms are not necessarily doomed to obsolescence by nimble outsiders*" (p. 14).
Olleros (1986) investigated another often neglected aspect of this issue, namely the burn-out of pioneers, thus suggesting that entrant firms might also encounter problems under conditions of discontinuous change. Other scholars have focused on key determinants of incumbent survival and argued that strong, visionary leadership is one such important capability (Rosenbloom, 2000; Tellis, 2006). Hence, while it is clear that incumbents sometimes fail due to discontinuities, it should be pointed out that this is not always the case and that there is some conflicting evidence.

hamper a firm's innovative efforts and make the firm vulnerable to profound changes in the underlying technology. Similar patterns have been identified by other scholars. For example, Abernathy (1978) noted that the decreased competitiveness of some firms in the automotive industry was related to their striving for increased efficiency since these efforts reduced their ability to be innovative. He argued that in order to remain competitive over time a firm needs to be efficient and innovative simultaneously (Abernathy, 1978; Hayes & Abernathy, 1980) and referred to this challenge as the productivity dilemma.

Firms therefore face a paradox when developing new products and processes: they need to take advantage of their core capabilities without letting them be turned into core rigidities (Leonard-Barton, 1992). This dilemma has often been described as a key challenge in innovation management (Magnusson and Martini, 2008). One reason for these difficulties is that capabilities are associated with certain values, which are difficult to change. As managers work together they tend to develop a common set of beliefs, a 'dominant logic' based upon their history (Prahalad and Bettis, 1986). Other scholars have used the term 'inertia' when describing how people within an organization tend to proceed as they always have (Adams et al., 1998). Argyris (1977) underlined the importance of double-loop learning, i.e. that firms need to learn not only by identifying errors but also by revising underlying values and assumptions.

The literature on discontinuous innovation and incumbent failure has often looked at the firm's resources and capabilities when trying to explain the difficulties that are encountered. Tushman and Anderson (1986) made a distinction between competence-enhancing and competence-destroying innovations. They argued that innovations which destroy the value of a firm's existing competencies are very difficult to manage, because established firms are bound by traditions, sunk costs and internal political constraints. Henderson and Clark (1990) nuanced those arguments related to competence destruction by classifying innovations as either architectural or modular. In their study of the photolithographic alignment industry, it was found that incumbents were good at handling innovation on a modular level, but often failed to recognize and respond to architectural innovations, i.e. changes in the linkages between different components in a given product. The authors pointed out inertia on the organizational level and bounded rationality as the main reasons for this dilemma. Christensen (1997, p. 34) used the following quote in order to illustrate how organizational structures and product architectures are interlinked: "*When Tom West, Data General's project leader and a former long-time DEC employee, removed the cover of the DEC minicomputer and examined its structure, he saw 'Digital's organization chart in the design of the product'*". Hence, competence destruction seems to be easier to handle on a component level than on an architectural level.

Another competence-related aspect of discontinuous innovation is the role of complementary assets. The term was coined by Teece (1986) who looked at how firms sustain their competitive advantages under different appropriability regimes. He argued that firms may

retain their competitiveness under a weak appropriability regime if they have access to complementary assets. A complementary asset can be defined as a resource or capability that is needed in order to retain the investments in a new technology. Those assets can include for example distribution channels, service organizations, relationships in the value chain, brands, complementary products and technologies. It has been shown that a key determinant of how incumbents perform under conditions of technological change is related to whether their complementary assets are rendered obsolete or not (Tripsas, 1997). Studying the typesetter industry, Tripsas found that established firms could manage a competence-destroying shift by relying upon their complementary assets and thereby obtain more time to renew their resources and capabilities.

Scholars in organization theory have emphasized that power and politics may hamper an incumbent's response to a discontinuity. An organization can be thought of as a set of different actors, which must cooperate to accomplish something, but at the same time compete for the internal pool of resources. Since organizational changes tend to imply a shift in the existing constellation of power, a resistance to change is created (Cyert and March, 1963). Studying Olivetti's response to the shift to electronic calculators, Danneels et al. (2009) pointed out how attempts to enter the new technology were continuously hampered by what the electronics engineers at the company referred to as "the mechanical establishment". Similar conflicts seem to have taken place at Kodak in the 1990s (Swasy, 1997). Cooper and Schendel (1976) provided analogous arguments, stating that "*decisions about allocating resources to old and new technologies within the organization are loaded with implications for the decision makers; not only are old product lines threatened, but also old skills and positions of influence*" (p. 68). Drawing upon evidence from Polaroid's efforts to manage the shift to digital imaging, Tripsas and Gavetti (2000) further suggested that another source of inertia may be related to the cognitive capabilities among senior managers.

Neoclassical economic theory has also highlighted some explanations of incumbent failure under conditions of discontinuous change. Arrow (1962) claimed that firms with an existing strong market position have low incentives to invest in innovation initiatives. Several reasons for this unwillingness have been pointed out; Reinganum (1983; 1984) suggested that incumbents are less willing to cannibalize on their existing revenue streams and have lower incentives to undertake ventures which are more uncertain.

2.2 Discontinuous innovation and the environment

Over time, increased attention has been paid to the position of firms and how they interact with the surrounding environment. Afuah (2001) suggested that the benefits of vertical integration change as the industry evolves; once a new technology has displaced the former one, the industry enters a period of high uncertainty, as suggested by Utterback (1994). However, as the industry starts to stabilize, firms must obtain skills and knowledge that make

them competitive, which usually implies a closer interaction with suppliers and this often results in a higher degree of vertical integration (Conner and Prahalad, 1996). Afuah (2001) underlined that firm boundaries are not static and called for more research into how technological discontinuities affect transaction costs and the industry structure.

It has also been argued that the effects an innovation has on customers and suppliers must be taken into consideration (Afuah and Bahram, 1995). Innovations may be competence-destroying or architectural not only for the firm, but also for customers and other actors. In line with this argument, Afuah (2000) looked at co-opetitors, defined as the "*suppliers, customers, complementors and alliance partners with whom it must collaborate and compete*" (p. 387), as a complementary asset. He argued that the technological shifts which destroy the value of those co-opetitors may create particular problems for established firms.

In addition, more attention has been given to the role of the market and customers. It has been suggested that competence destruction is the least explanatory variable of discontinuous changes, whereas the extent to which the technology expands the market or breaks established linkages between manufacturing and the market are more important (Utterback, 1994; Utterback and Kim, 1986). Mitchell (1989, 1992) made similar observations, suggesting that those shifts which did not change the existing linkages with existing markets and customers were easier to handle for incumbents. Glasmeier's (1991) study of the Swiss watch industry's response to the rise of digital watches can be regarded as a good illustration of this argument. She claimed that an established production network in a region tends to be beneficial for the involved actors if the underlying technology does not change. When the technology shifted, the lack of coordination in the network turned into a core rigidity. Additionally, the distribution model for watches was altered. The Swiss watch manufacturers had built a distribution network which was based on jewellery stores. These stores made a steady profit from repairing watches, and hence they were less willing to sell cheap electronic watches that did not need to be repaired.

2.3 Disruptive innovation

As outlined in the previous section, several scholars have pointed out the importance of looking beyond firm boundaries and into the role of the market when trying to understand the difficulties that discontinuous innovations imply. These ideas were further developed by Clayton Christensen in a series of articles (e.g. Christensen, 1993; Christensen and Bower, 1996; Christensen and Rosenbloom, 1995; Christensen, 1996; Christensen et al, 1998) and popularized in *The Innovator's Dilemma* (1997) by the same author.

Christensen wrote his doctoral dissertation about the rigid disk drive industry (1992) and identified an anomaly – something that previous literature could not explain. The pattern of entrant-incumbent dynamics in this industry was inconsistent with the findings in e.g. Tushman and Anderson (1986) and Henderson and Clark (1990). Several technological shifts occurred in the disk drive industry during the period 1970-1990, but the discontinuities that toppled established firms were not competence-destroying or architectural. Instead, it was the emergence of smaller, simpler and cheaper disk drives with an initially lower storage capacity which often created insurmountable problems for established firms. Over the six generations of disk drives that were studied, incumbents lost market share to entrants when a new generation was introduced, something that previous theory could not account for. Christensen (1997) therefore rejected those explanations which had primarily looked at supply-side factors[4].

Instead, he looked at the role of the market and drew upon resource dependence theory (Pfeffer and Salancik, 1978; Pfeffer, 1982) and the concept of value networks (Christensen and Rosenbloom, 1995) in order to explain incumbent failure.[5] Given that this theory had hardly been used in previous literature on entrant-incumbent dynamics, it merits some further explanation. Resource dependence theory drew largely upon Katz and Kahn's (1966) work which argued that organizations must be regarded as open systems. Pfeffer and Salancik (1978) claimed that previous studies of organizations had been too focused on the internal issues and overlooked the role of the environment. As indicated by their book titled *The external control of organizations: a resource dependence perspective*, the authors instead looked beyond the boundaries of the organization. They argued that organizations depend on

[4] Christensen and Bower (1996) write: "*We contest the conclusions of scholars such as Tushman and Anderson (1986), who have argued that incumbent firms are most threatened by attacking entrants when the innovation in question destroys, or does not build upon, the competence of the firm. We observe that established firms, though often at great cost, have led their industries in developing critical competence-destroying technologies, when the new technology was needed to meet existing customers' demands*" (p.199).

[5] It is clear from several of the publications by Christensen that he draws upon resource dependence theory. For instance, Christensen (1997, p. xxiii) states that: "*Companies depend on customers and investors for resources*". After having described the events that took place in the disk drive industry, the same author (1997) wrote: "*this observation supports a somewhat controversial theory called resource dependence, propounded by a minority of management scholars, which posits that companies' freedom of action is limited to satisfying the needs of those entities outside the firm (customers and investors, primarily) that give it the resources it needs to survive.*" (p. 117). For further illustrations of this point, see for instance Christensen and Bower (1996, p. 3).

critical resources in order to survive. When an organization does not control all factors required to achieve its objectives, it needs to obtain resources from its environment and consequently, it is to some extent controlled by those actors who supply the resources it needs. Hence, it is uncertain whether an organization would obtain its required resources given the unpredictable nature of the environment. This idea has several implications, for instance, that firms tend to serve those actors which provide them with resources and that organizations often reduce their freedom by building relations to others in order to lower the uncertainty. Since the customers and owners are often the key stakeholders that provide the firm with resources, they exercise an indirect but still significant control on what decisions are taken and how resources are allocated inside a firm[6].

Bower (1970) provided similar arguments when suggesting that the demands of established customers constrain the freedom of action for firms. This perspective is manifested in Christensen's research in the concept of value networks defined as "*the context within which the firm identifies and responds to customer's needs, procures inputs and reacts to competitors*" (Christensen and Rosenbloom, 1995, p. 234).[7]

Christensen explained the pattern of incumbent failure in the disk drive industry by arguing that the smaller drives which offered a lower storage capacity were problematic since they did not fit into the firm's established value network. The initially inferior performance implied that such products could only prosper in niche segments which were small and offered lower margins. Existing customers did not demand smaller disk drives and therefore, the incumbent made a seemingly rational decision when not developing such drives. Instead, the established firm kept launching products which eventually overshot its customers' needs of storage capacity. As the storage capacity of the smaller disk drives improved, they eventually became good enough to displace the former generation. A firm's existing products may therefore be substituted by products which initially underperform along the most important dimensions, but provide sufficient performance while at the same time bringing new attributes to the market. Consequently, the firms which listened to their most profitable customers and moved up-market were misled. Eventually they lost market shares to entrant firms who had emerged in a new value network, with new customers. Christensen (1997) documented similar patterns in many other areas, such as mechanical excavators, steel production and motorbikes.

A key determinant of the probability of success for incumbents is therefore the extent to which a new technology addresses the demands of existing customers, since they seem to

[6] The link between resource dependence and the resource allocation process is further explicated in Christensen (1997, p. 119): "*Good resource allocation processes are designed to weed out proposals that customers don't want. When these decision-making processes work well, if customers don't want a product, it won't get funded; if they do want it, it will.*"

[7] Almost identical definitions can be found in Christensen (1997, p. 36) and in Christensen and Raynor (2003, p. 44).

influence the firm's resource allocation process to a great extent. A firm has good reasons to satisfy its existing value network since this largely defines its competitive advantage and supplies it with resources. But at the same time, the network hampers attempts at developing innovations which are not requested by existing customers. From this theoretical standpoint, Christensen explains the pattern of incumbent failure by making a distinction between sustaining and disruptive technologies. Sustaining technologies have in common that they improve the performance of established products along the dimensions that existing customers value. Disruptive technologies on the other hand, start with a lower performance along these dimensions and also introduce some new functions or attributes. They are described as typically being simpler and cheaper than the sustaining technology.[8] Hence, this dichotomy is different from more widely used ones like "incremental" versus "radical" or "competence-enhancing" versus "competence-destroying". The disruptive versus sustaining terminology instead addresses to what extent an innovation is demanded by existing customers in an established value network or not. Therefore, a radical innovation can be sustaining and an incremental innovation can be disruptive, depending upon their impact on existing customers.

Through his studies of the disk drive industry among others, Christensen showed that established firms usually win sustaining battles whereas entrants often succeed in disruptive battles. Incumbents appear to be "held captive" by their investors and their most important customers. Therefore, resources are not allocated to initiatives that are initially less profitable.[9] Christensen referred to this pattern as the innovator's dilemma, arguing that disruptive technologies present a particular challenge for incumbents since they require managerial skills that are different from the ones needed to succeed in sustaining battles.

Theory on disruptive innovation has often been perceived as rather pessimistic regarding the ability of established firms to succeed in these shifts. The main reason for this appears to be that firms are controlled by forces beyond their own boundaries (customers). However, Christensen (1997) also proposed a couple of managerial solutions to this problem. One of the most influential ones is that incumbent firms can develop disruptive innovations by nursing them in an independent organization. Such a structure can shelter the initiative from the forces of resource dependence that tend to allocate resources towards sustaining innovations. By doing so, firms avoid letting existing customers control their resource allocation process, which tends to drain disruptive initiative of funding. Some guidelines for how to commercialize such innovations have also been offered. Given that the eventual

[8] Christensen (1997) defines disruptive technologies in the following way: "*Generally, disruptive technologies underperform established products in mainstream markets. But they have other features that a few fringe (and generally new) customers value. Products based upon disruptive technologies are typically cheaper, simpler, smaller, and, frequently, more convenient to use*" (p. xviii).

[9] Christensen (1997) writes: "*The evidence is very strong that as long as the new technology was required to address the needs of their customers, established firms were able to muster the expertise, capital, suppliers, energy, and rationale to develop and implement the requisite technology both competitively and effectively*" (p. 111).

application of a disruptive technology is often uncertain, a trial-and-error process is recommended where firms should try to fail early and inexpensively. Another option could be to obtain the required resources and capabilities by acquiring another company.

2.3.1 Extensions and improvements of the theory on disruptive innovation

Over the last decade, the theory of disruptive innovation has received a lot of interest, in a wide range of different settings. For example, two renowned journals in the innovation management field have devoted special issues to the subject, the *Journal of Product Innovation Management* (2006) and *IEEE Transactions on Engineering Management* (2002).[10]

The researchers working in this field have increasingly sought to frame disruption as a theory.[11] A number of books have been co-written by Christensen, applying the disruptive innovation theory to many different issues, e.g. healthcare and education.[12] Scholars have used this notion in fields such as psychotherapy (Simon and Ludman, 2009), orthopedics (Hansen and Bozic, 2009) and political science (Mukunda, 2010). The concept has also had a profound impact on management. Christensen (2006) describes how several large companies such as Kodak and Intel have used his model to develop and launch disruptive innovations successfully.[13]

The theory has also been improved in several different ways. Christensen and Raynor (2003) made a distinction between low-end and new market disruptions. Low-end disruptive innovations evolve in the lower segments of the market, typically by having a business model which enables the firm to offer cheaper products with a performance that is initially inferior. Steel minimills and discount retailing are both examples of this. New-market disruptive innovations prosper among customers that have not been addressed previously. The personal computer and the first portable transistor radios can serve as illustrative examples of new market disruptive innovations. Schmidt and Druehl (2008) elaborated further on these

[10] Danneels (2004, p. 246) provided a compelling illustration of the wide impact that Christensen's work on disruptive innovation has had: "*It is rare that a scholarly work draws so much attention as Harvard Business School professor Clayton Christensen's work on disruptive technology. His book The Innovator's Dilemma (1997) has sold over 200,000 copies since its release in May 1997 and has received extensive coverage in business publications. Christensen was elevated by the business press to the status of ''guru'' (Scherreik, 2000). His work also has been cited extensively by scholars working in diverse disciplines and topic areas, including new product development (NPD), marketing, strategy, management, technology management, and so forth.*"

[11] Christensen and Raynor (2003, p. 55) state that: "*Disruption is a theory: a conceptual model of cause and effect that makes it possible to better predict the outcomes of competitive battles in different circumstances.*"

[12] See e.g. Christensen et al. (2009), Christensen et al. (2004) and Christensen et al. (2008).

[13] There are other examples of less successful attempts to apply these theories. For instance, Christensen founded the Disruptive Growth Fund together with Neil A. Eisner in 2000. The fund made investments based on the theory of disruptive innovation. It was closed a year later, after having lost 64 percent of its value (Nasdaq lost about 50 percent in this period). For more information, see Scherreik (2001).

concepts, arguing that new market disruptions can be categorized as emerging either in fringe markets or in more detached markets.

Govindarajan and Kopalle (2006a) also sought to improve existing classifications, claiming that Christensen's original definition was too narrow since it only took cheaper, simpler and initially lower performance products into consideration. They instead proposed that a disruptive innovation can be defined as: "*an innovation which introduces a different set of features, performance, and price attributes relative to the existing product, an unattractive combination for mainstream customers at the time of product introduction because of inferior performance on the attributes these customers value and/or a high price—although a different customer segment may value the new attributes.*" (Govindarajan and Kopalle, 2006a, p. 15). Christensen (2006) acknowledged that this definition is better than his original 1997 definition since it captures a wider range of similar phenomena. Therefore, it makes sense to relate to Govindarajan and Kopalle's definition throughout this dissertation.[14]

Other scholars have developed Christensen's theories, for instance by addressing the competitive dynamics (Adner and Zemsky, 2005) and by developing ways to measure and assess the disruptiveness of an innovation (Govindarajan and Kopalle, 2006b). Further contributions have been made by drawing upon diffusion theory and by looking at various aspects of the market and the customer. Christensen (1997) essentially explains the pattern of disruption by looking at different customer segments, suggesting that a disruptive technology prospers in low-end segments or in new markets and later on invade the mainstream market. Hence, existing literature has to a large extent maintained a diffusion-oriented view on customer attributes such as the perspective developed by Rogers (1995) and used by Moore (2002). Slater and Mohr (2006) identified parallels between the work by Christensen (1997) and Gordon Moore's book *Crossing the chasm* (2002). Moore (2002) drew upon diffusion theories which suggest that an innovation penetrates a market according to an S-shaped, epidemic pattern. He claimed that many innovations do not reach the mass markets and presented several ways of approaching the early majority of the market. Slater and Mohr (2006) argued that the challenges related to disruptive innovation are similar in many ways.

The diffusion perspective on disruptive innovation has been further developed by several other scholars. Linton (2002) explained how the diffusion of disruptive innovations can be forecasted and Kassiech et al. (2002) presented several differentiating market strategies. Adner (2002) also maintained a diffusion oriented perspective, stating that the structure of demand needs to be addressed in order to understand the impact of disruptive innovations. He looked at different performance thresholds, i.e. critical performance levels that must be

[14] Disruptive innovation is a notion that has become very popular. It is often used in many different ways and the original meaning of the term is therefore sometimes lost (Lindsay and Hopkins, 2010; Linton, 2009). Frequently, such terms as discontinuous, disruptive and radical are used interchangeably (e.g. Assink, 2006). Govindarajan and Kopalle's definition is useful as it is similar to the original work on the topic, albeit a bit extended.

met. The functional threshold can be thought of as the minimum performance that the customer can tolerate and the net utility threshold also takes price into consideration. Adner further argued that an important reason for displacement of one technology was the decreasing marginal utility associated with further improvements of the sustaining technology. Hence, several extensions and improvements have been made over time, primarily by drawing upon diffusion theory and by developing a more detailed understanding of the market.

The managerial recommendations related to disruptive innovation have also been improved over time. As stated previously, the resource allocation process can be managed by creating a separate organization. Another way of managing it is to make use of strategic buckets, i.e. specifying which resources should be used for disruptive and sustaining initiatives (Chao and Kavadias, 2007; Hogan, 2005).

When it comes to the actual commercialization, other scholars have provided some guidelines. Some of the recent work in this area has focused increasingly on the role of the market and the customer. For instance, Danneels (2004) and Henderson (2006) underlined the importance of developing a "customer competence" in order to succeed with disruptive innovation. In line with these suggestions, King and Tucci (2002) claimed that those firms which had "transformational experience", i.e. a history of experimenting with new markets and value propositions were more likely to handle these innovations in a better way. Similar arguments were brought forward by Dew et al. (2008) who argued that effectual reasoning was probably a better alternative than causational reasoning when handling disruptive initiatives. Causation refers to the process of creating and prioritizing means to achieve a pre-specified goal whereas effectuation concerns the opposite – how to use existing means to achieve an unknown goal. The arguments presented by Kassiech et al. (2002) resemble the ideas postulated by other scholars. Drawing upon Prahalad and Hamel's (1994) notion of expeditionary marketing they suggested that a more open-ended approach was needed when dealing with disruptive innovation, since its placement in the value network may not be clear from the beginning. Govindarajan and Kopalle (2004) provided an analogous argument, stating that firms must be aware of what is happening to the needs of their customers. Christensen and Raynor (2003) argued that one way of doing so would be to focus on the job that customers try to get done, rather than looking at different performance dimensions. Hence, many scholars have pointed out the importance of a more experimental approach. They use different terms and draw upon slightly different bodies of literature, but remain vague regarding what actually constitutes a "customer competence" or "expeditionary marketing" and how firms can develop such capabilities.

Over time, the literature on disruptive innovation has also paid more attention to the business model concept. Some authors have tried to extend the theory to incorporate disruptive services and business models, i.e. innovations which are not technological but are business models which possess characteristics similar to those of disruptive technologies (Christensen

and Raynor, 2003; Charitou, 2001; Charitou and Markides, 2003). Markides (2006) contested this notion and argued that business model innovation was a significantly different phenomenon than the one originally described by Christensen (1997). Christensen provided a nuanced and extended argument when he reframed the fundamental challenge of disruptive technologies as "*a business model problem, not a technology problem*" (2006, p. 48). As an illustration, he quoted Andy Grove of Intel who explained why Digital Equipment Corporation (DEC) declined in the shift to computers that are based on microprocessors: "*It wasn't a technology problem. Digital's engineers could design a PC with their eyes shut. It was a business model problem, and that's what made the PC so difficult for DEC*" (Christensen, 2006, p. 49). This is the main reason why Christensen used the term *innovation* instead of *technology* in his more recent work (e.g. Christensen and Raynor, 2003; Christensen, 2006). Hence, a disruptive technology now seems to be thought of as a technology that is incompatible with an incumbent firm's existing business model. However, it is still a bit unclear what is actually meant by this and what the implications of such an expanded conceptualization are, both for theory and for management. This statement therefore necessitates a review of the literature on business models and related theory on value and networks.

2.4 Business models, value and networks

While traditional theory in strategic management has addressed the fit between resources and markets, the business model literature has provided a more holistic and systemic perspective upon this issue. Existing literature is still somewhat ambiguous regarding what actually constitutes a business model, but generally, the business model concept is concerned with how a firm creates and captures value (Chesbrough and Rosenbloom, 2002).

Some scholars have defined it in terms of a set of answers to certain questions (e.g. Yip, 2004; Osterwalder and Pigneur, 2005;). The definitions that focus on a set of questions or parameters are problematic for several reasons. Firstly, the theoretical foundations are often lost when stating that a business model is an answer to some questions. Secondly, these definitions become arbitrary since there is no obvious delimitation regarding which factors should be excluded, and consequently the concept becomes a blurred. The fact that Shafer et al. (2005) identified 12 different definitions during the period 1998-2002, which in turn generated 42 different business model components, can be regarded as one indication of this confusion. Thirdly, and perhaps most important, when thinking of business models as frameworks or answers to a set of questions, it becomes difficult to point out in what ways and why established firms often struggle to renew their business models.

Another stream of research has focused more explicitly on the interactive and holistic nature of business models. For instance, Zott and Amit (2009) regard the business model as "*a system of interdependent activities that transcends the focal firm and spans its boundaries*".

Similar interpretations have been provided by e.g. Itami and Nishino (2009), who stated that a business model contains two components – a business system and a profit model. They also underline that such a system exists beyond firm boundaries. Weill and Vitale (2001) argued that there are three important dimensions of a business model: the participants, the relationships and the flows that connect these participants. Other scholars have also pointed out the boundary spanning nature of business models and that this concept addresses how and why value is created and distributed in a network (Akkermans, 2001).

Based on the above, it can be concluded that business models are generally concerned with how firms create and appropriate value by interacting with their environment. Hence, value and networks can be thought of as two important components of the business model concept. These two notions are therefore briefly described in the coming two sub-sections.

2.4.1 Value and utility

There are many different definitions of value and utility. Given the importance of the concepts with regard to disruptive innovation and business models, they merit some further elaboration here.

Economists have often referred to utility theory and marginal utility when trying to understand value. Total utility refers to the satisfaction that comes from the possession of a good (Bowman and Ambrosini, 2000). A basic assumption is that consumers use their income in a way that optimizes their utility. Marginal utility is usually defined as the utility someone gets from obtaining or losing one unit.

In economics, value is often considered to be subjective. This means that a good or service can be valued by one actor but considered useless by someone else (von Mises, 1963). From this standpoint, Menger (1950) developed the notions of use value and exchange value. The use value is the actual value a user retrieves from a good or service, and the exchange value is normally the price that is paid for it. If the use value is larger than the exchange value, a consumer surplus has occurred. Buyers may have different objectives when they acquire a product, and therefore they are also willing to pay different prices. Since the value of a product is normally not realized until it is used, which often happens at a different point in time than the purchase, there is usually an inherent uncertainty or degree of speculation in most transactions.

The distinction between value and price is also common in the marketing literature. Value is sometimes considered to be a financial expression of what a customer obtains for what is paid. Anderson and Narus (1998) argue that the customer's incentive to buy can be thought of as the difference between the value and the price. Hence, a price reduction does not

change the obtained value according to this definition; it would merely increase the customer's willingness to buy.

Other scholars have pointed further at the subjectivity of value and argued that it can be defined as the perceived benefits in relation to the perceived sacrifices (Monroe, 1991; Flint et al., 1997; Christopher et al., 1991). Interestingly, such definitions do not aim to quantify value in monetary terms. While the paid price can be thought of as one out of many potential sacrifices, this definition would suggest that value is subjective in the sense that different actors obtain different benefits and make different sacrifices. These include for instance the costs related to the transaction, installation and maintenance (Walters and Lancaster, 1999).

From this perspective, it has been argued that value is something context dependent and that it can be created in many different ways. Normann and Ramirez (1994) refer to the relation between customers and suppliers as offerings, which are valuable if they create either relieving value or enabling value. Relieving value is thought of as the labor that is removed, and enabling value is created by helping the purchasers to do things differently or enable them to do what was not possible before. According to the authors, offerings do not necessarily have to be products or services, but can also consist of e.g. risk distribution and access to information.

Value can therefore be thought of as being created in a certain context, and hence the value of an offering is dependent upon its surrounding environment (Håkansson and Waluszewski, 2001). Consequently, actors may have diverging preferences since they are exposed to different tradeoffs between benefits and sacrifices. Additionally, it should be pointed out that value creation does not equal value appropriation since a new creation of value can result in an undesired distribution of value (Björkdahl, 2007).

Summing up this section, it can be concluded that value is something subjective, since tradeoffs between benefits and sacrifices are both perceived and context-dependent. What is considered to be valuable is determined by who makes the assessment and on what level it is done. Value can be created on many different levels and be distributed on several levels, both inside a firm and in a network.

2.4.2 Networks

The amount of management research that maintains a network approach has increased significantly over the last decades. This trend marks a shift from research that centers around individuals or single firms towards a more systemic and contextual way of addressing social phenomenon (Borgatti and Foster, 2003). Generally, networks can be defined by a set of ties (relations) among nodes (actors). Nodes can be different types of organizations as well as

individuals or groups (Wasserman and Faust, 1994). Hence, networks exist and can be analyzed on many different levels (Ford et al, 2002).

Networks can be thought of as a view alternative to the market-and-hierarchy argument developed in transaction-cost reasoning (Williamson, 1975). Transaction-cost scholars suggest that firms exist in order to handle transaction costs. To search, specify and implement a purchase on the market is sometimes very expensive and under these circumstances, firms may decide to internalize an activity instead. This way of reasoning therefore suggests that the boundaries of the firm are determined by the transaction costs. A low transaction cost implies that firms are more willing to use the market in order to acquire a certain good or service. Networks, on the other hand, can be regarded of as a hybrid form of firms and markets. It is an alternative to organizing with distance to customers or through vertical integration.

Over the last decades, network theories have become increasingly prevalent in a wide range of literature streams related to e.g. leadership, supply chain management, power, stakeholder relations and innovation. Moreover, social network analysis has emerged as a method for describing networks and how they evolve. This dissertation will primarily draw upon industrial network theory (e.g. Håkansson, 1989), and partly upon actor network theory, which is often referred to as ANT (e.g. Latour, 1987).

The industrial network approach offers some different dimensions for analyzing interaction among actors in an industrial network (Håkansson, 1987), which makes it suitable for the purpose of this dissertation. This stream of literature differs from more diffusion-based theories of innovation in that a much more nuanced view of the network is maintained. While diffusion theory tends to look primarily at customers (or adopters) the network approach maintains a more complex and systemic view of adopters and looks at other actors as well. Scholars who draw upon this perspective often analyze networks by looking at actors, the resources they control and the activities that they perform.

The resources that actors possess and transform have a value in a network and thus, firms depend upon their context. The outcome for an individual company is not solely based upon its own decisions. Rather, it is the result of all interactions taking place in a network and companies have to adapt to their environment continuously. In this sense, networks are based upon restricted freedom (Ford et al., 2002) and actors are thus thought of as interdependent in the sense that the outcome is not entirely controlled by one single actor (Pfeffer and Salancik, 1978).

Actor Network Theory (ANT), has some commonalities with the industrial network approach. This network perspective emerged in the field of Science and Technology Studies (STS). One noteworthy difference from other theories in social science is the idea that non-human artefacts such as technology are also regarded as actors in a network. Proponents of

ANT often argue that the interplay between human and non-human agents is often missed by other perspectives. Latour (1993) claimed that while a separation is often made between human and non-human, there is always an interplay between them, and that this interaction needs to be better understood. Networks are therefore assumed not only to contain firms or individuals, but also machines, culture, nature etc. – actors which in turn have their own impact on the network. An ANT scholar is therefore interested in studying and describing how networks result in organizations, how hierarchies prevail and collapse. In this sense, ANT is different in focusing more explicitly on issues like power and politics. This theory has often been used in order to describe and explain how networks or power structures are created and how they evolve over time. Such processes are considered to be highly uncertain and a matter of continuous negotiation and conflict (Law, 1992). Changing or building an actor network is largely a matter of handling controversies and overcoming resistance. ANT's more explicit focus on power and conflict makes it a good complementary perspective to industrial network theory (Mattsson, 2003) when looking at disruptive innovation from a network point of view.

2.5 Disruptive innovation − some areas in need of development

Clearly, the concept of value networks and the work by Christensen among others have contributed to an increased understanding of the challenges related to discontinuities, but there are still several questions that have been insufficiently attended to, especially with regard to business models and value networks. However, few studies have addressed them in a more focused manner. The preceding sections have described existing theory on disruptive innovation, its foundations and how it has evolved over time. This section seeks to identify areas that need to be developed further. Towards the end of each sub-section, a research question (RQ) is formulated.

2.5.1 Disruptive innovations in established value networks

The literature on disruptive innovation now distinguishes between low-end and new market disruptive innovations. Additional work has been conducted regarding in what segments these innovations actually emerge. Utterback and Acee (2005) argued that too much emphasis had been put on "attack from below". They noted that many technologies such as fuel injectors and wafer boards were not initially cheaper or simpler than the technology that they later on replaced. By explicating a third dimension of technological innovation called ancillary performance, they noted that Christensen's original definition (lower price, lower traditional performance and ancillary performance) was only one out of eight possible situations. In doing so, they called for an expanded view of the phenomenon. Carr (2005) also argued that too much attention had been given to disruption from the low-end and

suggested that many disruptive innovations in fact start to prosper in high-end segments and later on take over the mainstream market.

As stated previously, Govindarajan and Kopalle (2006a) suggested a broader definition which also included high-end and mainstream products with a lower traditional performance and new attributes. The authors claim that there are several reasons why such innovations are problematic for established firms. Mainstream customers may not demand the new performance attributes, the product can have an insufficient initial traditional performance, the market niche may be too small and therefore it may not offer any significant profits. They use the cellular phone as an illustrative example. It emerged in the 1980s among executives who were willing to pay a high price for a phone which offered worse sound quality but was portable. At this point, the mainstream customers still demanded regular phones since they did not appreciate the value proposition that mobile phones offered then. As the performance improved and the prices declined, cellular phones eventually penetrated the mainstream customer segments.

In his review and critique of the disruptive innovation framework, Danneels (2004) asked whether disruptive innovations never emerge in high-end or mainstream segments of the market. Apart from this paper which raised the question, little attention has been paid to disruptive innovations which flourish in established value networks. Christensen (1997) argued that the characteristics of disruptive innovations made them prosper in new value networks since the established customers do not demand a technology with these properties. While his empirical work on disk drives, mechanical excavators and steel production illustrated such a pattern, this may however not always be the case.

One reason why this issue has been neglected could be that existing literature on the topic has maintained a diffusion-oriented view of the market. As was mentioned before, several contributions to the disruptive innovation literature have been made by drawing upon traditional diffusion theories (e.g. Slater and Mohr, 2006; Linton, 2002; Adner, 2002). While these improvements are important, this stream of literature has primarily sought to understand the role of the market in terms of different segments, not the customer or the surrounding value network. The role of the customer is often highlighted, but rarely addressed in further detail. Such a simplification may be valid for consumer products or in other cases when the buyer is one homogeneous actor, with one specified utility function. But it may be overly simplistic and conceal some important issues when a disruptive innovation is introduced in a more complex business-to-business setting. Thus, previous literature has maintained a somewhat binary view of the market and assumed that an innovation is either demanded by a firm's existing customers and becomes easy to handle, or prospers elsewhere and thereby becomes problematic to commercialize due to the forces of resource dependence.

Another reason why disruptive innovation in existing value networks has been overlooked could be that it may be thought of as a contradiction in terms. Why would a technology with

an inferior performance and some new properties be in demand from an established customer base? But since mobile phones and many other products with disruptive characteristics have initially prospered in a high-end segment, it should arguably be possible that they can also emerge in established customer segments[15]. Given that previous literature has stated that disruptive innovations may prosper in low-end segments, in new markets and in high-end segments, it would be strange if they could not also emerge in an established customer segment. Moreover, as firms operate in different segments of the market, a disruptive innovation is likely to be introduced in the value network of some firm. However, it is unclear how and why this would happen and therefore, more empirical evidence is needed on this issue along with further theoretical development. Hence, the first research question concerns the phenomenon of disruptive innovations in existing value networks:

Research question 1: Can a disruptive innovation emerge in an established value network and if so, how can this be explained?

2.5.2 Disruptive innovation as a business model challenge

As stated above, if disruption is a relative phenomenon, happening to different firms at different points in time[16] (Christensen and Raynor, 2003), virtually all disruptive innovations should prosper in the value network of some firms, unless they create a completely new market. This observation raises the question of what challenges firms encounter when trying to introduce a disruptive innovation in an existing value network. Would those firms which are operating in a segment where the disruptive innovation emerges be better off than others? And if not, what challenges would they encounter when trying to bring a disruptive innovation to an established customer?

Existing theory on disruptive innovation is somewhat ambiguous on this matter. The early work by Christensen would arguably suggest that this issue is not very problematic for established firms. Christensen (1997) showed that incumbent firms failed to introduce such technologies since they could not find any financial logic in doing so. Drawing upon resource dependence theory, he argued that these forces controlled the resource allocation process of the firm and therefore, firms failed to invest in such initiatives and were displaced later on. Hence, it seems that previous literature would not regard disruptive innovations in a firm's

[15] Mobile internet connections can serve as an illustrative example – while the traditional performance in terms of speed was lower than for broadband, it introduced portability as a new performance dimension. Despite these disruptive properties, regular broadband users were willing to trade off some speed in order to have a portable internet connection.

[16] Christensen and Raynor (2003, p. 50) points out that a key determinant of success for an entrant firm is whether the innovation is disruptive to all incumbents: "*If it appears to be sustaining to one or more significant players in the industry, then the odds will be stacked in that firm's favor, and the entrant is unlikely to win.*"

established value network as problematic since such an initiative would be aligned with the existing forces of resource dependence.

On the other hand, the statement that disruptive innovation is a business model problem (Christensen, 2006) indicates that it might actually be rather problematic to introduce these innovations in an established value network. Business models are largely concerned with how value is created and appropriated from a firm's surrounding network. Hence, the term has a lot in common with Christensen's work, which introduced value networks as a key determinant of incumbent failure. Though new business models can be developed in a new value network, this is arguably not necessarily the case. A new business model can be introduced while still targeting existing customers. It is clear from the section on business models above that there are many other aspects of a business model than just the customer, for instance the value proposition, the revenue model, the way to reach the customer etc. But these dimensions have not been further investigated in the disruptive innovation literature, which has addressed one element of a business model, namely whether existing customers demand an innovation or not[17].

An additional reason for studying in what ways a disruptive innovation is a business model challenge is that insights into this matter can generate important managerial implications. While the work on disruptive innovation pointed out that the environment imposes constraints on incumbent firms, the managerial solutions have been surprisingly focused on how firms should organize themselves and not on how they can manage the environment. Thus, the main managerial recommendations related to disruptive innovation have either focused on issues related to the firm itself, or pointed out the importance of experimenting and understanding customers, but remained vague regarding how this can actually be done. This could be one reason why practitioners have often found the work on disruptive innovation to be good at predicting and describing difficulties, but weaker in terms of solutions[18].

If a disruptive innovation is viewed as a business model challenge, it should arguably be possible to develop new managerial solutions to the innovator's dilemma that do not concern how the internal resource allocation process should be handled. In the case when a firm is highly vertically integrated and controls the entire supply chain, this solution may suffice. But when a firm interacts with an external network of actors, the launch of an independent venture can be thought of as a prerequisite for succeeding with disruptive innovation. This is

[17] Christensen and Bower (1996, p. 212) write "*Our findings support many of the conclusions of the resource dependence theorists, who contend that a firm's scope for strategic change is strongly bounded by the interests of external entities (customers, in this study) who provide the resources the firm needs to survive.*" This quote can be regarded as an important illustration of the fact that previous literature has primarily looked at customers, but paid little attention to other elements of the business model or the surrounding environment.

[18] For instance, Simon Waldman, Director of Digital Strategy & Development at The Guardian, wrote in an email conversation that he found Christensen to be brilliant at diagnosis but quite one-dimensional in terms of a cure.

an internal, organizational issue and has in fact little to do with business models. Though the main problem has been described as related to the firm's external environment, the managerial solutions have thus far focused mainly on internal organizational issues rather than business models and the interaction with other actors. As noted by Pfeffer and Salancik (1978), a firm which depends on the environment for resources, can either adapt its internal activities or try to change the environment. Previous literature on disruptive innovation has primarily focused on the first option, but at the same time, Christensen's (2006) statement that disruptive innovation is a business model problem suggests that more work can be done on how firms interact with their environments.[19] Hence, the issue of how a disruptive innovation is a business model challenge needs to be studied, partly since it may generate some important managerial implications. The second research question can be formulated as follows:

Research question 2: How and why is a disruptive innovation a business model challenge?

[19] Interestingly, Christensen has also written extensively about business model innovation (see e.g. Johnson et al, 2008), but has not really integrated this with his work on disruptive innovation or explained further in what way this is a business model problem. Moreover, it is clear that Christensen and many other scholars writing on disruptive innovation acknowledge that there are other aspects of a business model than whether a customer demands an innovation or not (see e.g. Hwang and Christensen, 2007). However, within the theory on disruptive innovation these aspects are hardly attended to.

3. Methodology

This chapter provides a description of the research design and methods that have been used in order to answer the aforementioned research questions. The first section contains a motivation of the methods employed in this dissertation and the following section covers data collection, sample selection and analysis. This section also provides some brief information about the different industrial contexts where the studies have been conducted. The last sections discuss the validity and reliability of the employed method and also contain some reflections on the research process.

3.1 Choice of method

The literature review in the preceding section found that there are certain phenomena related to disruptive innovations which need to be better understood, for instance if these innovations can prosper in established value networks. Given that detailed illustrations are needed in order both to address these issues and to outline more particular challenges and managerial implications, a qualitative method would enable the kind of descriptions that are needed when addressing these research questions as it enables "*richness and holism, with strong potential for revealing complexity*" (Miles and Huberman, 1994, p. 10). Moreover, a qualitative approach is often preferred when the research aims to develop new theory (Flick, 2006).

Moving on from the choice of method to the choice of a research design, it was decided to use a case study approach. A case study concerns the detailed and intensive analysis of one phenomenon, for instance an organization, a technology, or an individual. Such a study often seeks to highlight the complex, dynamic and specific nature of a case rather than overlooking it. Hence, this approach is significantly different from a deductive, quantitative approach which rather aims to downplay the particularities of the context and the specifics of the data.

Case studies often impose constraints upon the generalizability of the findings. But this research design is still to be preferred here since the thesis is of an exploratory character seeking to understand some specific issues related to disruptive innovation. It is often useful to conduct case studies when trying to develop new theory rather than testing existing theory (Eisenhardt, 1989). A case study approach is therefore chosen since it enables the kind of nuanced documentations that are required in order to address the above formulated research questions.

3.2 Data collection and analysis

The research questions explicated above have been addressed by conducting five empirical studies (see Table 1). The data collection and analysis related to each study are described in the following sub-sections.

3.2.1 Study 1 − Surviving Disruptive Innovation

The first study that was performed within the scope of this PhD research concerned the problems incumbent firms face under conditions of disruptive technological change. The main purpose of this study was to gain practical and detailed insight into the challenges related to this kind of shifts. Additionally, the study aimed to address how and why disruptive innovations prosper in an established value network and what challenges incumbent firms encounter in these situations.

In order to explore this further, a camera manufacturer named Hasselblad was targeted. The firm was approached since it had gone through a technological shift recently and encountered significant difficulties when doing so. The change from analog to digital imaging implied that the company went from stable profits to collapsing revenues within only a couple of years. An additional reason for studying a firm that had experienced the shift to digital imaging is that Christensen (1997) stated that this was a disruptive technology vis-à-vis analog photography. [20]

While many articles had been written in the popular press about how Hasselblad had 'overslept' the digital revolution, no one had really performed a detailed investigation of what actually happened to the company. This fact created further reason to study the fate of Hasselblad. An additional reason for targeting this company was its geographical proximity and the opportunity to approach key persons who had been working at the company. It turned out that the firm had explored digital imaging in various applications since the late 1970s. In order to fully understand the problems that were encountered, a historical study of the company was deemed to be the right method. By doing so, insights could be gained regarding how a disruptive innovation emerges and what challenges a firm encounters when trying to commercialize it. Given that disruption is a relative phenomenon and that these events take place during a long period of time, a study of this firm provided an opportunity to study the dynamics of the process in a comprehensive way.

[20] Christensen (1997, p. xxix) stated that digital imaging was a disruptive technology that would displace silver halide photographic film. While it is clear that a technological shift has occurred and that it has caused a lot of industrial turbulence, it is still interesting to look at this shift in retrospective and see how the transition took place and why some established firms encountered problems.

	Study 1	Study 2	Study 3	Study 4	Study 5
Name of study	Surviving disruptive innovation	Managing discontinuous innovation	Inhibitors and triggers of discontinuous innovation	Facit and the displacement of mechanical calculators	Disruptive innovation and business model renewal
Research objectives	Explore disruptive innovation empirically	To understand how firms work actively with generating discontinuous innovations	Explore what factors influence the success or failure of discontinuous innovations	Investigate how and why a disruptive innovation may emerge in a high-end or mainstream market	Explore barriers and enablers of business model renewal in relation to disruptive innovation
Unit of analysis	Firm level	Firm level and product level	Product and business model	Firm level	Product and business model
Research design	Qualitative: in-depth historical case study	Qualitative: multiple case study, combined with some quantitative data	Qualitative study of nine discontinuous product innovations and their success or failure	Qualitative: in-depth historical case study	Qualitative: multiple case study
Data collection	Interviews, access to internal documents	Interviews, discussions, workshops, access to innovation idea databases	Interviews, discussions, workshops	Interviews, archival studies	Interviews

Table 1 gives an overview of the studies that have been conducted within the scope of this thesis.

Though no formal relationship with Hasselblad has been maintained, extensive amounts of information have been accessed. After having performed a couple of open-ended interviews with people who have been in top management positions at Hasselblad over the years, plenty of internal documents such as annual reports, strategy documents, business plans and mail conversations were reviewed (see Table 2 and 3 on the following pages). Archival sources can be regarded as a good complement to other sources of data. Such data can help the researcher to comprehend how certain events unfolded over time and to understand what certain actors did at a certain point in time. But when only using such sources, it may lead to a fragmented view with a lack of contextual understanding (Flick, 2006).

In this study, archival data were mainly used in order to ensure the accuracy of the information obtained from the conducted interviews. Former CEOs and managers of R&D and business development have been accessed in order to understand the specific challenges they faced when shifting from analog to digital imaging. The field research interviews began with general open-ended questions, asking the interviewees how they perceived the challenges posed by the disruptive technology and how they tried to deal with them. Follow-up interviews and discussions also took place in order to confirm that the gathered information had been interpreted correctly. This interaction has taken place over more than two years, and often the follow-up discussions have been held by phone. It is difficult to estimate how much time this work sums up to, but it is clear that these sessions have helped to verify and sometimes nuance certain findings. Additionally, some email correspondence with photographers who had experienced the technological shift has taken place, mainly in order to confirm the firm-internal sources.

The data collection and analysis have largely been conducted in parallel, thus following an abductive approach to research (Dubois and Gadde, 2002). After the first round of data collection in 2007, the data were discussed and analyzed during several sessions together with the other authors of the first appended article. Based on these interactions, a first write-up and within-case analysis was performed, which eventually resulted in the first paper. One way of structuring such an analysis is to put information in chronological order and to identify certain key events (Miles and Huberman, 1994). This approach was employed and a couple of critical events were identified by observing that many interviewees referred to certain incidents. These include for instance when Sony launched one of the first cameras not using film in 1981, the founding of Hasselblad Electronic Imaging in 1985, the attempts at developing a digital camera in the 1990s, the ownership changes that took place and the development of a new camera system in the late 1990s.

Type of document	Time
Hasselblad annual reports, Hasselblad Electronic Imaging Annual reports	1984-1994, 1985-1992
Minutes from board meetings	1989-1995
2 Internal company presentations regarding digital imaging	1997, 1997
Mail conversation between the R&D manager and the CEO	1995; 14/2, 1996; 8/10,1995
Internal memorandums regarding digital imaging	27/10, 1992; 14/6, 1997; 14/8, 1995; 1996*[21]; 13/1, 1997; 1994-95; 16/6, 1996; 6/1, 1997; 9/10, 1996
Report concerning Hasselblad Electronic Imaging	June, 1993
Minutes from meetings at the division for digital photography	24-25/3, 1994, 18/8, 1995
The Tokyo Meeting (on product strategies for the future) Short summary	1996
New Camera – Market Research and Concept Studies	7/4, 1997
Minutes from 14 product board meetings	1996-1998
A proposal for a new analog camera system	4/7, 1997
Product Proposal – Wedding photographer's digital camera system	13/5, 1996
Mail conversations between the digital and analog R&D managers	19/2, 1998; 3/4, 1997
Business plans − technical photography and digital imaging	14/5, 1998; 27/2, 1998
Mail conversation between Hasselblad and Philips	4/9 – 22/11 1997
Requirements and preferences in the Project Crystal Ball	30/8, 1995
The "Facit" crisis of Hasselblad, internal PM	1/1, 1994
A proposal regarding tasks for the division of digital photography	27/2, 1997
Mail conversation between an R&D manager and UBS	16/1, 1997
Agreement for a CCD sensor component between Hasselblad and Philips	3/11, 1994
PM "The exclusivity issue of the Philips FT19 CCD-sensor"	2/9, 1996
Hasselblad product development process	6/6, 1995
Summary of the Hasselblad International Marketing Conference	19/4, 1991
Report to the Hasselblad foundation about the future of digital imaging	November, 1997
PM regarding corporate culture at HEIAB	10/9, 1990
Meeting notes: Distribution Strategy & Hasselblad Customer Care	23,4, 1996
Interaction with Leaf Systems	9/4, 1996; 29/3, 1996
Hasselblad "Works" − Digital Photography Business Concept	22/4, 1996
Area sensors for High Quality Digital Cameras	1996*
Minutes from meeting regarding Digital Photography Strategy	24/4, 1996
Concept study of digital flexbody and an internal PM on the subject	1997*; 19/6, 1996
Definition and positioning of products for digital imaging	11/5, 1993
The mK*nK image sensor, by Philips Imaging Technology	1995

Table 2 provides an overview of some of the most important archival sources that have been accessed in this study.

[21] The documents which are marked with a * in the right hand column do not have a date on them, they have been dated according to where in the archives they have been found.

Respondent title	Respondent function	Interaction
Three CEOs from the period 1976-2004	In charge of creating and enacting the corporate strategy.	Four interviews, totaling approximately twelve hours.
CFO, 1978-2004	Responsible for financial issues.	Three interviews, totaling more than ten hours, extensive discussions and follow-up interaction.
Board member, 1990-2006	Labour union representative	Two interviews, totaling about five hours, discussions by phone.
R&D Manager, 1979-1998	Founder and CEO of the subsidiary Hasselblad Electronic Imaging (HEIAB), 1985-1992, responsible for digital photography, 1992-1996.	Three interviews, in total more than ten hours. Several follow-up discussions both by phone, mail and in person.
Market Manager and developer of digital business strategy, 1996-2004	Area manager in South America during the 1990s, in charge of digital business development for several years.	Three interviews of about 10 hours in total. Several mail conversations and discussions by phone.
Three electronics engineers	Worked at HEIAB and then on digital imaging in the 1990s.	Three interviews, in total about five hours.
Hasselblad manager	In charge of the Swedish operations for several recent years.	One interview, about one hour.

Table 3 contains information about some of the people who were interviewed within the scope of this study as well as their functions and the kinds of interactions that have taken place.

After this first round of data collection and analysis, theory on disruptive innovation was revisited and it became clear that this case exhibited some characteristics that made it theoretically interesting. Digital imaging had unlike many historical examples emerged in the established value network of the incumbent firm Hasselblad. Hence, the case presented an interesting contrast to the typical pattern of low-end disruption as described by Christensen (1997), and therefore offered an opportunity to explore how a disruptive technology prospers in an established value network. Moreover, the fact that Hasselblad's customers demanded digital photography at a rather early point as a complement to analog photography made it possible to study other parameters than the customer, and thereby to address in what ways a disruptive innovation is a business model problem. These observations triggered additional research into the case. The study therefore went into further detail regarding how and why

digital imaging prospered in this value network and what challenges the studied firm encountered. Questions related to these issues were asked to at least two senior managers from one era and compared to the internal documents that had been accessed.

The case descriptions about Hasselblad emerged once similarities had been observed between the archival data and the interview data, thereby triangulating the findings. The large amounts of primary and secondary sources of evidence along with the follow-up sessions should most likely have resulted in an accurate interpretation of the studied events. A detailed case description of approximately 50 pages was written based upon these data and another within-case analysis was performed. The second appended paper and the description of the Hasselblad case in the third paper emerged from this analysis.

3.2.2 Study 2 – Managing discontinuous innovation

This study has been performed as one part of a research project called the Discontinuous Innovation Project (DIP). Within the scope of this work, empirical data have been gathered from three Swedish firms. They come from the personal care industry (more on this in study 3), the mechanical engineering industry and video surveillance.

Initially, the study was quite broad and exploratory in order to look for interesting empirical observations that could be further investigated. The main purpose was to explore how firms are working with challenges related to discontinuous innovation and more specifically to disruptive innovation. Open-ended, semi-structured interviews were conducted at these firms, in several cases together with one or two other researchers[22]. The questions concerned such issues as idea management and discontinuous innovation, selection mechanisms and business development. This broad scope enabled the researchers to obtain insights which helped them to identify issues of further interest. Hence, the study was largely abductive, where the initial round of interviews generated knowledge that could be followed up with more detailed investigations later on. The interviewees all had in common that they had been working on some projects which were of a more discontinuous nature compared to the established business. Additionally, some technology-specific documents were obtained under secrecy. In total, three workshops were also held together with these and other firms where key findings were reported, validated and discussed in further detail.

A formal relationship has been maintained with two of these companies during 2007-2009. These relationships enabled extensive access to information that it would have been difficult to access otherwise. Moreover, innovation audits were performed at these two firms during 2007 by the Center for Business Innovation, which the author belongs to. Within the scope of these two audits, interviews were conducted with managers and directors who had positions that were related to the innovation process. The interviews were semi-structured, asking the

[22] Jennie Björk and Mats Magnusson.

respondents about such issues as the company's current processes, its organization, its idea management system and innovation strategy. In addition to this, scorecards regarding the creative climate and the innovation work in general were sent out on a broader scale. While this work was performed by a team of researchers and industry partners and did not directly generate any data that were used in the papers, it still served as vital background information. Furthermore, it helped the author to gain more practical insights into innovation work at companies, which in turn made it easier to understand what kinds of challenges were both industrially and theoretically relevant. This partnership also enabled access to databases, internal presentations, follow-up discussions and key employees. Working together with firms over a longer period of time also creates an important contextual understanding of present challenges and ways of working.

During this first round of data collection, four interviews were conducted at each firm. At the firm in the mechanical engineering industry, the respondents came primarily from the concept development department. The main task for these people is to test and develop ideas into concepts, which in turn can result in new products. The interviews lasted for about one hour. Each interview concerned one discontinuous product innovation, how it had been developed and the main problems which had been encountered.

Similar issues were addressed at the second firm, where four interviews of approximately 90 minutes were performed. The company is present in the video surveillance industry and is driving the ongoing shift from analog CCTV to digital, IP-based video surveillance. Some of the interviewees were working on technological issues, others were managers of R&D and one of the co-founders of the company was also interviewed. The questions concerned how the firm is working with new ideas which lie beyond the scope of its current business. The fact that this technological shift was disruptive in many respects triggered further interest in the company and the industry and it was therefore revisited in the fifth study.

Case descriptions were written based upon this information after a round of discussions with the other two researchers participating in the study. The descriptions were related to existing literature on discontinuous innovation and it was concluded that this stream had largely overlooked the difficulties encountered by firms which try to launch innovations that are discontinuous for the customer, i.e. incompatible with existing processes and practices or require a significant change in firm behavior.

The study went into further detail at the firm operating in the personal care industry, looking at how idea management systems can be designed in order to capture, generate and develop both discontinuous and steady-state innovation ideas. This issue was considered of particular interest at that time since it has been stated in the literature that discontinuous and disruptive innovations need to be treated differently, but that knowledge is needed regarding how such systems can be designed. The studied firm was targeted since it had a long experience of idea management and had tried to change its system in order to handle both minor and more

discontinuous initiatives. In total, more than 30 interviews were performed. Many of these interviews were conducted together with other researchers within the scope of the previously mentioned innovation audit. This work provided important background information but also offered an opportunity to ask different people at the firm how the idea management system worked in practice. People who had a relation to the idea management system were targeted, for instance R&D managers, contributors to the system and the persons who were in charge of it and had designed the system. The interviews were semi-structured and focused explicitly on the idea management system, how it works, its advantages and drawbacks and how it has changed over time. Follow-up interviews were also conducted in order to make sure that the results were correct. These, in combination with key statistics from the firm's idea database where descriptions of ideas within the company are stored, have increased the validity of the findings.

One consequence of a broad and exploratory approach when undertaking a study is that its final results are beyond the original objective. This was the case with some parts of the described study and therefore, it did not directly lead to any corresponding paper in this dissertation. However, it still helped to identify some areas of interest which have been further addressed in other studies like the third and fifth ones. The aforementioned idea management case resulted in a paper; see Sandström and Björk (2010) for further information. This article was not included since in the end, it did not really fit into the overall research objectives of the dissertation.

3.2.3 Study 3 – Inhibitors and triggers of discontinuous innovation

The third study was performed at the previously mentioned established firm which has been a global player in the personal care industry for many decades. The company is developing and manufacturing diapers, feminine pads and incontinence products. These products have in common that they are mainly based upon absorption technology. The industry can be regarded as technologically mature and well consolidated. There are a couple of large companies such as Kimberley-Clark and Proctor & Gamble which dominate the industry on a global level.

From the 1980s onward, the studied company lost market shares in Europe within the diaper and feminine pad categories due to increased competition. The firm pioneered the incontinence market in the 1970s and is a dominant actor in this business today. Over the years, the company has sought to sustain its leading position by launching innovative incontinence products, but it has remained a follower in the diaper and feminine pad markets. Incontinence products are sold to end-consumers, retirement homes and hospitals. The performance of these products in terms of absorption capacity has increased steadily over time, and thus the company has focused increasingly on new attributes over the last decade.

The study at this company was initiated after the aforementioned innovation audit had been performed by the Center for Business Innovation in November 2007. One outcome of the audit was that the company needed to better understand how discontinuous innovations could be selected and developed. A five-month research project was started which aimed to understand how discontinuous innovations had been both rejected and developed in the past. This input would in turn generate recommendations regarding how the firm could design its development process related to the recently launched New Business Development unit.

Though it was not obvious that the study would ultimately fit into this thesis, it resulted in an article that met the overall purpose of the thesis, and therefore it was included. The project was performed together with Ralf-Geert Osborne, master thesis student from Delft University. In total, the evolution and fate of eight discontinuous innovation projects were studied and documented through semi-structured interviews with both current and former employees at the company.

Two rounds of interviews were conducted within the scope of this study. The interviews were carried out by two researchers, thereby eliminating any potential personal bias. All interviews were recorded, transcribed and listened to afterwards. This work has been documented in Osborne (2008) and should be regarded as important background information about innovation activities at the studied company. In the first round of interviews, the questions were more general and open-ended. The respondents were asked to identify innovation projects which had been discontinuous to the firm as well as the main inhibitors and triggers of them. All the respondents had worked at the company for a long time and were able to explain how different innovation initiatives had evolved. A majority of the respondents were working in the R&D department and others were more involved in market-related activities (see Table 4); thereby insights were gained regarding both technological and more commercial issues.

Respondent title	Respondent function	Interaction
Manager of Innovation and Knowledge	Responsible for the development of the screening process. Primary contact person during the course of the study.	Two interviews, about one hour each. Extensive interaction by phone. The respondent read and validated the paper emerging from the study.
Research Director	In charge of research at the studied firm.	Two one hour interviews.
Two fellow scientists and one former fellow scientist	The most senior position for scientists.	Two one hour interviews per person in all but one case.
Two senior scientists	The second most senior position for scientists	Two interviews per person, approximately one for each session.
Three persons in charge of product portfolio management	Responsible for the development of the resource allocation process for more incremental product development projects.	One 90 minute interview with all three respondents and to individual 60 minute follow-up interviews with two of the respondents.
One sales manager	In charge of supporting and developing the sales of heavy incontinence products.	One interview which lasted about 90 minutes, discussions by phone. The respondent also proofread the resulting article.
One manager of the idea system	Responsible for the idea management system and had been working previously on developing a discontinuous product innovation.	One interview by phone which lasted for about one hour.

Table 4 provides information about the people who were interviewed within the scope of this study (adopted from Osborne, 2008).

The gathered data were compared and contrasted to existing literature on discontinuous innovation and business model renewal through a cross-case analysis. Some of the cases were discontinuous with regard to the firm's established competence base whereas other cases were more related to the customer and the surrounding value network. After this analysis it became clear that one of those eight projects had some disruptive characteristics and was therefore deemed to be particularly interesting for this dissertation. It was identified as more relevant in relation to the other ones since value networks and business models seemed to play important roles in determining the success or failure of this product launch. In addition to this, the case provided an opportunity to understand how challenges related to the value network can be managed since the studied product started as a commercial failure but

eventually took off after a couple of business model changes had been made. In this sense, the case was interesting since it was largely related to the second research question that is dealt with in this thesis.

More emphasis was put on this case in the second round of interviews. As the challenges of particular interest were related to the commercialization aspects, people in charge of those issues were specifically targeted. All of the interviews were recorded and transcribed except the two interviews which were performed by phone. The case description that emerged from this research was later on read and validated by the person who had been working with the main business model changes that this product had implied, and by the innovation manager. A within-case analysis was now conducted where the gathered data were compared to existing challenges related to business model renewal. This analysis resulted in the fifth appended paper. After the termination of the project, a final presentation was given to the company where the main findings and conclusions were communicated. During this session, the general interpretation of the collected data could be validated one more time.

Hence, this study was in many ways a collaborative one in the sense that it involved an interaction with a firm which in turn had specified a couple of deliverables from the project. Collaborative research is often criticized for reducing the reliability and replicability of the undertaken research. However, this should not be regarded as a major concern for the study above. The main reason is that while some of the research has created recommendations that have in some cases been enacted by the company, this was not the case for the parts of the studies that the related paper and its conclusions were based upon. These recommendations were concerned with the evaluation of business ideas within the scope of the new business development unit. The paper that emerged from this study is based on a case that the authors have not been influencing during the course of the study.

As can be seen above, an abductive approach has been employed in this research project. It started as a general exploration of inhibitors and triggers of discontinuous innovation; several different cases were identified, and after a cross-case analysis one seemed to be of particular interest, which in turn triggered further research into this case. As can be seen in this study and the previous one, a broad approach results in a lot of freedom, which in turn may imply that some of the gathered data are eventually not of direct use for the dissertation. Nevertheless, they have generated important insights which have been further developed in other studies and corresponding papers.

3.2.4 Study 4 – Facit and the displacement of mechanical calculators

Facit was a Swedish manufacturer of typewriters, mechanical calculators and office machines. In 1971-1972, the company went from almost 50 years of expansion and continued profitability to being close to bankruptcy. The shift from mechanical to electronic calculators was the main reason why Facit encountered problems. Prior to the transition, the industry was characterized by high entry barriers and extensive vertical integration, both up-stream and downstream. A few large companies which controlled specialized machinery for the manufacturing of components dominated the industry (Majumdar, 1982). These firms also had large sales organizations and maintained close relationships to their industrial customers. The shift to electronics created insurmountable challenges for many of these companies, and Japanese firms like Sharp, Casio, Canon and Busicom entered the scene in the mid-1960s. By the early 1970s, some Western semiconductor firms like Texas Instruments and Rockwell entered the industry, which was now subject to rapid incremental development and a sharp decline in prices.

While some work has been done regarding Facit and the shift to electronics (e.g. Starbuck and Hedberg, 1977; Starbuck et al., 1978), this case has not yet been addressed from a disruptive innovation perspective. Other scholars have focused on such aspects as leadership and organizational impediments (Pettersson, 2003), but the value network dimension of this incumbent failure has not been investigated before. Moreover, the fate of Facit is often mentioned by scholars, but rarely treated in detail.

The fact that the initial diffusion of digital technology happened in very advanced segments such as military or scientific applications (Utterback, 1994), then entered Facit's segment of office machines, and later on yielded consumer products triggered the author's interest in the industry and the company. While it was clear that electronic calculators had disruptive properties, the initial investigation made it plain that electronic calculators did not emerge in the way that Christensen's framework would suggest. Nevertheless, it was evident from an early point that value networks and the environment played an important role in the transition from mechanical to electronic calculators. Additionally, the fact that electronic calculators prospered in Facit's market segment in the late 1960s and early 1970s made it an interesting case to study within the scope of this dissertation. A historical case like this was also deemed to be suitable since the dynamics of the shift could be followed and analyzed in retrospect. An additional reason for studying these companies was that extensive information could be accessed at the Facit archives in Åtvidaberg, Sweden.

A study of Facit would therefore be suitable for exploring where and how a disruptive innovation actually prospers and what challenges a firm encounters. The books and texts that had been published regarding the company's fate (Pettersson, 2003; Torekull et al., 1982; von Kantzow, 1991) were read and then an extensive amount of historical documents were reviewed. In total, two weeks were spent going through the Facit archives in Åtvidaberg, Sweden, where the company used to be headquartered. Two weeks were not enough to allow

a complete investigation of the abundant sources available. The author therefore decided to focus on documents which concerned strategic decisions related to the transition from mechanical to electronic calculators. The following documents were reviewed:

- Annual reports from the period 1959-1974
- Minutes from board meetings, 1964-70, 1972
- Minutes from top management meetings, 1961-72
- Forecast of future sales of electronic calculators 1970-72, 1970
- Statistics regarding prices on electronic calculators 1967-1970, 1970
- Data on Facit's profitability 1960-1970, 1970
- Consulting report on cost savings by H. Bohlin et al., 1962
- Ciceronen, company magazine, 1960-72
- Internal documents related to the collaboration with Sharp

In addition to the archival sources, interviews have been conducted with former directors of the company, e.g. the CEO of Facit from 1957 to 1968, one member of the top management team and one person who worked with the market-related aspects of electronic calculators. In total, six interviews were performed, totaling approximately 20 hours. The interviewees were centered around open-ended questions regarding the emergence of electronic calculators, its impact on the company's capabilities and the established business model. Moreover, those issues which were identified as particularly interesting from the archival studies were further addressed during the interview sessions. One potential weakness of this study is that some people whom it would have been interesting to interview have passed away. However, the combination of interaction with key individuals and access to rich archival sources has still generated a sufficiently good understanding of this case to address the issue of value networks and disruptive innovation.

The collection and analysis of the data were guided by existing theory on disruptive innovation. After the first week of studies in the archives, it became clearer in what ways the introduction of electronic calculators illustrated several important challenges that existing theory had largely overlooked. This interpretation of the gathered data was presented to other researchers who had been interested in the case.[23] A case write-up and a within-case analysis were conducted. These data were in turn compared with the data from the first study regarding Hasselblad and the gathered data about IP video surveillance. The third appended article is based upon this analysis.

[23] Mats Magnusson and Jan Jörnmark.

3.2.5 Study 5 – Disruptive innovation and business model renewal

Previous studies and existing literature have identified the importance of changing the business model in order to succeed with innovations which have more disruptive properties (e.g. Christensen, 2006). However, little is known regarding the specific challenges and managerial solutions in terms of business model renewal in relation to these innovations. The study was arranged in order to fill this gap and sought to investigate what challenges firms encounter when trying to renew their business models in relation to innovations of a more disruptive nature.

In order to understand why incumbent firms seem to struggle under conditions of disruptive change, both established firms and entrants were targeted. By doing so, these groups can also be contrasted to one another. The companies come from a wide range of different industrial settings such as video surveillance, floor finishes and healthcare products. The video surveillance case had been identified as interesting within the scope of the second study and was revisited. The other case companies were targeted because they had experience of launching product innovations which required changes in the business model. An additional reason for studying these firms was that they could be accessed. By approaching these companies, insights could be gained into what factors influence the success or failure of these innovations.

Having looked at the phenomenon of disruptive innovation in great detail in several of the previously described studies, this study broadened the sample a bit and went into less detail. Since the study aimed to point out how firms actually try to handle these challenges and since one can expect some variety here, a lower level of detail and a larger sample were deemed to be appropriate. Hopefully, this research strategy could also help to improve the generalizability of the findings. As has been stated by Christensen (2006), disruptive innovation is primarily a business model problem. Hence, a special emphasis was put in the interviews on how and why the innovation required a new business model, how the firms went about undertaking such a change and what challenges they encountered. On average, 2-3 interviews were conducted at each company. The respondents all had in common that they had tried to align the business model with the value creation associated with the disruptive innovation (see Table 5). They were targeted with specific questions regarding how the innovation created value, for whom and in what ways this creation and distribution of value required changes in the business model. Thus, as stated previously, this data collection did not go into as much detail as the other ones, but instead drew upon a slightly wider sample. By carefully targeting interviewees with well-specified questions, the relatively low number of interviewees per case was partly offset. All interviews were recorded and listened to afterwards. In addition to this material, official documents such as annual reports, press releases and marketing material were reviewed.

Case write-ups were made afterwards, the respondents proofread the case descriptions and were offered the opportunity to make the cases more anonymous if needed. The different

cases were compared and contrasted to each other in a cross-case analysis in order to look for patterns across them.

Company and cases	Respondent	Interaction
A European company in the healthcare industry	The director of marketing	One interview which lasted for about two hours, some discussion by phone
	The engineer who developed the product and worked with it for 25 years	One phone interview for about one hour.
An entrant firm in the floor finishes industry	The founder and CEO of the company.	One two hour interview
A European entrant firm into the video surveillance industry	The technology manager	One interview, which lasted for about two hours.
	Two people in Business development	One two-hour interview session.
	Two PhD students working on technological convergence and industrial transformation in the security industry	One discussion section which lasted for about 90 minutes.
An established firm in the floor finishes industry, two different cases.	R&D manager	An interview and discussion session of about two hours.
	Senior engineer	Extensive contact by phone on several occasions.
	Division manager	One interview which lasted for about two hours.
	Former director of the market organization	Two interviews, about two hours each.

Table 5 provides information about the people who were interviewed within the scope of the fifth study.

3.3 Validity and reliability

When assessing the employed methodologies, reliability and validity are two important criteria. Reliability can be defined as the possibility to replicate the study. Given that several of the conducted case studies are based upon historical events which have been described through both accessing key interviewees and internal documents, it should be possible to replicate these studies. This kind of formal documentation is often considered to be stable, unobtrusive and exact (Yin, 1994). It can be reviewed by another person who would most likely draw similar conclusions. The reliability of the three studies which do not rely upon archival sources is admittedly weaker. However, the documentations and explanations of the explained methods above should still make it possible to repeat the studies.

Validity can be thought of as either internal or external. Internal validity refers to how well the collected data match the reality that they seek to represent. There are several ways to improve the internal validity. One way of doing so is to use different sources of data and then triangulate (Yin, 1994). In the abovementioned studies, the internal validity was enhanced by using several different sources such as interviews and access to a vast amount of archival data. Since the case studies emerged from similarities in those different sources and were often subsequently confirmed by conducting follow-up interviews, the internal validity could be increased. Another way of improving it is to compare data with existing literature (Eisenhardt, 1989). Such comparisons and contrasts have to some extent been made in the articles that emerged from the different studies.

Interviews are subject to selection and respondent bias, as these data by necessity mirror an individual's beliefs, values and experiences (Flick, 2006). As was stated in the descriptions above, this issue has been handled by interacting with the respondents throughout the studies. Key respondents have been asked to proofread and comment on case descriptions and moreover, the follow-up sessions, seminars, workshops and company presentations that have been held have contributed to ensuring a correct documentation. Furthermore, interviews have often been recorded and transcribed and in many cases performed together with another person, which also contributed to increasing the reliability of the studies.

A couple of other measures have been taken throughout the course of this research in order to offset the abovementioned problems. It is important to make sure that the interviewee can express opinions without being subject to undesired repercussions. When required, the author has therefore on several occasions signed Non-Disclosure Agreements. However, as the presented work is more concerned with innovation processes and networks than with innovation content, this was often not necessary. In those cases when an interviewee wished to be anonymous this was also arranged.

While this dissertation addresses the role of value networks and business models with regard to disruptive innovation, it has primarily relied upon sources from focal firms rather than their surrounding networks. There are several reasons why this approach has been employed.

Firstly, the thesis is primarily concerned with the challenges that these firms encounter, how they introduce disruptive innovations and try to change their business models. Secondly, while the firm's environment is of great interest, it can still be studied and understood by approaching the firm. After all, the focal firm is the one actor that is subject to the external control and is the one that encounters the difficulties which need to be studied with regard to disruptive innovation. As the conducted research is concerned with the challenges a firm encounters and how the innovations emerge, the focal firm is arguably the actor that it is most suitable to address. Thirdly, it would be interesting to study a network in its entirety, but such an approach is by necessity more time consuming and would thus have drawn upon fewer, more detailed studies which in turn would have resulted in a reduced generalizability. Within the scope of this doctoral research project it has therefore not been possible to collect data from entire networks.

The external validity can be defined as the possibility to draw general conclusions from the conducted research. It is often argued that case studies impose constraints upon the external validity of the findings, given the explicit focus on a certain event (Yin, 1994). It should be pointed out here that the presented work aims to develop new theory rather than testing existing theory. According to Eisenhardt (1989) a case study is the appropriate research strategy when little is known about a phenomenon and existing theories seem inadequate or insufficient. This dissertation does not aim to provide an exhaustive set of answers. The purpose is rather to improve existing theory related to disruptive innovation.

The potential weakness in terms of external validity has been handled in a couple of different ways. Some generalizations can be made by carefully choosing which cases to investigate. An attempt to do so is made in the first study and the resulting paper about Hasselblad and the shift to digital imaging. The second appended article draws upon this study of one firm in the camera industry, and then discusses on a more general level whether this pattern is applicable to other industries where microelectronics has displaced other technologies. While such generalizations are partly speculative, they may still inform the reader and trigger further research into the same area.

The external validity can be increased analytically, i.e. by relating cases to theory and thereby reaching conclusions which are more general. The cases have helped to illustrate and point out issues which need to be better understood theoretically. Such an empirically informed perspective can hopefully in turn result in conclusions which are still valid. The fourth appended article and this covering paper focus explicitly on doing so. These documents seek to develop theory by synthesizing theory and the observations that have been made in other articles and studies.

The fact that some studies draw on a wider set of cases should hopefully also result in a higher external validity since they can be compared and contrasted to each other. In this dissertation the studies and corresponding papers differ in terms of how detailed the cases

are. Some of the articles are written with a high level of detail whereas other studies draw upon a wider range of cases. The articles which draw upon a wider sample should hopefully result in a broader and more comprehensive understanding of the studied questions.

3.4 Reflections on the research process

As can be seen in the descriptions of study 2 and study 3, the undertaken work has not always been as structured and linear as its eventual outcome in the form of this dissertation. Therefore, a couple of remarks on the research process need to be made.

Throughout this research process, the issue of discontinuous innovation has been addressed more generally in some studies and thus, not all of the gathered data made a direct contribution to the dissertation. Though the final outcome of this doctoral work follows an overall research objective, the underlying research has in many ways been less straightforward.

During the course of this doctoral work, a couple of critical incidents have driven the dissertation towards its outcome. One such event was when the author realized that the emergence of digital imaging in Hasselblad's high-end segment of the market and the resulting challenges were in many ways inconsistent with what existing theory on disruptive innovation would predict. In 2007, discussions took place with Jan Jörnmark[24] regarding whether the displacement of Facit's mechanical calculators was a disruptive event or not. The argument was never really settled, which in turn compelled the author to take a closer look at what actually happened to the company. The third study helped generated the important insight that existing literature on discontinuous innovation had maintained a somewhat simplistic view on customers and value creation. This observation also shed some light on the IP video case and the fate of Hasselblad. A conference paper was written based on these thoughts but was eventually excluded from the dissertation (Sandström, 2008). In order to better explain the theoretical inconsistencies that had been observed, the author then revisited existing work on disruptive innovation and started to read more literature on value, networks and business models. This work in turn resulted in the fourth appended article, which is a purely theoretical article. The last two articles are largely based upon these insights, but are more empirically oriented.

The performed research has therefore been iterative; empirical studies have shed new light on existing theory and previous studies, which in turn has had an impact on the design of the following studies and articles. One of the main challenges related to case study research is to find and construct a study that is so detailed and specific that it addresses the formulated research questions (Yin, 1994). Hence, the method used implies a high demand on the

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sampling of cases and the collection of data. The sampling procedure employed in this dissertation has been largely driven by theory (Miles and Huberman, 1994). Cases which have been relevant for the literature on disruptive innovation, value networks and business models have been identified. Those cases which have exhibited theoretically interesting characteristics have been revisited and studied in further depth. Thus, the sampling procedure has been based upon theory, but the process has also been largely iterative.

The obvious drawback of this approach is that some studies have been of little direct importance for the dissertation. However, this process has enabled the kind of flexibility and continuous learning that is often necessary, since the eventual outcome was unclear when the work was initiated.

4. Summary of appended papers

This thesis is based on six papers, which are appended in full versions at the end. In this chapter, the main findings from each paper are briefly presented. These results are developed further in the coming two chapters, which contain an analysis and discussion.

The first article was also the first publication that emerged from this doctoral research. It was written in mid 2007 after the first round of interviews and data collection had been conducted regarding Hasselblad and the transition to digital imaging. It is therefore less detailed than the following articles on the firm. One key finding that emerged in the article was that existing theory had not really dealt with the specific challenges that different firms face. This finding helped the author to realize that theory on disruptive innovation needs to be improved, which in turn triggered a more detailed investigation of Hasselblad as well as further theoretical and empirical work on the subject. Hence, this paper has played an important role in the development of this thesis, but primarily by identifying issues that could be further explored. Therefore, it has been included in the dissertation.

The following two papers essentially provide empirical illustrations of how disruptive innovations arise in established value networks and in what way they are business model challenges. These observations in turn called for further theoretical development and therefore, the third paper aims to develop the theory on disruptive innovation, partly by introducing new theoretical perspectives on the subject.

The fifth and sixth articles to some extent give further case evidence of the challenges related to disruptive innovation and business models, but they are also more managerially oriented and have thus contributed to the managerial implications described in section 8.

4.1 Paper I: Exploring factors influencing incumbents' response to disruptive innovation

This paper looks at how the characteristics of an incumbent firm affect its response to disruptive innovation. Studying a high-end, niche player in the camera industry like Hasselblad, it is argued that previous literature has maintained a somewhat simplified view of established firms. Frequently, these firms are treated as one population vis-à-vis entrants and little attention is paid to the different challenges that they face.

The paper shows that Hasselblad's niche strategy and its limited resources created specific problems. The initially lower image quality associated with digital technology made it difficult for the firm to experiment with it, despite the fact that many studio and catalog photographers benefited largely from digital imaging at an early point. Having focused on the

high-end segment for decades and built up a reputation for delivering supreme image quality, it became difficult to experiment with the technology. Additionally, the limited resources available implied that Hasselblad had to collaborate extensively in order to meet the digital challenge. The paper also illustrates how various changes in ownership over the years created a strategic inconsistency which further augmented the difficulties. In conclusion, this paper suggests that both challenges and managerial solutions to the innovator's dilemma are largely dependent upon the particular characteristics of firms.

4.2 Paper II: Hasselblad and the shift to digital imaging

As stated in the literature review, previous research has suggested that disruptive innovations emerge either in low-end segments or in new markets. However, it is unclear whether and why they also can prosper in mainstream or high-end segments, and what the challenges would be under these circumstances.

It is clear from the descriptions in the paper that it is problematic to illustrate this emergence by using Christensen's (1997) graphs of how disruptive innovations prosper. These graphs essentially suggest that technologies with an initially lower traditional performance start to prosper in lower segments where the ancillary attributes are valued. Digital imaging, on the other hand, grew in a high-end segment despite its lower image quality and thanks to its other properties. Hence, it attacked from below in terms of performance, but emerged in a high-end segment, i.e. in Hasselblad's part of the market. Such a pattern is largely incompatible with Christensen's framework and thus calls for an improvement of it.

The paper provides a detailed empirical illustration of how and why a technology with disruptive characteristics may emerge in an established value network, despite its lower traditional performance. This pattern is largely inconsistent with Christensen's framework and it indicates that the challenges were more related to the established business model and the value proposition Hasselblad had historically brought to the market, which in turn implied that less resources were allocated to digital imaging in the 1990s.

4.3 Paper III: High-end disruptive technologies with an inferior performance

The third article in this dissertation resembles the second one in being rather empirically oriented. It draws upon case studies and aims to further investigate how and why disruptive innovations emerge in established value networks, as well as pointing out some related challenges. As stated in the literature review, little attention has been paid to this issue and more knowledge is needed in this area. The article aims to fill this gap by presenting and analyzing three illustrative case studies. They are all related to a transition from analog to

digital technology: calculators, cameras and video surveillance. In the first two cases incumbent firms were studied (Hasselblad and Facit) and in the case of video surveillance an entrant firm was targeted. These cases also have in common that the new technology exhibited disruptive characteristics, but did not prosper in a low-end segment or a new market. Rather, they were introduced either in the mainstream or the high-end segments of the market where the former technology had existed previously. The main reason for this seems to be that the ancillary attributes of the technology could compensate the lower traditional performance, for instance by removing certain activities and actors thereby creating an increased value for the customer.

The article argues that the questions of how and for whom value is created need to be further addressed in order to fully comprehend the challenges related to disruptive innovation. Moreover, diffusion models may be over-simplified and a more nuanced view of customers and networks is needed, particularly in a business-to-business setting where there are several different actors affecting adoption.

4.4 Paper IV: Value, Actors and Networks – a revised perspective on disruptive innovation

The previous articles identified two main areas of disruptive innovation theory which need to be improved. Firstly, it was argued that too much focus has been put on performance dimensions rather than value and utility. Secondly, existing literature had maintained a somewhat simplistic view of customers and networks. These findings call for a better theoretical understanding of the phenomenon of disruptive innovation. The fourth appended paper aims to nuance and improve existing literature on this topic by drawing upon several bodies of literature that have not been used in this setting before.

The article seeks to develop theory on disruptive innovation with regard to these two aspects. An extended conceptualization of the phenomenon of disruptive innovation is proposed. It is argued that these innovations can be understood as a change along two dimensions – actors and value. Disruptive innovations create utility in new ways and may imply a new distribution of value in a network of actors that control different resources and perform different activities. This perspective also makes it more clear in what way a disruptive innovation is a business model problem (Christensen, 2006). This issue is dealt with in further detail in the following articles and in the coming sections of this covering paper.

4.5 Paper V: Managing business model renewal

Literature on disruptive innovation has stated that disruptive innovation is a business model problem, but remained unclear regarding how and why this is the case (Christensen, 2006). The fourth article in this dissertation provided additional insight into this issue by drawing upon literature on networks, value and utility, but also pointed out that more knowledge is needed regarding how firms can renew their business models and why it has often turned out to be difficult to do so. The fifth and the sixth articles in this dissertation address these issues.

While several scholars have pointed out that a competitive advantage can be obtained by changing the business model (Teece, 2009; Chesbrough, 2007) and that this may be particularly important when introducing disruptive innovations (Doz and Kosonen, 2009), more work is needed concerning how firms can actually go about doing so. Furthermore, given that established firms seem to be better at introducing products than changing their business models, more knowledge is needed both regarding the challenges and managerial solutions related to business model renewal.

In order to fill this gap, the article first reviews existing literature on business models. It gives special attention to the interdependent nature of business models and Zott and Amit's (2009) definition of a business model as "*a system of interdependent activities that transcends the focal firm and spans its boundaries*". The paper moves into further detail regarding interdependence by using literature on industrial networks, stating that networks are based upon restricted freedom (Ford et al., 2002) and that they can be analyzed in terms of actors, resources and activities (Håkansson, 1987).

The article draws upon an illustrative case study which is particularly interesting in not only offering insights into challenges, but also showing how firms can go about renewing their existing business models. It is argued that business models are difficult to reconfigure since such a change often requires a shift in existing linkages between a firm and its surrounding network. Developing a product innovation is in this sense easier since it is much more an internal issue than a boundary spanning activity. Bearing this interdependence and restricted freedom in mind, the article offers some guidelines regarding how firms can go about trying to change a business model when having introduced a disruptive product innovation.

4.6 Paper VI: Disruptive innovation as a business model challenge

This paper draws upon several different case studies, which illustrate both the challenges and how firms can proceed when trying to change their business models. It uses data from both incumbents and entrant firms, since it is widely believed that they have different abilities to succeed with disruptive innovation. As was mentioned in the literature review in section 2, several scholars have pointed out the importance of having a customer competence (Danneels, 2004) and that disruptive innovation is a business model challenge (Christensen, 2006). But little is known regarding in what way this is the case and how firms can actually implement this advice or what the specific challenges are.

The article aims to fill this gap in the literature by pointing out how firms work when trying to change their business models and what problems they encounter. One challenge concerns how the new value creation associated with the innovation is sometimes incompatible with the existing competencies and activities of key actors. Disruptive innovations may also create a new distribution of value, which in turn can imply that some actors lose power or status. Drawing upon Zott and Amit's (2009) interpretation of business models as interdependent and boundary-spanning, it is argued that changing a business model is difficult since such a change often involves actors beyond the boundaries of the firm. Attempts at business model renewal therefore take place under conditions of interdependence. Clearly, this issue imposes constraints upon efforts to change the business model as firms cannot maintain a complete control over their network. Nevertheless, the empirical illustrations show that networks can be changed and some managerial implications are provided.

5 Analysis

This section reviews key findings from the appended articles in order to answer the previously explicated research questions. It serves also as input for the more theoretical discussion in section 6 and the managerial implications provided in section 8.

5.1 Disruptive innovations in established value networks

As already described in the theoretical review in chapter 2, there has been little focus on disruptive innovations which emerge in established value networks. Since these innovations can emerge in both low-end and high-end segments and in new markets it would be strange if they were not sometimes in demand from the mainstream market, despite their lower traditional performance. Moreover, given that different firms operate in different segments, a disruptive innovation is likely to emerge in the value networks of some firms, unless it evolves in a completely new market. The empirical data in the appended papers show that this is indeed the case and point out that ancillary performance in some cases may compensate for the lower traditional performance associated with a disruptive innovation.

Both digital imaging and internet-based, digital video surveillance emerged by creating value in a new way for the customer's organization through the removal of labor, simplification of the work process and the introduction of new performance dimensions. For instance, IP-based digital video cameras allow easier installation and lower maintenance costs. These attributes compensate for the initially higher price and lower image quality in some traditional market segments. The net utility threshold for a disruptive technology (Adner, 2002) seems sometimes to be lower in high-end or mainstream segments since these customers can use the technology in order to lower overall expenses. While the price was higher and the technology in many ways inferior, its ancillary performance attributes conveyed value at a more systemic level and justified investment. The case of IP video suggests also that this threshold may be different depending upon the actor being targeted within the customer's organization. The studied firm chose to approach IT rather than security departments since surveillance has increasingly become based on IT. When installing cameras in an existing network, the overall cost of owning a surveillance system can be reduced and this value creation compensates for the higher price and the lower traditional performance in terms of image quality. Moreover, while the popularity of the technology has grown among mainstream customers, the other parts of the value network have changed to some extent. One such notable difference is that IT companies have become increasingly prevalent in the installation phase while traditional installers of analog CCTV have been slower to adapt the new technology.

Hasselblad, the camera industry and the shift to digital imaging is another interesting example of how a technology with initially lower traditional performance emerged in an established value network. Digital imaging exhibited disruptive characteristics since it offered a lower mainstream performance in terms of image quality and also brought new attributes to the market. These include for instance the ability to take a huge number of pictures at a low cost, to view photos instantly, and to replicate, send and manipulate them more easily. Despite its lower image quality, digital imaging started to prosper in the high-end segment which Hasselblad had dominated for decades. The technology emerged in the shape of digital backs, which are components that could be attached to Hasselblad's medium format cameras instead of a film magazine. A digital back essentially contains an image sensor and image processing software. In the 1990s several firms emerged based on the business idea to manufacture digital backs and sell them to the large installed base of Hasselblad photographers. This add-on was particularly appealing to studio photographers who could save days of downtime waiting and finish assignments in much less time. Additionally, the fact that the images were digital, enabled the photographers to manipulate and edit them, and to produce a relatively better end result, despite the lower image quality. This utility was so great that throughout most of the 1990s, photographers were willing to pay up to 15 000 USD for a back that offered a lower image quality than film. The first digital backs offered 4 megapixels whereas Hasselblad's analog medium format photos corresponded to approximately 36 megapixels.

The case of industrially coated wooden floors based upon UV technology, which is presented in the sixth paper, is another illustration of how a disruptive innovation can prosper in an established value network. For a long time, this technology offered poor traditional performance in terms of durability. It was therefore often used to complement traditional coatings. Nevertheless, UV-based coating was adopted rapidly by the manufacturers of wooden floors, mainly because it enabled radically more efficient production. The production line could be shortened, and the process was more stable and consumed less energy. In this case, the end-user of the floors had to bear the lower durability while the floor manufacturers benefited from the ancillary benefits of the disruptive technology. The technology was therefore quickly adopted by the industry and, over time, the durability has improved.

While the literature on disruptive innovation assumes that the properties of these innovations imply that they emerge in new value networks, the above findings show that this is not necessarily the case. They may also prosper by distorting or modifying existing value networks, despite their lower traditional performance. Such innovations seem to do so by creating value in new ways, for instance by removing labor or changing established activities. The new performance attributes may compensate for lower traditional performance to the extent that the technology is demanded by mainstream customers.

5.2 Disruptive innovation as a business model challenge

It was pointed out earlier that the literature on disruptive innovation states that the main challenge is related to the business models of established firms (Christensen, 2006). However, there are no good explanations for how and why this is the case, apart from those related to being "held captive" by existing customers and inability to look for new segments. Certainly, the customer and the resources it provides to the firm constitute one key element of a business model, but not the only one. Many definitions of business models focus explicitly on the creation and appropriation of value (e.g. Chesbrough and Rosenbloom, 2002; Hwang and Christensen, 2007) and others regard the business model as a structural template which answers a set of questions (e.g. Chesbrough, 2007; Yip, 2004; Teece, 2009; Osterwalder and Pigneur, 2005). These questions are often related to the value proposition, the revenue model, the customer, how to reach the customer, etc. Hence, although the customer is not the only component in a business model, the other parameters have received little attention. The empirical evidence provided in this thesis illustrate in what ways a disruptive innovation is a business model challenge.

The case of Facit is described in the third appended paper and provides a description of how a disruptive technology becomes more problematic once it starts to distort the established business model. Electronic calculators followed a top-down diffusion pattern in parallel with the sharp decline in prices during 1960-75. These products initially were very large and expensive and primarily used by the military or by larger research facilities. As their price went down, the technology entered Facit's business machines segment. Electronics in many ways was competence-destroying for Facit and therefore, the firm began to collaborate with the Japanese firm Sharp. Facit bought calculators from Sharp, gave them a different design and sold them on under its own brand. The data collected suggests that this collaboration worked quite well in the period 1965-1970. Facit was able to get a foothold in the growing yet still small market for electronic calculators while Sharp got an opportunity to sell larger volumes benefiting from Facit's global sales organization. At this point, digital technology did not distort Facit's established network – the value proposition was similar to that offered by mechanical calculators and it fitted into the company's vertically integrated business-to-business sales model.

In the early 1970s, however, the rapid miniaturization of electronics meant that a new, significantly different value proposition entered the market. Portable, pocket calculators were introduced and Japanese producers were increasing their volumes and targeting consumer markets[25]. Since Facit's sales model was based on small volumes and directed to professional

[25] The pocket calculator can be regarded as a new market disruptive innovation. It offered lower computing performance than the electronic desktop calculator but was smaller, simpler, cheaper and brought a new performance dimension to the market, namely portability. However, it should be underlined that the technology had prospered in significantly more advanced segments prior to reaching the consumer market, thus following more of a top-down diffusion pattern. Moreover, pocket calculators were in demand from both professionals and consumers. The case of digital imaging followed a similar, but not identical pattern.

users, its established, strong relations with customers had become less important. Calculators for both professionals and other users increasingly were being sold via other sales channels, e.g. bookstores and discount stores. The declining prices and reduced size of these products implied that manufacturers had to sell much larger volumes in order to remain profitable and Facit's sales model was not designed for this purpose. This issue appears to have exacerbated the difficulties Facit encountered and can be regarded as an important explanation of why the collaboration with Sharp became increasingly problematic over time as new sales channels became more important.

This case provides a compelling description of how the network impact determines the performance of a firm under conditions of disruptive change. In 1965-1970, electronic calculators fitted into Facit's existing business model. At this time, the main challenge for the company was of a competence-destroying nature. But as the technology improved, the sales model shifted from one based upon strong ties with a few customers to one based on mass distribution and lower margins. This made Facit's sales model and its strong relations to customers obsolete.

The Hasselblad case is another good illustration of how a disruptive innovation is a business model challenge. The firm struggled to enter digital imaging, despite the fact that their customers were demanding the technology from quite an early point. One of the reasons for this was that digital imaging was competence-destroying since the company's capabilities were related largely to precise mechanics and not electronics. However, the internal conflicts and struggles can also be explained by the fact that digital imaging was in many ways incompatible with the value proposition that Hasselblad had offered in the past. In the 1980s, the company had built a successful and profitable business around digital technology and image transmission. But this business was based on products other than cameras, for instance scanners for tele-photo transmission and various software applications. In these applications, digital technology could be used to improve the quality of the transmitted images and therefore was compatible with Hasselblad's core values. Moreover, this business was never really a threat to existing activities but was rather a complement. This initiative also struggled to gain legitimism in the beginning, but it is clear from the case description that developing a digital camera was a much more controversial issue. Ever since Hasselblad's cameras had been used on the moon in 1969, the brand had been associated with very high image quality. Digital photography created value in a different way and many elements of the firm such as the market organization and the mechanical engineers, believed that this offering was incompatible with the brand, which was perhaps the firm's greatest asset. Consequently, Hasselblad became increasingly polarized from 1993 and on. Eventually, a new, financially oriented owner stopped the digital development project in 1996 and changed the focus to a new camera system with modern features such as autofocus that would be compatible with the digital backs manufactured by other firms. This camera kept to the traditional values of Hasselblad such as superior image quality and became the firm's main priority in 1998-2003.

However, the project was severely delayed and the company struggled during these years when the transition to digital imaging came into motion. When the new system was finally launched it emerged that many customers had shifted to Canon's and Nikon's high-end cameras and hence, the new camera could only offset the sharp decline to an extent. Eventually, Hasselblad had to acquire a manufacturer of digital backs and could deliver a complete digital system in 2005, after being on the brink of bankruptcy for several years.

It can be seen from the two case descriptions above how the challenges that Hasselblad encountered were different from those confronting Facit during the time when the technology prospered in the segments in which these firms were operating. While the customers of both firms were demanding the technology, it brought a significantly different value proposition to Hasselblad's customers, at an early point. In other words, in the case of Facit, the technology was initially compatible with the business model, but this was not the case for Hasselblad. In the case of Hasselblad, the value proposition related to digital imaging did not fit the historical relations with customers. Digital imaging therefore became a highly controversial issue inside the firm – it provoked much conflict which seems to have paralyzed the company. Eventually efforts in this direction were stopped in favor of an initiative which was more in line with the value proposition Hasselblad had offered in the past.

These empirical cases suggest that the magnitude of the challenges faced by an incumbent not only depends on whether the disruptive innovation prospers in a new value network or not. If it prospers by distorting an established value network, it can become problematic if it imposes changes to the existing business model. These challenges seem to be different from those described in the original disruptive innovation theory which states that that the main problem is related to the control that existing customers impose on the resource allocation process within a firm. Incumbents essentially struggled to find a financial logic for entering a technology that their customers were not demanding, and which offered smaller profit margins.

The Hasselblad case shows that there was in fact demand for digital imaging from Hasselblad's customers, on which basis the company could have obtained profitable revenues. Given that several firms were founded and grew based on manufacturing digital backs it seems that a sufficiently large market existed and that the opportunity could have been financially attractive. Digital imaging emerged in the same segment as analog photography and thus the company became reliant upon the established market organization and relations to these customers. Hence, the main problem was rather that the new value proposition that was associated with digital imaging might distort the relations Hasselblad had with its customers in the past. It seems that customers control firms not only by supplying them with resources. The *relations* and *value propositions* that customers associate with a certain firm may hamper its efforts to introduce a disruptive technology.

The case of IP video is another example. IP-based video surveillance created value in a new way. Initially, it offered worse traditional performance that was accompanied by some new performance attributes. As a consequence of this new value creation, the technology distorted the established network constellation in several ways. Many integrators and users of video surveillance had little knowledge about how IP cameras were installed and used. Hence, the technology had an impact on the activities of several actors. Additionally, IP video affected the role of security managers in the end customers' organizations. IP surveillance meant that security was increasingly becoming an IT issue, which in turn reduces the power of the security manager vis-à-vis the IT manager. This caused security managers to be skeptical about the new technology.

The dominant analog players in the CCTV industry were used to targeting security departments with a different value proposition and could therefore be "held captive" by one actor in the customer's organization since security departments did not appreciate or understand IP video in the same way as IT departments. Conversely, entrant firms faced a challenge since the adoption of their technology depended upon changes often beyond their direct control. When value is created on a more systemic level and the disruptive technology prospers in another part of the customer's organization, some actors may gain influence at the expense of others. The convergence of IT and security is an ongoing process and entrant firms can influence it to some extent, but are nevertheless depending upon it and those changes may be complicated due to political barriers inside the adopting organization.

This case shows that there are many different distortions that can occur in established networks. Actors may need to change their activities, some of their resources may lose value, they may lose power and the new distribution of value may create resistance. Hence, disruptive innovation can be considered to be a business model challenge since it can distort the firm's existing network constellation and may break the established linkage between value creation and appropriation. A network is held together by mutual interest but at the same time is characterized by converging and diverging incentives (Law, 1992). The introduction of a disruptive innovation which in its turn has an impact on the surrounding network is therefore likely to be met with resistance from some actors.

It seems to be difficult for a firm to impose executive power against actors that are beyond its boundaries. In this sense, business model initiatives seem to be different from the development of new products, which is more an internal, firm-specific challenge. For sure, product innovation efforts also depend upon linkages with the external environment, for instance when it comes to purchasing critical components, but business models are concerned explicitly with value and the linkages between the firm and its surrounding environment.

Put differently, several of the supply-side related challenges described in the literature on discontinuous innovation can also be found beyond the firm's boundaries. For instance, a distortion of an established network constellation can occur when a disruptive innovation is

competence-destroying (Tushman and Anderson, 1986) for certain actors. This was the case with IP video surveillance, which rendered obsolete many of the skills of traditional security integrators. A similar dilemma can be identified in the fifth paper which concerned an incontinence diaper that introduced many disruptive characteristics. In this case, certain key actors needed to renew their skills since the new product had to be used in a different way. A disruptive innovation can also be architectural and change the linkages between different components (Henderson and Clark, 1990) inside the customer's organization. Here, the case of IP video is illustrative. As security becomes increasingly an IT issue, the adoption of IP video implies that cameras are installed into an IT infrastructure, which is different to an analog environment. These changes create political barriers to adoption. As pointed out by Cyert and March (1963), firms compete with other organizations but there is also internal competition within a firm. An architectural change may distort the established constellation of power and some actors may be hesitant about an innovation. In the case of IP video, conflicts between IT managers and security managers can be thought of as an example of this argument.

It would be strange if challenges such as the ones described above could only be found on the supply-side of the market. Companies in the vicinity of a focal firm also have an established set of structures, resources and capabilities, and disruptive innovations which imply creative destruction along any of these dimensions will be inherently problematic, even though the customer would benefit from adopting them. Afuah and Bahram (1995) offered similar arguments in stating that a discontinuous innovation must be analyzed in terms of its impact on the supply chain where the firm is present. The findings in this dissertation indicate that such ideas have been largely overlooked by the literature on disruptive innovation which would benefit from this approach. Moreover, the findings presented here reveal another aspect of these challenges which Afuah and Bahram (1995) paid little attention to, namely the interconnectedness that characterizes these networks and the fact that a firm often cannot exercise full control over its surrounding network, which it still depends on.

Disruptive innovations seem to be problematic since a shift in an established business model is dependent upon actors that are beyond the boundaries of the firm. At first sight, this challenge in many ways is similar to the one originally described by Christensen (1997) which emphasized how firms are held captive by established customers. However, Christensen focused explicitly on the resource allocation process and argued that firms struggle because the disruptive innovation is not demanded by its current customer base. The findings in this dissertation suggest that while the power of customers plays an important role, disruptive innovations may be problematic even though they may be in demand from existing customers and other elements of the network.

The disruptive innovation is sometimes *not demanded by certain actors* in the firm's existing business model. The reasons for this seem to be related not just to the performance of the innovation but also to value creation and distribution, as well as the impact on different actors, their incentives and their competencies. Hence, rather than being subject to resource dependence as described by the existing theory on disruptive innovation, firms seem to struggle with disruptive innovation due to interdependence, which can be defined as follows:

"Any event that depends on more than a single causal agent is an outcome based on interdependent agent. (…) Interdependence exists whenever one actor does not entirely control all of the conditions necessary for the achievement of an action or for obtaining the outcome desired from the action" (Pfeffer and Salancik, 1978. p. 40).

The empirical findings reviewed in this section show that neither the customer nor the firm controls all the means for accomplishing something. Rather, there seems to be an interplay between different actors throughout the network which in turn imposes constraints upon the focal firm. In this sense the challenges described above differ from those originally formulated regarding disruptive innovation. The external environment imposes control over firms in other ways than providing them with resources. Actors and their power, as well as the established activities and flows of resources in a network make it difficult for firms to experiment with their business models. Hence, a disruptive innovation can be regarded as a business model challenge since it distorts established network constellations and the interdependent nature of business models makes it difficult to change them.

Historically, much of the work on discontinuous innovation has focused on the supply side and the firm's existing resources and capabilities (e.g. Tushman and Anderson, 1986; Henderson and Clark, 1990). Work on disruptive innovation emerged forcibly in the 1990s arguing that the previous literature had overlooked the role of the market and how customers control the resource allocation process. The results reviewed above suggest that the theory on disruptive innovation in its turn missed out other elements in the environment and the interconnectedness that characterizes the relations between a focal firm and its surrounding network.

6. Discussion

This section synthesizes the findings reviewed above and develops the theory on disruptive innovation. It does so first by pointing to two problems with existing theory after which it introduces some of the literature on value and networks which contributes to the theoretical part of this dissertation.

6.1 Problems with the existing theory on disruptive innovation

Literature on disruptive innovation states that the properties of these technologies imply that they prosper in new value networks, which in turn make them problematic to handle for incumbent firms. The empirical findings reviewed above suggest instead that they can also emerge by changing established value networks and that these innovations emerge in a less binary way than has been suggested. Why has this issue not been highlighted in the existing literature?

One reason could be that existing theory arguably would suggest that such modifications are not so problematic for firms and that the subject therefore is worthy of little attention. But the empirical data in this dissertation show that they might be quite difficult to deal with due to interdependencies and distortions in established network constellations. Another reason could be that many definitions of disruptive innovation state that the properties of these innovations inevitably make them prosper in new value networks.[26] But the brief review of the empirical data above indicates that this may not always the case and that disruptive technologies may be in demand from mainstream customers at an early point, despite their lower traditional performance.

The reason why these issues have been overlooked could also be that the existing theory was unable to handle them properly. The fact that the introduction of a disruptive innovation does not seem to be as binary as was previously argued may therefore be a theoretical concern, and if so, several managerial challenges and solutions might also have been overlooked.

Moving back to the theory on disruptive innovation, it can be seen that it does not apply the same assumptions to all the issues it seeks to describe. Previous work on the subject

[26] For instance, Govindarajan and Kopalle (2006a) define a disruptive innovation as an innovation that "introduces a different set of features, performance, and price attributes relative to the existing product, an unattractive combination for mainstream customers at the time of product introduction because of inferior performance on the attributes these customers value and/or a high price—although a different customer segment may value the new attributes. Subsequent developments over time, however, raise the new product's attributes to a level sufficient to satisfy mainstream customers, thus attracting more of the mainstream market" (p. 15). Christensen (2006) acknowledged that this definition is better than his original 1997 definition and hence, it is clear that previous theory has assumed that the specific properties of a disruptive innovation makes it prosper in a new value network. The empirical findings in this dissertation show that this is not always the case.

essentially links theories on resource dependence to the firm's resource allocation process. In doing so, it shows that firms tend to allocate resources to those initiatives responding to customer demands. The focal firm is assumed to be constituted of a set of actors that may have diverging opinions and incentives. Christensen (1997) illustrates how the daily competition for resources inside the firm inevitably tends to allocate resources to those actors whose projects will result in offers that the firm's customers have demanded. These forces move the incumbent firms in the wrong direction and eventually they are displaced by entrants who were not "held captive" by an established customer base. Hence, the existing theory assumes heterogeneity in the incentives and competencies inside the focal firm.

On the other hand, this heterogeneity is quite surprisingly not assumed to exist in the firm's surrounding environment or inside the customer's organization. Instead, a diffusion-oriented perspective on the market is maintained in which different segments of the market are analyzed. The customers and the surrounding network are essentially operationalized as one actor that exercises power by supplying the firm with resources. The role of different actors, and their competencies and incentives have been largely overlooked and attention has focused on the resources that firms obtain from their customers. This can be illustrated by the following quote from Christensen and Bower (1996):

"Our findings support many of the conclusions of the resource dependence theorists, who contend that a firm's scope for strategic change is strongly bounded by the interests of external entities (customers, in this study) who provide the resources the firm needs to survive." (p. 212)

Within this somewhat narrow interpretation of resource dependence theory, the theory cannot address other elements of the business model than whether existing customers initially demanded the innovation or not. Moreover, this conceptualization of resource dependence actually stands in contrast to the original works on the subject, which took a more nuanced view of the surrounding environment than the current theory on disruptive innovation:

"A variety of interest groups, individuals, and organizations have contact with a given focal organization; each of these evaluates the organization and reacts to its output and actions. Each has a particular set of criteria of preferences that it uses in this evaluation process, and consequently, organizational effectiveness is a multifaceted concept, where the effectiveness of the organization depends on which group, with which criteria and preferences is doing the assessment." (Pfeffer and Salancik, p. 32) [27]

The empirical findings reviewed above suggest that the simplified interpretation of resource dependency may be misleading and that a network contains many different actors with different competencies and incentives as indicated by the quote above. Going back to

[27]For further illustrations of how resource dependence scholars look at the environment, see e.g. Pfeffer and Salancik (1978), p. 26, p. 36.

Christensen and Rosenbloom's (1995) definition of value networks it can be concluded that this "*context within which the firm identifies and responds to customer's needs, procures inputs and reacts to competitors*" (p. 234) is characterized in fact by more heterogeneity than is assumed in the literature. There are many actors that perform different activities, control different resources and have their own subjective opinions of whether or not a disruptive innovation is valuable. The empirical evidence suggests that these factors play an important role in addressing how and why disruptive innovations prosper and what challenges they are likely to imply with regard to business models.

6.2 Proposed theoretical improvements

This section seeks to develop the theory on disruptive innovation by drawing upon literature on value and on networks. It is argued here that technological performance needs to be translated into value creation and distribution and that a different, more nuanced conceptualization of networks is needed in order to capture and explain the empirical findings in this dissertation.

6.2.1 From performance to value and utility

The cases described above suggest that disruptive innovations can evolve in established value networks, despite lower traditional performance. Rather than emerging in a completely new value network, the disruptive technology prospered by bringing a new value proposition to the market, which in its turn modified or distorted existing value networks. A lower traditional performance does not necessarily imply therefore that a disruptive innovation emerges in a new value network and later takes over the mainstream market. The description above suggests that digital imaging created an increased total utility for studio photographers at an early point, despite lower photo quality. The observation that disruptive innovations can emerge in an established value network despite lower traditional performance implies that previous research puts too much emphasis on the technology and its different performance dimensions.

Several scholars in technology management have underlined the importance of translating the performance and functionality of a technology into value and utility (e.g. Granstrand, 1994; Saviotti and Metcalfe, 1984). The techno-economic analysis developed and used by Oskarsson and Sjöberg (1991) and Lindmark (2006) can be regarded as one such example. Wunker (2005) claims that customers do not want a particular product, they want a certain result to be accomplished in relation to a specific problem. Interestingly, Christensen and Raynor (2003) argued that one part of the solution to the innovator's dilemma is to focus on the job that customers want to get done. This statement is consistent with the findings presented in this dissertation. However, its implications go against much of Christensen's

earlier work which defines and analyzes disruptive innovations along certain performance dimensions, rather than looking at how value actually is created.

The literature review in chapter 2 shows that economists usually think about value as inherently subjective. A good can be perceived as valuable by one individual and less valuable by another (von Mises, 1963). Menger (1950) suggests that there is a difference between exchange value and use value. The exchange value is the price paid for acquiring a good whereas the use value is the utility that the buyer receives from using the product. A positive difference between use value and exchange value can be defined as a consumer surplus. The empirical findings in this dissertation suggest that consumer surplus can be created in mainstream markets despite the lower traditional performance of a disruptive innovation.

Value can be thought of as a perceived tradeoff between benefits and sacrifices (Christopher et al., 1991). Hence, different actors obtain different benefits and make different sacrifices. The sacrifices can include the costs related to transaction, installation and maintenance (Walters and Lancaster, 1999). The value of a good therefore is dependent on its context. In several of the empirical cases reviewed above, the lower traditional performance was compensated for by ancillary performance attributes which created increased utility for the customer, for instance by simplifying their work, removing labor and changing activities in the specific context in which they were introduced. This context does not necessarily have to be a low-end segment or a new market as the previous literature would suggest, disruptive innovations can also emerge in mainstream markets. When shifting attention from performance dimensions towards value and utility, it becomes easier to understand how and why a disruptive innovation prospers in established networks among mainstream customers.

6.2.2 A more comprehensive view of networks

As stated earlier, the literature on disruptive innovation largely maintains a diffusion-oriented perspective. It essentially looks at the impact of the market in terms of different segments, but the network itself has been rather understudied. Partly as a consequence of this, the disruptive innovation framework has maintained a somewhat binary perspective on adoption. If an innovation is demanded by the firm's customers it would make sense to develop it since the customers supply the firm with important resources and such an innovation would be referred to as sustaining. On the other hand, if there is no existing customer demand, the forces of resource dependency will prevent the firm from launching the product and the innovation will be classed as disruptive. This theory suffers from a somewhat simplistic interpretation of organizations and networks.

It would be misleading to regard customers as homogenous entities in a business-to-business setting in which several actors with sometimes diverging utility functions are involved. In

these circumstances the adoption of an innovation is rarely a discrete action, there may be many different perceptions of a product both along the supply chain and inside the customer's organization. Different actors are likely to be affected in different ways and these effects need to be studied in order to understand the adoption of a disruptive innovation. Ford et al. (2002) argue that a network can be analyzed on many different levels. First, it can be the *single actor*, i.e. the company, organization, team or individual. Whether it is the individual, firms or firm unit that is considered to be the actor depends on the context and objective of a study (Håkansson and Snehota, 1995). The next level is the *relationship* between certain actors and the third level is the *whole network*. The authors underline the importance of investigating changes at all these levels in order to understand how networks evolve. Network scholars often claim that markets are characterized by interrelatedness between firms and their surrounding environment (e.g. Håkansson, 1989). This interaction can be studied by looking at the actors, their resources and their activities or actions. This fractal perspective of networks, along with the empirical observations, suggest that a more heterogeneous view of networks is needed. The empirical findings above indicate that the interconnectedness of networks and the fact that actors exist at many different levels need to be taken into consideration.

If actors can be found at many different levels, both in the network and inside the customer's organization, it is important to look at how each would be affected by the introduction of a disruptive innovation since value is both perceived and contextual. Actors may be affected in different ways since they may possess different resources and perform different activities. Hence, they will arguably have different opinions and these diverging preferences may in turn impact on the adoption or not of a disruptive innovation. Moreover, value can be realized for an actor inside the customer's organization other than the acquirer. The buying organization has an aggregated utility from obtaining the good, but this is more difficult to measure, and it may be distributed over many different functions or individuals. Consequently, the distribution of value throughout the network requires further study than previous literature has suggested. Though the adopting organization may benefit from the adoption of a disruptive innovation, this value can be distributed in different ways across the affected actors, which can create barriers to its adoption.

The literature on disruptive innovation takes a somewhat simplistic view of customers, classifying them as either low-end, high-end or non-consumers. The main focus is on the market and its different segments, rather than actual customers and the various actors inside and beyond the boundaries of the customer's organization. There may be some discrepancy between the different perceptions of use value and actual use value for these different actors.

Developing a more nuanced perspective on customers and networks makes it possible to explain in a more detailed manner in what ways a disruptive innovation is a business model challenge. A disruptive innovation will sometimes not be demanded by certain actors because of its incompatibility with their established activities. The new distribution of value

may create clear incentives for some actors to block the innovation. In some cases the value proposition associated with the disruptive innovation may not fit with the firm's relations with its network making its introduction problematic. Resources are only valuable in certain contexts and an innovation that is incompatible with existing resources and activities will be inherently difficult to commercialize. Hence, disruptive innovations can be considered to be a business model challenge since they distort the firm's network constellation and may break the established linkages between value creation and appropriation.

Changing the business model is difficult since the actors embedded in an industrial network depend upon relationships with others. As stated in the literature review, business models can be defined as "*a system of interdependent activities that transcends the focal firm and spans its boundaries*" (Zott and Amit, 2009, p.1). Other scholars provide similar conceptualizations, stating that a business model can be thought of as a set of participants, their relationships and the flows between them (Weill and Vitale, 2001). A network involves both actors and their relations (Dubois, 1998). Firms that try to change their network therefore are to an extent reliant upon actors beyond the boundaries of the firm (Håkansson and Ford, 2002; Ford et al., 2003).

A more heterogeneous conceptualization of networks makes it possible to understand in what ways a disruptive innovation is a business model challenge. Clearly, it will be difficult to manage under these circumstances of interdependence but the fact that firms are subject to interdependence rather than resource dependence as Christensen and Rosenbloom (1995) describe arguably would suggest that firms can exercise *some* control over their networks. Furthermore, the key challenges will be related more to how firms handle their relationships in the network than how the internal resource allocation process is managed. Scholars in the field of industrial network theory have argued before that this is the key challenge (Håkansson and Snehota, 1989) and the findings in this dissertation suggest that this is also largely the case with disruptive innovations. The disruptive innovation can be regarded as an actor as it impacts its surrounding network both financially and in a more sociological sense. Changing a network to suit one's own objectives can be thought of as an uncertain process involving overcoming resistance. Power struggles and conflicts are likely to prevail and firms will be forced to engage in a continuous process of negotiation (Law, 1992).

Summing up, two important changes to existing theory on disruptive innovation have been proposed in these sub-sections. Firstly, the focus should be shifted from different performance parameters towards how value is actually created and distributed. Secondly, customers and the surrounding value network can be conceptualized as a set of actors that perform activities and control resources. Hence, customers cannot be regarded as homogenous units with one specific utility function, but rather as a collection of actors with different capabilities sometimes governed by different incentives.

6.2.3 Towards a more symmetric theory on disruptive innovation

It has been shown that the existing theory does not explain how a disruptive innovation prospers in an established value network since it assumes heterogeneity within the firm, but not in its surrounding network in terms of the diverging incentives among actors. Put differently, the existing theory lacks symmetry. A theory can be regarded as symmetric if it applies the same basic assumptions regardless of the domain it describes (Foss and Hallberg, 2010)[28]. Foss and Hallberg argue that a good theory ideally should fulfill the symmetry criterion, for several reasons. For instance, a theory that applies different assumptions to the subjects concerned may be concealing some important aspects of the reality. A change towards a more symmetric theory may therefore reveal new insights and improve the predictive power of a theory.

The proposed theoretical development along the value and network dimensions arguably would result in a more symmetric theory on disruptive innovation as it would assume similar degrees of heterogeneity inside the firm and in the surrounding environment. This revised theory also is capable of describing and explaining phenomena that the previous literature has overlooked. The two research questions investigated in this thesis have not previously been carefully explored and one reason for this may be that existing theory was asymmetric. Current theory assumes that the lower traditional performance of a disruptive innovation implies that it will not emerge in the mainstream market. If we shift focus towards value and away from technological performance, it becomes possible to explain the empirical observations that show that disruptive innovations can emerge in the mainstream market of an incumbent firm. The literature states that disruptive innovation is a business model challenge but does not explain in what ways, apart from whether existing customers have demanded the innovation or not. A more nuanced view of networks makes it clearer how a disruptive innovation affects an established business model and why it is difficult to handle this issue. The more symmetric theory outlined above makes it possible to investigate issues that the previous theory has not dealt with sufficiently.

6.2.4 A symmetric theory opens up for new managerial solutions

According to Foss and Hallberg (2010), development towards more symmetric theories can enable new insights. It was concluded above that disruptive innovations are problematic to handle since established business models are characterized by interdependence and that this issue is different from the original focus on the resources that customers supply to the focal firm. This conclusion is based on the development of a more symmetric theory on disruptive

[28] The development of public choice theory can be thought of as an example of a shift towards a more symmetric theory. For a long time, economists assumed that firms and individuals on the market were rational and sought to maximize their own utilities, and that the political sphere was protected from such behavior. In politics, human action was regarded as altruistic. Public choice scholars (e.g. Downs, 1957; Tullock, 1989) highlighted this asymmetry and argued that political decision-making also was governed by self-interest.

innovation, which assumes similar degrees of heterogeneity inside the focal firm and the surrounding network. A more symmetric theory also reveals some new managerial solutions.

Existing literature has argued that disruptive innovations need to be developed in a separate organization that shelters them from the forces of resource dependency that would starve them of resources (Christensen, 1997). Recommendations regarding actual commercialization have received less attention and need to be more specific. The importance of thoroughly understanding the customer is often pointed to as crucial (e.g. Govindarajan and Kopalle, 2004; Christensen and Raynor, 2003; Danneels, 2004), but few guidelines are provided regarding how firms can actually achieve this.

The key challenge in disruptive innovation has been identified as related to the firm's surrounding environment, but few managerial solutions have been suggested regarding how the environment can actually be managed. This is interesting given that resource dependency scholars (Pfeffer and Salancik, 1978) state that there are two ways to manage the external control of organizations. One is to adapt the organization to the environment and the other option is to try to change the environment. However, this latter alternative has received surprisingly little attention thus far which might be one reason why practitioners have sometimes been disappointed by the managerial prescriptions that are available.

One of the reasons why this option has been largely ignored might be down to the rather simplistic conceptualization of the environment. It has been assumed that the lower traditional performance of a disruptive technology renders it undesirable by mainstream customers and that therefore incumbents will not invest in it and then will encounter problems once the technology matures. This simplification results in a somewhat pessimistic description of the dilemma that incumbents face. Being trapped in their established value network where the lower performing product is not desired the main solution is to break free from this external control by establishing an independent organization.

This rather fatalistic view of disruptive innovation originates from the assumptions that the traditional technological performance of an innovation determines whether or not it will be adopted, and that customers control firms by supplying them with resources. Shifting to a more symmetric theory in line with the above arguably would result in a different, more optimistic perspective on how firms can succeed with disruptive innovations. While it is clear that firms are subject to influences from their networks, which in turn restrict their freedom, it is still possible to influence these networks to an extent (Håkansson and Ford, 2002).

If we assume that the surrounding network includes a wide range of actors with different incentives, different resources and that undertake different activities, it becomes clear that firms can exercise some, limited, control over their networks. For instance, the firm can decide which actors to target and how to do this. Moreover, a focus on value instead of on performance trajectories would suggest that firms can influence whether customers demand

an innovation or not. As already stated, value can be thought of as a subjective, perceived, and context dependent trade-off between benefits and sacrifices. Hence, firms arguably should be able to influence the adoption of a disruptive technology, for instance by changing perceptions through its marketing or by influencing the context in which it is introduced.

When assuming interdependence instead of a somewhat narrow interpretation of resource dependence, a range of managerial solutions can be developed. Clearly, trying to change the network in one's own favor is a non-trivial issue since firms can impose only limited control over their surrounding networks. Acting with restricted freedom is difficult, but nevertheless, it is possible. Some guidelines for how this can be done are provided in section 8 on managerial implications.

6.3 Reflections on proposed changes towards symmetry

One way to frame the work described in this dissertation vis-à-vis previous work on disruptive innovation, would be to regard theories in social science as a balance between generality, simplicity, and accuracy (Weick, 1979). Weick argues that a theory cannot be general, simple and accurate at the same time and that it is possible to pursue only two of these qualities. Scholars are consequently forced to make tradeoffs between these three factors. Previous work on disruptive innovation has generated a theoretical framework which performs very well in terms of simplicity. It highlights a very important issue, namely the role of a firm's surrounding network for trying to understand the impact of discontinuities. But this simplicity has been achieved at the expense of generality and accuracy.

The present contribution should be seen not as an attempt to dismiss earlier work on the subject, but as an attempt to revise and extend it by increasing its symmetry. The work in this dissertation suggests a different tradeoff among simplicity, accuracy and generality. Consequently, its conclusions are less simple and more difficult to develop into an analytical framework.

On the other hand, the theoretical developments above make it possible to describe and understand several previously overlooked issues. Therefore, the findings in this dissertation have implications for the limitations of applications of the existing theory on disruptive innovation. Previous work focuses explicitly on how the resources provided by customers makes it problematic to develop disruptive innovations since this flow of money imposes great control over the firm. In linking resource dependency to the process of resource allocation, the previous theory is limited. It cannot address how disruptive innovations emerge by modifying or distorting existing value networks or in what ways they present a business model challenge. Based on the modifications suggested, these issues can be addressed and it becomes possible to develop new managerial solutions.

Whether the theory on disruptive innovation should retain its shape or adapt to the directions outlined in this dissertation will largely be a matter of preference. If the researcher or practitioner is looking for a theory that is simple and deals with completely new value networks and the power of customers, the existing theory will be preferred. However, many disruptive innovations arguably evolve by modifying existing value networks which would limit application of existing theory to a few empirical settings. In particular, current theory might be more useful for studying consumer products and other innovations that have little impact on their surrounding networks. However, the fact that current research increasingly tries to deal with the relations between disruptive innovations and business models calls for a more symmetric theory since this would make it possible to look beyond how existing customers control the resource allocation process of firms.

7. Conclusions

The purpose of the research described in this thesis was to develop the theory of disruptive innovation with a focus on business models and value networks. The by now extant literature on disruptive innovation has created an increased understanding of the challenges related to discontinuities. It brought a different perspective upon the issue by shifting attention from supply-side factors towards the environment and the role of customers. The findings in this thesis provide further illustrations of the importance of addressing firms' surrounding networks. This dissertation has also pointed out and addressed a couple of issues that need to be better understood. Two research questions have been derived and answered, both in this covering paper and in the appended articles. The next subsections outline the answers to the research questions and propose some directions for future research.

7.1 Disruptive innovations in established value networks

The literature review in section 2 of this covering paper suggests that disruptive innovations in established value networks have received little attention. The first research question was therefore formulated as follows:

1. Can a disruptive innovation emerge in an established value network and if so, how can this be explained?

The empirical evidence presented in this dissertation suggests that disruptive innovations can prosper in existing value networks, despite their lower traditional performance. They seem to do so by bringing a new value proposition to the market. The ancillary performance attributes that accompany the lower mainstream performance may create increased value for the customer, for instance by simplifying work, removing labor and changing the activities inside the customer's organization. Hence, disruptive innovations may emerge by imposing changes in established value networks rather than in completely new ones.

In order to explain this, a revised perspective on disruptive innovation has been proposed. It has been argued that it may be better to look at how disruptive innovations create value and utility, rather than to focus on the various performance dimensions. The empirical findings indicate that a more nuanced conceptualization of customers and networks is required. The focal firm has been seen as a set of actors which compete for resources – but the customers and the surrounding network have been essentially operationalized as one distinct actor that exercises power by supplying resources to the firm. There may be several actors in the customer's organization and beyond it that have direct impacts on the adoption of these innovations.

In other words, it is argued that a more symmetric theory is needed to explain these issues and that such a theory would assume similar degrees of heterogeneity inside the focal firm as

in the surrounding environment. An expanded view of disruptive innovation has been presented. It is suggested that a disruptive innovation can be thought of as a shift along two dimensions: actors and value.

7.2 Challenges related to disruptive innovation and business models

The literature has stated that disruptive innovation is a business model problem (Christensen, 2006), but is essentially focused on one aspect of the business model, namely whether or not the firm's existing customers demand it. This led to the second research question:

2. How and why is a disruptive innovation a business model challenge?

In part due to an explicit focus on customers and the resource allocation process inside firms, the existing theory does not really address how disruptive innovation is a business model challenge. The more symmetric theory proposed in this dissertation makes it clearer in what ways this is the case.

It has been argued that not only customers, but also important actors in the firm's established business model constellation, hamper the development of disruptive innovations. These actors are found both inside the customer's organization and in the surrounding environment. The established network constellation of actors, resources, and activities makes it difficult to introduce disruptive innovations since a different creation and distribution of value may be incompatible with existing competencies and incentives. Moreover, business models in many ways are interdependent as they concern the relationship between the firm and its network. The limited degree of freedom imposed by networks implies that firms can get stuck in their existing business models since they can only exercise a limited control over their environments. Firms seem to encounter problems when developing disruptive innovations, even when there is customer demand. A disruptive innovation exerts force and creates conflict in a network and therefore, incumbent firms, who are operating in an established network, struggle to introduce them. The challenges identified are in many ways different from those described in the literature. Rather than being controlled by the resources that customers supply, firms seem to be controlled by the established relations and interdependencies in their existing business model.

7.3 Directions for future research

This dissertation has sought to expand and improve the existing theory on disruptive innovation. From this work, a couple of directions for future research can be pointed out. One of the limitations of the empirical evidence presented here is that it looks primarily at relationships between the innovating firm and its customers. While this is done in a more nuanced way than in the previous literature, a network or supply chain is still very broad and it would be interesting to see more studies of entire networks in industries undergoing disruptive change. Arguably, this would provide a better understanding of the challenges and their magnitude. As supply chains extend across several firms and functions, the nature of the aforementioned problems can be further addressed by performing such studies.

The work described in this thesis makes a systemic and interdependent interpretation of business models. The fifth appended article combines the literature on industrial networks with the literature on business models and suggested that the challenges related to business model renewal are related largely to interconnectedness and the conservative nature of networks. This same article argues also that many of the barriers to and enablers of business model innovation are quite general and are similar to those previously described in the field of new product development[29]. Given that established firms seem to be good at generating new products but struggle to develop new business models, there are opportunities to add to this literature. A deeper look into business models from an industrial network perspective might reveal more about how business models can be renewed.

Empirical evidence on these issues could be obtained by studying the ongoing transition to digital, IP-based video surveillance. It has been investigated in some detail within the scope of this dissertation and although only some 30 percent[30] of the market has adopted this technology until now, it is becoming increasingly clear that incumbent firms have lost market shares in the transition to IP video. Given that this technological shift seems to imply challenges that are different from those described in the previous literature, it should provide a fertile ground for future research. The studies in this dissertation would seem to indicate that entrant firms will continue to dominate the transition to IP surveillance. They have entered a positive feedback loop where growing revenues have been invested in new, more competitive products. Conversely, analog incumbents encountered problems during the 2008-09 recession and have been forced to lay off employees. But more importantly, the sales model and the ways to reach customers have changed with the shift to IP and incumbent firms are struggling to change their business models. As the third appended paper shows, this shift has several implications for the actors, resources, power structures, and activities related to established firms. It will be very interesting to see how this industry transforms in the coming years.

[29] See e.g. Chesbrough (2009) and Teece (2009).

[30] This figure was obtained in September 2010 from a firm that is operating in the IP video surveillance industry.

The more symmetric perspective that is proposed in this dissertation opens up new opportunities to develop recommendations that go beyond handling the resource allocation process. Although some implications for management are suggested in this dissertation, more work can be done in this area. Further research is needed on how firms actually go about when trying to change their business models and introducing disruptive innovations.

8. Managerial implications

A more symmetric theory has some implications for why entrants under some circumstances displace incumbent firms. It is argued in this thesis that the management of disruptive innovation is largely about understanding value creation and distribution in a network characterized by interdependencies. The decline of established firms and the dominance of entrants should be related therefore to different abilities to undertake such changes. The empirical data presented in this dissertation suggests that established firms struggle to develop disruptive innovations even though their customers may demand them. Hasselblad's problems in the shift to digital imaging can be thought of as a good illustration. During the 1990s, several entrant firms started to manufacture digital backs which could be attached to Hasselblad cameras. Developing a Hasselblad product that offered lower image quality turned out to be very problematic. This is partly in line with Tripsas's (1997) argument that technological discontinuities need to be analyzed in terms of their compatibility with a firm's complementary assets. The Hasselblad brand can be thought of as such an asset, which in some ways hampered its entry into digital imaging. However, this event is not only related to complementary assets, also it illustrates that established firms struggle to change their relations to existing customers.

Lack of a network may be advantageous for entrants, since it means they will not be subject to the same core rigidities as established firms (Leonard-Barton, 1992). Incumbents often develop stronger relations to their networks over time, which provides them with a competitive advantage in the old technological paradigm, but seems to prevent them from experimenting with new value propositions. Previous research in strategic management has shown that start-ups are more willing to change their business models over time and that this flexibility is a key determinant of success (Boccardelli and Magnusson, 2006). Entrant firms by definition are more loosely coupled, therefore their business model is more adaptable since there are fewer constraints and interdependencies (Pfeffer and Salancik, 1978).

Entrants should be more able to adopt a probe-and-learn approach and to eventually succeed in finding the right business model. The ongoing shift from analog to IP-based video surveillance is a good illustration of this argument. It seems that entrant firms in this industry have done better in terms of targeting new actors inside the customer's organization and approaching them with a different value proposition. The opportunity cost seems to be higher for established firms since it appears to be riskier to experiment within the scope of an established network. How then can firms proceed when trying to renew their business models in order to succeed with a disruptive innovation?

One advantage of a more symmetric theory on disruptive innovation is that it enables new managerial solutions. As noted in the theoretical review, the existing theory on disruptive innovation states that the main problem are on the demand-side, but that the managerial solutions have up until now largely focused on the supply-side. The main reason for this

appears to be that the literature focused explicitly on how customers control the resource allocation process inside firms by supplying them with resources. Within this perspective, the focal firm can manage disruptive innovation by re-designing its way of allocating resources, but the network cannot be addressed in more detail. Consequently, previous work looks at the market's impact on firms, but pays only limited attention to how firms can actually manage their networks. When instead assuming heterogeneity inside the customer's organization and in the surrounding network, it becomes easier to find new managerial solutions.

As already noted, managing in a network is very different from handling issues that are internal to the firm since no individual actor can be in complete control of a network. Firms depend upon other actors and can impose only limited control over them. Thus, while a firm's relations are the basis of its current work and development, these relations may also inhibit further development activities. Actors embedded in an industrial network have limited freedom of action since they depend upon relationships with others. A network perspective would suggest that it is difficult to manage under conditions of limited freedom and that the risks are higher (Adner, 2006). Clearly, management is a different issue under these circumstances since firms cannot exercise hierarchical power over their networks. Nevertheless, it is possible to influence the network to ones' own benefit (Knight and Harland, 2005). For instance, previous research shows how firms that develop open source software have successfully motivated user communities to take part in the development of software by using subtler control mechanisms than executive power (Dahlander and Magnusson, 2008).

Given that business models are interdependent and systemic, finding the right business model for a disruptive innovation becomes a matter of altering, modifying, or aligning the existing network to favor the innovation. This can be done by targeting new actors, helping actors to change their activities, altering the revenue model, or changing the value proposition. Business models transcend the boundaries of a firm (Zott and Amit, 2009) and therefore, finding the right business model for a disruptive innovation is ultimately a process of negotiation and alignment of the surrounding network. Below, some guidelines for how this can be done are proposed. Some brief empirical illustrations from the appended papers are provided, along with some references to tools and frameworks that could be useful. Eventually, some reflections on these guidelines are given.

8.1 Map and analyze networks and value

By mapping and analyzing the key actors in a network, potential enablers and inhibiting actors can be identified. The empirical findings in this dissertation suggest that the attitude of an actor towards an innovation can be regarded as a function of its incentives and its competencies. Starting with competencies, previous research points out that an innovation can be discontinuous for different actors and in different ways (Afuah and Bahram, 1995), for instance, it can be competence-destroying. Some actors may be willing to support an innovation, but lack the competencies to do so. As all actors are bound to act within their area of competence, this criterion can be regarded as a prerequisite for adopting an innovation.

Secondly, the incentives that govern each actor need to be understood. This includes how economic value is created and distributed. There are several existing techniques for doing so, for instance customer utility mapping (Kim and Mauborgne, 2000) and techno-economic analysis (Lindmark, 2006). A techno-economic analysis essentially concerns the mapping of how technical attributes interplay and create economic value. Different methods for assessing the job to be done instead of looking at different performance dimensions may also be helpful (Wunker, 2005). As an innovation may create increased economic value by destroying value elsewhere, the distribution of value needs to be analyzed. Clearly, the economic dimension of value is important, but the impact upon established power structures and the surrounding context also needs to be analyzed. Some actors may have good reasons to block an innovation if it reduces their power or creates a distribution of value that is undesirable for them.

The motivation of an actor thus may depend upon whether it will benefit or not from it, and whether or not it is capable of using the innovation. The empirical data in the dissertation provide some illustrations of how firms map and understand their surrounding networks along these two dimensions. For instance, in the case of IP video the firm managed to identify several actors in the downstream network and inside the customer's organization that had diverging incentives and competencies. Integrators of traditional CCTV did not command IP video and security managers were largely hostile towards the new technology. One reason for this would seem to be that when security becomes more an IT issue, security managers lose some of their status and power vis-à-vis other actors inside the customer's organization. Hence, some actors had an incentive to be skeptical while others were disinterested since the innovation was incompatible with established competencies.

It should be pointed out that these actors can be found both inside the different firms in the network and beyond them. Hence, in mapping a network, it needs to be analyzed in a systemic way since there are many different actors that are intertwined in the exchange of goods and services. This approach differs from those postulated previously which essentially regard the customer as a single actor, with one specific utility function.

As emerged from the literature review in the chapter 2 of this dissertation, it is not clear how and why a disruptive innovation prospers in an established value network. Going back to the case of Hasselblad and digital imaging, it can be seen that the guidelines offer some guidance on this. When translating the different performance attributes associated with the technology into how it actually creates value, it becomes clear why this technology prospered in Hasselblad's high-end segment in the 1990s, despite its lower performance and higher price. Digital imaging removed the studio photographer's activity of film finishing and waiting. Additionally, an infinite number of images could be captured, sent, replicated, and manipulated at a very low cost. In this case, the technology had little impact on the established network constellation. Nevertheless, it created considerable difficulties for an incumbent firm such as Hasselblad, which had a business model that was largely related to its strong brand and superior image quality. The established relationship between the company and its customers was deemed to be incompatible with this new way of creating value. Consequently, it became problematic for the firm to develop the technology since the market organization and many mechanical engineers argued that it was not worthy of Hasselblad's brand. A mapping of the network and a focus on value creation rather than performance would have highlighted the main challenges and explained how and why firms encounter difficulties when a disruptive technology is introduced in an established value network. This is an improvement to existing theory, which does not really deal with the issue since it has been assumed that the properties of a disruptive innovation imply that they emerge in completely new value networks.

The case in the fifth appended paper provides another compelling illustration of the importance of mapping and understanding the surrounding network. The studied incontinence diaper created a new distribution of value which was incompatible with the existing network constellation inside the customer's organization. Some key actors such as the caregivers did not have the competencies required to use the product. Consequently, sales did not take off despite the fact that the product created more value than its predecessors. When a disruptive innovation is introduced, it needs to be understood in terms of whether it is compatible with the incentives and the competencies of each actor in the network.

8.2 Adapt and align the network and the business model

Once the surrounding value network is properly understood, firms need to adapt this constellation, i.e. figure out which actors should be targeted and which should be avoided. As already pointed out, some actors have a direct interest in adopting the innovation while others may have an equally large interest in blocking it.

Actors do not differ only in terms of their incentives and competencies, they also differ in terms of the importance for the adoption of an innovation. Some may be critical for the adoption; others may have little impact on the success or failure of it. Reconfiguring the

established network constellation therefore becomes an issue of finding allies and negotiating with or avoiding enemies.

Revisiting the incontinence diaper case, it can be seen that the firm started to target new actors. Given that the purchasers were not able to take account of the new, more systemic value creation, the firm turned instead to management. Additionally, it realized that the product could not be used without involving the caregivers, even though they did not know how to use the product correctly.

The previously described case of IP video is another example here. It is clear from this case that the disruptive technology had different impacts on different actors. The traditional security integrators and managers did not have the necessary knowledge and some of them had few incentives to favor adoption, since they would lose status in relation to IT managers. Targeting IT people more directly and others who were not threatened by the technology was the right way forward.

Firms also need to figure out *how* the actors should be approached. Under conditions of interdependence, changing the network in favor of the innovation becomes a matter of aligning incentives and renewing competencies. As pointed out earlier, some innovations can destroy the competence of established actors. If these actors are crucial for the adoption, the firm needs to influence and encourage them to change their activities. In several of the cases studied in this dissertation, firms sought to do so by providing training and educational activities, thereby facilitating the process of creative destruction[31]. These activities also contribute to changing the motivations of some actors.

Delving more deeply into the issue of incentive alignment, a couple of measures for doing so have been identified. Several of the studied firms were engaged in a wide range of marketing activities explicitly aimed to build networks with opinion leaders which could persuade others of the benefits of the innovation. In the IP video case, the studied firm tried to interact with both IT and security managers and get them to agree on the benefits of IP video.

Other cases illustrate how firms explained their value proposition in different ways in order to reflect the new value creation and to make it more appealing to certain actors, thereby aligning incentives. When introducing technologies that create value in new ways, this value often needs to be communicated differently (Björkdahl, 2007). In the case of the incontinence diaper, the value proposition was changed from the sale of incontinence products to providing *better incontinence care at lower total cost*. The management of retirement homes and hospitals were more concerned with the total cost of incontinence care

[31] Several of the firms studied in the fifth and the sixth appended papers engaged in training activities and tried to renew the competencies of key actors. In the early 1990s, Hasselblad engaged in similar efforts. The company launched something called Hasselblad University, an initiative which aimed to educate photographers regarding how digital imaging works.

than were the purchasers and therefore, this type of communication turned out to be more effective[32].

Finding the right business model is ultimately about identifying which actors to target, how incentives can be aligned, and how resources and activities can be modified in order to match the new value created. The brief empirical illustrations provide some examples of how these guidelines can be applied in order to map and understand the firm's surrounding network. This input is vital for developing a new business model that fits with the creation and distribution of value associated with a disruptive innovation.

8.3 Reflections on the guidelines

The guidelines provided above can help firms to identify and handle challenges related to disruptive innovation. They may initially appear rather broad and not necessarily relevant only to disruptive innovations. It should be underlined here that the guidelines deal with how the firm can manage its surrounding networks, not its own resources and capabilities. Therefore, these guidelines do not address the challenges related for instance to competence destruction, architectural innovation, or the role of complementary assets. Rather they focus explicitly on identifying and managing the challenges that lie beyond the firm's boundaries. In this sense, the guidelines provide a more detailed understanding of how a business model can be impacted by a disruptive innovation and the ways in which it needs to be changed.

These guidelines address the factors that ought to influence the design of a new business model. As stated previously, the underlying perspective is similar to the '*hypercube of innovation*' (Afuah and Bahram, 1995) which points out that an innovation needs to be mapped in terms of its impact on different firms throughout the supply chain. However, the guidelines presented here differ in offering a more fine grained description of these actors in terms of resources, activities, power, and incentives. They differ also in assuming that an established network constellation is built on interdependence, which in turn suggests that finding the right business model is ultimately an issue of understanding the incentives that govern different actors and how these incentives can be aligned.

Although the proposed guidelines may be different from what has been suggested previously with regard to disruptive innovation, they share some features with previous work in other areas such as supply chain management and strategic management. Supply chain management has for a long time dealt with how actors, resources and activities can be linked together (Johnsen et al, 2000). It has been argued that the challenges related to interdependencies can be managed by understanding the incentives, exchanging information, and trying to find solutions that are mutually beneficial (e.g. Lee, 2004). When introducing

[32] The firm in the IP video industry also sought to communicate its value creation differently. It focused on the total cost of owning a surveillance system rather than the price of single products.

disruptive innovations, firms can learn by adopting a similar way of thinking. It is important to be aware of an innovation's impact on the surrounding network and to find ways to motivate actors to work in the same direction. Under conditions of interdependence, firms that seek to maximize only their own value at the expense of their networks may be worse off as this behavior may dissolve the networks. However, it should be noted that the introduction of innovations differs from management of a supply network in an important way. Innovation activities are different from more operational issues in the sense that the degree of uncertainty is often higher and that it is initially more difficult to quantify the precise value of adoption. To compromise and find ways to share both risk and profit may be even more important when aligning a network in favor of an innovation[33].

Scholars in strategic management have frequently pointed out that strategy is ultimately about finding a fit between the resources and capabilities of a firm and its surrounding environment (e.g. Grant, 2008). Earlier recommendations regarding disruptive innovation differ in regarding the environment as something that cannot be influenced. The guidelines proposed in this dissertation have a lot in common with for instance the work by Normann and Ramirez (1993; 1994) who regard strategy as the management of a value-creating system where the firm and its network work jointly towards value creation. In this perspective, the main strategic task is reconfiguration of the roles and relationships in the value chain. In some respects the guidelines also resemble Network Value Analysis, as developed by Peppard and Rylander (2006). This approach aims to describe how value is created and distributed in a network, how a firm's activities impact on it, and how other actors will behave. These views differ for instance from the positioning school (e.g. Porter, 1985) which maintains a more adversarial perspective on the environment.

Having offered some guidelines and described some cases of firms that encountered problems, it is interesting to revisit some of these cases and discuss whether things could have turned out differently with this perspective. The guidelines provide a better understanding of the main challenges and point to some ways to handle these issues. In this sense, they help firms to identify appropriate measures. However, this is not to imply that some of the firms would have survived or prospered by doing so. The challenges faced by individual firms are often more complex and difficult to address.

To return to the Hasselblad case, it can be seen that several firm- and technology-specific issues made it problematic for Hasselblad to handle the transition to digital imaging. For instance, digital technology is often associated with a very fast pace of development, which exacerbates the difficulties. When the technological shift was underway in the late 1990s, better and cheaper cameras rapidly penetrated the market, which increased the problems for Hasselblad. A similar pattern applies to the transition from mechanical to electronic

[33] See e.g. Holmström and Stalder (2001) for an illustration of how important it is to share risks and benefits when adoption depends upon many different actors.

calculators. Once the calculators were based upon integrated circuits, prices declined quickly while computing performance continuously increased. Hence, there are several issues related to technological improvement which are important, yet difficult to deal with theoretically.

In these cases, there were also several firm-specific factors which augmented the problems. Hasselblad suffered from several changes in ownership which created strategic inconsistency over time. Additionally, the short term scope of ownership which the Union Bank of Switzerland declared in 1996, along with its intention to make leveraged buyout seems to have increased these difficulties. Clearly, such factors are hard to incorporate into a managerial framework but nevertheless they have a considerable impact on the eventual performance of a firm. It should therefore be pointed out that the guidelines presented above assume that individuals are both able and willing to handle disruptive innovation in a rational way that maximizes the long term value of their company. Management needs to attend to these issues, but the dominant logic of established firms may sometimes prevent this from happening (Prahalad and Bettis, 1986). The empirical data in this dissertation would suggest that management attention is sometimes lacking but that it is still an important prerequisite for succeeding with disruptive innovation.

The Facit case also includes some specific factors that are hard to address managerially. For example, in the 1950s, the firm recruited some of Sweden's top electronics researchers and set up the subsidiary Facit Electronics. There was little knowledge about electronics in Sweden at the time and Facit identified and recruited the key people in the country. Hence, both Facit and the labor market in which it was located lacked a sufficient competence base in electronics. These macro-economic conditions are difficult to integrate into the proposed guidelines but they do play an important role and should not be overlooked.

Having underlined the heterogeneity in the challenges faced by specific firms, the proposed guidelines still mark an improvement to what existing theory on disruptive innovation has offered. The aim is to propose a more detailed approach that makes it possible to understand where and how a disruptive innovation prospers, to understand the enablers and disablers of its growth and how firms can develop new business models when introducing these innovations.

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Paper I

Exploring Factors Influencing Incumbents' Response to Disruptive Innovation

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This paper explores how certain incumbent characteristics influence an established firm's response to disruptive innovation. More specifically, it looks at the challenges a middle size, top segment company faced and how this affected its reaction to the disruptive threat. This is done by conducting an in-depth case study of Hasselblad, a manufacturer of professional cameras. It can be seen in this case study that Hasselblad's limited resources and its niche strategy affected how it managed the transition from analogue to digital camera technology. These characteristics made it difficult to allow experimentation with digital imaging in the main business since the available resources were severely limited and this initially inferior technology could harm the brand image. Instead, Hasselblad pursued collaborations and eventually launched a hybrid camera, which was compatible both with film and digital backs but did not become the expected success. Being close to bankruptcy, the digital resources needed were acquired and the company eventually survived the disruption. In conclusion, this paper argues that the managerial challenges and solutions to the innovator's dilemma depend upon the particular characteristics of incumbents and that this heterogeneity has not been sufficiently captured by previous literature. It also suggests that medium size, top segment firms can survive disruptive innovation through collaboration and acquisitions.

Introduction

The concept of disruptive innovation (Christensen, 1997) has received much attention from both academics and practitioners. Nevertheless, there are several areas that have not so far received sufficient attention. One such aspect is the heterogeneity of incumbents. While the literature on disruptive innovation has proved that incumbents frequently fail in the transition from a sustaining to a disruptive technology, it has so far shown limited interest in the differences between established firms. In the discourse regarding disruptive innovation, incumbents are often treated as one population vis-à-vis entrants rather than as many populations with different resources, market positions and strategies. Contrary to this, it appears reasonable that the capacity to respond to disruptive innovations depends largely on the characteristics of the incumbent and consequently that the managerial solutions proposed need to take these differences into consideration.

This paper investigates how certain incumbent characteristics influence the response to disruptive innovation. In particular, using an in-depth case study approach, it explores the challenges and managerial solutions for a medium size established firm in the high-end segment of its industry. The firm in question is Hasselblad, a manufacturer of professional cameras. Based on the observations made, it is argued that the managerial challenges and solutions to the innovator's dilemma depend upon the particular characteristics of an incumbent and that this term needs to be nuanced further. Moreover, the article suggests that a medium size company in a high market segment can survive disruptive innovation through collaboration and acquisitions.

This paper is organized as follows. The next section reviews the literature on disruptive

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innovation and entrant-incumbent dynamics. The subsequent section contains a description of the methods used in this paper. Then the case study about Hasselblad is presented in order to illustrate how a particular incumbent firm encountered severe problems, but eventually survived the disruption. The firm provides a particularly compelling example in that, despite early investment and recognition of the disruptiveness of digital imaging, it encountered problems in the transition to the new technology. The final section contains an analysis of the case study and a discussion about its theoretical and managerial implications.

Theoretical Exposition

It is well documented that many established firms find it hard to adapt to changes in the technologies they employ. Frequently, incumbent firms do not manage the shift to the new technology, they lose market share and the successful firms are found among the new entrants (Cooper & Schendel, 1976; Tushman & Anderson, 1986; Utterback, 1994). Christensen (1997) brought a new perspective to this issue by drawing upon resource dependency theory (Pfeffer & Salancik, 1978). This theory suggests that a firm's freedom of action is in fact controlled by actors outside the boundaries of the company, e.g., customers and investors. Hence, resource dependency theory posits that a firm's freedom of action is in fact limited to satisfying the demands of those actors that provide the resources it needs in order to survive.

By making a distinction between sustaining and disruptive technologies, Christensen explained the recurrent pattern of incumbent failure in technological shifts. Sustaining technologies have in common that they improve the performance of established products along the dimensions that mainstream customers demand. Disruptive technologies, on the other hand, initially underperform along these dimensions. The lower traditional performance and the ancillary performance attributes create a large market uncertainty around the disruptive innovation. At the same time established firms find it irrational to abandon their current, profitable customers in order to aim for a new, initially small market and an inferior technology. As the performance of the disruptive innovation increases it begins to attract customers from the sustaining technology and eventually displaces the old technology. Through his studies of the disk drive industry, Christensen showed that incumbents usually win sustaining battles whereas entrants succeed in disruptive battles. Hence, a key determinant of the probability of success for an innovation is the extent to which it addresses the needs of actors in an incumbent's current value network.

Christensen also derives a number of managerial solutions which have been further developed (Christensen & Raynor, 2003). It is argued that managers in incumbent firms basically have three options, they can *change the processes and values of the current organization*, *create an independent organization*, or *acquire a different organization*.

Firms that try to *change the current organization* in order to adapt to the disruptive innovation have a weak track record (Christensen, 1997). The main reasons for this are related to the resource dependence that the innovator's dilemma originates from.

An *independent organization* can be regarded as a structure in which an organization develops new resources that are different and separate from the rest of the firm. It has objectives that are largely independent from and outside the current operations of the firm. As the new technology evolves within the organization, the required processes and values are also developed (Macher & Richman, 2004). This is one of Christensen's most influential recommendations for how to manage disruptive innovations.

When firms are not able to develop disruptive innovations, they can adapt by *acquiring* companies that possess the resources that are needed for developing the new technology. By doing so, the competencies needed for developing disruptive innovations can be incorporated into the organization rather than developed.

Though the problems and solutions described above are well elaborated, they suffer from some drawbacks mainly due to a lack of clarity in the terminology used. In the discourse regarding disruptive innovation, incumbents are treated as one population vis-à-vis entrants, rather than as many populations with different resources, market positions and strategies. However, the forces of resource dependency should arguably vary depending upon the specific characteristics of an incumbent firm. For instance, firms operating in a high-end segment are likely to face different challenges from those faced by a company in the low-end of the market. This implies that there could also be a substantial amount of heterogeneity among the solutions to the innovator's dilemma or that the most suitable means of action actually depend upon the characteristics of the incumbent. Consequently, the managerial solutions can potentially be improved further by exploring how

the properties of an incumbent affect its response to a disruptive threat.

Moreover, given that disruption is a process and not a discrete event (Christensen & Raynor, 2003), it should strike at different points for different firms depending on the segment in which the firm is operating. Adner (2002) pointed out that the structure of demand needs to be addressed in order to clarify the nature and effect of disruptive innovations. Using the notion of thresholds, Adner also defined critical performance levels that must be met. The functional threshold of a product is the minimum performance that the customer can accept whereas the net utility threshold also takes price into consideration. The point in time when the net utility threshold is met by the disruptive technology should arguably depend upon which customer segment the incumbent operates in.

Furthermore, Danneels (2004) suggested that future research should investigate alternative routes for incumbents to access disruptive technologies, looking into the possibilities for using alliances, acquisitions and internal development in more detail. This paper will address some of these issues by exploring how certain incumbent characteristics influence its response to disruptive innovation. More specifically, it will look at the particular challenges encountered by a medium size established firm operating in the high-end of the camera market.

Methods Used

The case study below illustrates how Hasselblad failed to develop capabilities in digital imaging on its own and then survived through collaborations and an acquisition. This firm was targeted since it does not possess the characteristics of most incumbents that are studied in the field of disruptive innovation. The firm is operating in the high-end segment of the camera market, targeting professional photographers with a high demand on performance. An additional reason for studying Hasselblad is that it was possible to conduct interviews with current and former high-level managers of the company.

Though the authors have no past experience of working with Hasselblad, extensive amounts of information have been accessed. Since this paper focuses on corporate strategy and the implementation challenges that confront managers, senior managers who played a substantial role in forming the strategy were primarily interviewed. Managers of R&D have also been accessed in order to understand the specific challenges they faced when shifting from analogue to digital imaging. In total, more than 50 hours of interviews were performed and recorded with 11 people. Follow-up interviews were also conducted in order to ensure an accurate interpretation of the information. All field research interviews began with general open-ended questions, asking managers how they perceived the challenges posed by the disruptive technology and how they tried to deal with them. The same questions were asked to at least two senior managers from one era. In order to ensure the accuracy of this information, it was compared with a large amount of secondary data such as annual reports, media articles, old mail conversations between managers and book chapters written by former managers. In addition to this, all minutes from the board meetings during the period 1989–94 were accessed.

The description of this case emerged when all these sources of data had been analysed. In those cases when the written material that was accessed diverged from the interview data, follow-up interviews were performed. The gathered data has thus been triangulated by looking at several independent sources and making sure that these sources were mutually consistent. Moreover, the most important material has been read, accessed or discussed by several researchers in order to ensure an accurate interpretation.

Case Description

Hasselblad is a small niche player in the camera industry. The firm had for a long time about 500 employees in total and annual revenues of around SEK600 million. It has for decades been one of the leading camera manufacturers and has sometimes been referred to as the 'Rolls Royce' of the camera industry. The company received global recognition in 1969 when the first photos of Neil Armstrong on the moon were taken with a Hasselblad camera. During the following decades, a series of high-performing cameras for professional photographers were developed. This case study will focus on the late 1980s to 2005, which is the era when Hasselblad's analogue cameras were disrupted by digital imaging.

In 1981, the camera industry was shaken when Sony introduced the first camera that was not using film, the Sony Mavica. Given the poor picture quality of the Mavica, the CEO of Hasselblad at that time, Jerry Öster, concluded that the firm should wait and instead learn more about digital imaging by developing other applications. Öster thought that Hasselblad was too small to make the investments in

R&D required in order to overcome the weaknesses of the new technology and that it would take time before the technology would disrupt Hasselblad.

Attempts to Develop a New Camera System

During the late 1980s, Hasselblad became increasingly aware of the drawbacks of its analogue camera system. Cameras are not only about electronics or precise mechanics. There are many features which are related to optics and Hasselblad lagged behind in those areas. Therefore some R&D managers thought that the company needed to develop a completely new camera system with modern functions such as autofocus. Some proposals were made to the board but the project, which was called Nova, was never launched on a full scale. The main reason for this was that management thought Hasselblad was too small to afford such a project.

The Development of a Digital Studio Camera

The firm instead moved further into digital imaging in the early 1990s. A new CEO was recruited who had a background in electrical engineering and believed in the potential of digital imaging. In 1994, the company started the development of a digital camera. During this time digital and analogue photography were competing for the same resources. One member of the product board recalls that 'we had one budget in the product board and money had to go to either the digital camera system or the mechanical camera system'. It was eventually decided to move further into digital imaging.

When the development of a digital camera had started, it soon became apparent that this technology had some properties that made it fundamentally different from an analogue camera. The photo quality was lower at this point than with an analogue Hasselblad camera. Along other performance dimensions, digital photography had many attributes that made it attractive. Photos could be replicated, manipulated and sent at a much lower cost and much more conveniently than with analogue imaging. Thus, the business utility of digital technology was in fact very large at this point, yet different from what Hasselblad had offered previously.

With these properties in mind, the manager in charge of digital development, Lennart Stålfors, thought that the best thing to do was to develop a camera for studio photography. This customer segment would hopefully be willing to trade off some photo quality for the opportunity to take many photos, make copies and sending the photos in an easier way.

The development of the digital camera took place both in-house and in various collaborations. One of the largest projects was undertaken together with Philips. Among other things, this resulted in a sensor for digital cameras. 'Many large companies were willing to co-operate with us despite the fact that we were so small, our strong brand helped us a lot', Lennart Stålfors recalls.

A Change in Strategy

Partly as a consequence of having focused on digital imaging, Hasselblad lagged behind with its mainstream products. This was one of the reasons why the new owner, the Union Bank of Switzerland (UBS), in 1996 decided to cut off digital development. Moreover, UBS had a short-term scope of ownership and did not want to make investments that would be beneficial in the more distant future. An additional reason was that some managers, primarily in the marketing department, thought that the inferior quality of digital imaging would damage Hasselblad's brand. Others argued that the firm was too small to develop a digital camera on its own. Stefan Arvidsson, member of the board, says: 'In the long run we would not have been able to keep up with the others. Compare us to what the huge Japanese companies spend on development. I still think stopping the project was the right thing to do.' However, many people thought that this decision was a disaster. For instance, the Chief Finance Officer (CFO) at that time, Bengt Ahlgren said: 'Hasselblad did not have to develop everything on its own. Throughout the years our reputation had made us an attractive partner for collaborations.'

Instead of continuing with digital imaging, the new owner decided to develop a completely new camera system. As was mentioned before, this project had been considered in the late 1980s but had never been realized since it would have been very expensive for a small firm like Hasselblad. The new strategy was to pursue some collaboration and thereby follow the digital development, while focusing Hasselblad's own resources on analogue technology.

The development of Hasselblad's new camera system, the H1, was initiated in 1998. The camera was developed in collaboration with Fuji, who actually funded almost 50 per cent of the camera. The idea was to create a camera which was analogue but also compatible with digital backs, thereby facilitating the transition from analogue to digital imaging.

However, this project was heavily delayed and the product was not launched until late 2002, many years after what had been planned originally. Moreover, it had run SEK150 million over budget and did not have all the features that were originally intended. This delay turned out to be critical since the technological shift started to affect the company during those years. One member of the development team notes that: 'if the H1 would have been launched in 1998, we would have had four good years of revenue from it. When the H1 was finally launched it was a fantastic product, but that did not matter since most cameras were completely digital then.'

The H1 system was a hybrid, which could use both digital backs and conventional film. The digital backs were initially delivered by Kodak and PhaseOne. Since Hasselblad did not manufacture their own digital backs this meant that they could not deliver a complete digital camera themselves. At the same time, the performance of digital cameras had increased to the extent that Hasselblad's position was threatened by actors that had not even been their competitors before. One of Hasselblad's most profitable segments, wedding photography, had for decades been a market that was protected from competition. But within a few years, Hasselblad lost this market to Canon due to the shift from analogue to digital technology. Digital backs are very expensive and thus, a fully digital Hasselblad camera cost SEK100,000 more than Canon's similar products. The firm now experienced a severe drop in revenues. As the market for digital cameras expanded rapidly, Hasselblad encountered further problems being caught with a technology that was essentially analogue.

In early 2003, the company was bought by the Shriro Group, a Chinese firm which had been Hasselblad's distributor for more than 40 years. The new owner sold off all subsidiaries of Hasselblad, downsized the firm and had to bring more money into the company several times in order to avoid bankruptcy. Hasselblad now had to develop a complete digital camera system, which included digital backs. Given that the firm was close to bankruptcy, had suffered severe layoffs and had cut off all digital capabilities in the mid 1990s, the situation was desperate.

Shriro thought that it would be impossible under these conditions to develop a digital back and therefore started to look for potential acquisitions. Given that the new Hasselblad camera was compatible with digital backs, the synergies from buying a manufacturer of those backs seemed obvious. In order to avoid bankruptcy, Shriro had to invest extensively in the acquisition of Imacon, a Danish firm manufacturing digital backs. Imacon and Hasselblad were merged together and Hasselblad could now sell a complete digital camera system.

After having been close to bankruptcy in 2003–4, the company recovered financially and since then it has been profitable in manufacturing digital cameras for professional photographers. However, Hasselblad is still paying back a lot of debt to the owner for whom the acquisition of Hasselblad turned out to be far more expensive than anticipated. A long and dramatic journey for Hasselblad had been made, or as the CEO Lars Papilla expressed it in May 2004, 'the shift to digital technology was much more dramatic than we had expected.'

Analysis and Discussion

The case study of Hasselblad can indeed be regarded as an illustrative example of the innovator's dilemma. It clearly shows that the digital cameras were disruptive. While initially having a lower performance along traditional measures such as photo quality, it had other attributes such as the possibility to store, replicate, send and manipulate photos more easily and at a lower cost.

Despite recognizing the future importance of digital technology at an early point, Hasselblad encountered great difficulties in this technological shift. Resource dependency theory seems to provide one explanation for why this happened, as suggested by Christensen (1997). The continuous demand from investors to focus on profitability and therefore downsizing disruptive initiatives can be regarded as one example of this. Moreover, the particular characteristics of Hasselblad affected how the firm handled the disruptive threat from digital imaging. The company was relatively small and had a limited and demanding customer base. These properties imposed constraints on how Hasselblad could handle the innovator's dilemma.

Focus on the High-End Segment – An Obstacle for Experimentation?

It can be seen in the case study above that Hasselblad's niche strategy affected how the firm managed the transition to digital imaging. Digital cameras could not initially provide the superior performance that was demanded in the high-end segment where Hasselblad had established a unique position. The net utility threshold (Adner, 2002) was much higher for a firm like Hasselblad than for a company

operating in the amateur segment. In addition to this, Hasselblad's customers associated the brand with quality and superior performance and this image could have been damaged by experimenting with an initially inferior technology. The strong brand was one of Hasselblad's greatest assets and this seems to have created a large hostility against digital technology, particularly in the marketing department. The protected market position and the brand were probably two of the main reasons why the new owner decided in 1996 to cut off digital development and focus more on analogue imaging.

In this respect, companies in the lower segments had better possibilities for early experimentation and learning since they could sell digital cameras to amateurs with low demands on photo quality. The values associated with the Hasselblad brand implied that a transition to a lower performing technology was deemed to be very risky and, thus, the forces of resource dependency seem to have worked strongly in favour of the sustaining technology. Based upon a history of landmark events such as the photos taken on the moon, a dominant logic (Prahalad & Bettis, 1986) emphasizing extreme performance had emerged within the firm and this further implied that moving into digital technology was difficult. Clearly, the firm's core capabilities in the mechanical technology in this sense turned into core rigidities when facing the disruptive technology (Leonard-Barton, 1992).

Firm Size Limiting the Possibilities to Keep Options Open

The case study also illustrates how being a medium size company affected Hasselblad's response to the disruptive technology. When management decided not to develop a new camera system in the late 1980s it was largely a consequence of the limited resources of the firm. Moreover, the fact that much of the digital development in the early 1990s occurred in various collaborations such as the one with Philips illustrates how firm size affected the way Hasselblad handled the disruptive threat.

During the mid 1990s the firm continuously moved away from digital imaging and instead embraced the sustaining technology that had proven to be successful for so many decades. When the new owner decided to focus solely upon conventional camera technology and pursue only minor collaborations in the digital technology area, another step in this direction was taken. It appears that this decision was also affected by the firm's size and its available resources. It can be argued that the limited size of Hasselblad accentuated the difficulties involved in meeting the disruptive innovation as the company ended up in an either-or situation, due to its financial constraints.

Hence, the forces of resource dependency were very strong for a firm like Hasselblad. It would have been expensive for the company to pursue development in both the new and the established technology fields simultaneously. Hasselblad tried to keep the option of developing a digital camera open through collaborations and instead focus on a hybrid camera, but lost valuable time and resources in doing so. The fact that the new camera system launched in 2002 was to a large extent financed by Fuji also illustrates how the size of the firm affected its way of managing the technological shift. During this long and costly project, Hasselblad never had the resources or strategic focus needed to develop digital backs. When Shriro acquired Hasselblad and the firm was close to bankruptcy, it could eventually survive through an acquisition of Imacon, thereby providing a fully digital camera system.

Whether the outcome of this strategy should be regarded as a success or not is a subject that is open to interpretation. If the new owner hadn't brought additional funding to the company it would most likely not have survived, and it is still paying off debts to Shriro. On the other hand, empirical evidence from both other industries and the camera industry (e.g., Christensen, 1997; Tripsas & Gavetti, 2000) suggest that few companies survive disruptive innovation and therefore survival may here be regarded as some form of modest success.

An additional factor that seems to have affected how Hasselblad handled the disruptive threat seems to be ownership and the willingness to make long-term investments. An owner such as UBS who had a short-term scope of ownership was hostile towards investing in digital imaging and instead developed a hybrid camera. The takeover by Shriro seems to have enabled the kind of investment that was needed. Therefore, it appears that the various ownership changes created a strategic inconsistency over time that augmented the problems Hasselblad encountered, but the accessed data does not enable us to draw further conclusions about this.

Summarizing the above, it is seen that Hasselblad's size and strategy affected its response to the disruptive technology. For a firm like Hasselblad, the relative cost of pursuing digital technology was higher than for a larger incumbent and, hence, the inertia seems to be very strong in this setting. It can be seen in the case study how this forced Hasselblad to

handle the disruptive innovation through various collaborations and through an acquisition of digital capabilities.

Moreover, digital cameras could initially not satisfy the demands that Hasselblad's high-end segment required. In contrast to this, larger camera manufacturers such as Canon and Nikon could develop capabilities in digital photography while they were still producing conventional cameras. These firms had the sizeable resources that were needed in order to undertake these kinds of ventures. Furthermore, they were operating in the amateur segment for cameras, which could tolerate the lower performance that the disruptive technology initially provided.

However, it should be emphasized here that there are several examples of large incumbents in the low-end segment of the camera industry that encountered problems despite having larger R&D budgets. One such example is Polaroid (Tripsas & Gavetti, 2000) which initially sought to develop digital cameras and complementary assets but failed and after that focused on conventional cameras. Since this pattern is to some extent similar to what happened to Hasselblad, incumbent size and strategy can clearly not be the only factors that affect how established firms handle disruptive threats. This paper does not argue that these are the only, nor the most important determinants; rather, it claims that the particular characteristics of an incumbent affect the challenges in a disruptive shift and that they consequently also need to be considered when looking for managerial solutions to the innovator's dilemma.

Conclusions and Managerial Implications

This paper has explored how certain incumbent characteristics influence the way an established firm responds to disruptive innovation. In particular, it has looked at the challenges a medium size, top segment company faces, and possible ways of handling them. It can be seen in this case study that Hasselblad's limited size and its niche strategy made the firm highly vulnerable to the innovator's dilemma despite the fact that the disruptive effects of digital imaging were recognized and dealt with at an early point. Having a small and demanding customer base implied that Hasselblad became highly dependent on these customers and also lacked the resources to pursue extensive internal development projects.

Moreover, the case illustrates how the managerial solutions to the innovator's dilemma are affected by the particular characteristics of an incumbent. A relatively small niche player like Hasselblad could eventually survive the disruption through collaborations and an acquisition. This finding suggests that the heterogeneity of incumbents has been downplayed by the previous literature and it calls for further investigations to allow for the development of a more nuanced view of how established firms can respond to disruptive innovations.

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Paper II

Hasselblad and the shift to digital imaging

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Abstract

Hasselblad, a Swedish high-end camera manufacturer, started in the early 1980s to explore how digital technology could be used in their industry. Throughout this decade, the company sought to learn more about digital imaging by developing applications such as the telephoto transmitter Dixel. However, increased competition forced Hasselblad to leave this segment in the early 1990s. Instead the company started to work on a new digital camera system. Among other things, this project resulted in a 6 Megapixel sensor in 1996, but the project was eventually terminated when a new owner changed the strategy of the firm. Being close to bankruptcy in 2003, Hasselblad was sold to a new owner which merged it with Imacon, a Danish manufacturer of digital backs. In 2005, the company could finally deliver a fully digital camera system on its own and survived the shift to digital imaging.

Keywords: Hasselblad, digital imaging, photography, disruptive innovation, microelectronics, technology, management

Introduction

Already in 1977, Intel's co-founder Robert C. Noyce called attention to the rapidly increasing use of digital technology in many industries. While he argued that this trend would create a lot of entrepreneurial opportunities, Noyce also suggested that established firms will encounter major difficulties once their products are replaced by the new technology:

"Time and time again the rapid growth of the market has found existing companies too busy expanding markets or product lines to which they were already committed to explore some of the more speculative new markets or technologies."[1]

Noyce referred to the fact that mechanical calculators and watches had been removed from the market in the 1970s and argued that more such displacements would happen in the future as digital technology would provide better performance at lower costs over time.

In retrospect, it is striking how accurate Noyce's prediction turned out to be. In industry after industry, digital technology has disrupted the former technology and created countless problems for established and highly profitable firms. Since Noyce's article was written, many products such as telephones, music players, television screens, movie cameras and gaming machines have become digital. With few exceptions, these shifts have implied major difficulties for incumbent firms.[2] Over the last decade, the camera industry has been subject to precisely this kind of turmoil due to the shift from silver-halide photography to digital imaging. Several established firms have either encountered severe problems or gone out of business completely.[3]

This article will describe how a small Swedish manufacturer of high-end cameras called Hasselblad tried to nurture and develop digital photography from the early 1980s onward. It provides a good illustration of how digital technology emerges in various high-end niche applications and how it later enters the mainstream markets and displaces incumbents. In doing so, the presented work contributes to the literature on disruptive innovation and to our understanding of how industries are digitized. The rest of the article is organized as follows. The next section provides some theoretical background regarding technological discontinuities, which is followed by a detailed chronological description of how Hasselblad sought to manage the shift to digital imaging. Subsequently, a more theoretical and historical discussion is given along with some conclusions.

Technological discontinuities and digital technology

It is well documented today that established, successful firms often get into trouble under conditions of discontinuous technological change.[4] Several scholars have sought to explain what is sometimes referred to as "the incumbent's curse" by looking at the supply-side and firm capabilities.[5] For instance, Tushman and Anderson wrote about competence-enhancing and competence-destroying technologies. They argued that those technologies which render the technological skills of established firms obsolete tend to create major difficulties.[6] Drawing upon a case study of how Polaroid sought to handle the shift to digital imaging, Tripsas and Gavetti pointed out that cognitive barriers among managers prevented the firm from commercializing the new technology.[7] In another article, Tripsas studied the typesetter industry and argued that not only a firm's technological competences matter. The impact on firm-specific complementary assets, i.e. assets which were not directly related to the technology but helped the firm to sustain its competitive advantage, also played a key role in a technological shift.

In a series of articles from the mid-1990s, Clayton Christensen shifted the focus away from supply-side related factors towards looking at the impact a new technology has on the market. Drawing upon evidence from the disk drive industry, he argued that those technologies which were not initially demanded by a firm's existing customers were particularly difficult to handle.[8] Each new generation of smaller disk drives offered lower performance in terms of storage capacity and therefore started to prosper in lower segments or in new markets. The incumbents struggled to find a financial logic in entering an inferior technology which grew in a small, low-end niche of the market. As the performance improved, it eventually displaced the former disk drives and the established firms who were misled by existing customers. Christensen labeled those technologies which were cheaper, with initially lower traditional performance and some new attributes, as disruptive. Those technologies which kept satisfying a firm's existing customers were referred to as sustaining. In his book, *The innovator's dilemma*, it was shown that incumbents tend to win sustaining battles whereas entrant firms are better at introducing disruptive technologies since they are not held captive by an established customer base.

Digital technology has often turned out to exhibit disruptive characteristics. It has often started off with inferior traditional performance while bringing new attributes to the market. The rapid pace of development associated with digital technology has made it attractive for mainstream customers later on and then displaced the former technology. For instance, Christensen and Raynor used the transistor radio as an illustrative example of this pattern.[9] Compared to analog radios, it had a worse sound quality, but brought

some new attributes to the market, such as a lower price and portability. Therefore, it prospered among teenagers who could not afford a radio previously. This customer segment appreciated the portability and did not bother about the lower sound quality. In the 1950s, entrant firms like Sony created a mass market for transistor radios and, as the sound quality improved over time, this technology eventually displaced analog radios and established firms like RCA.

Clearly, Christensen's notions of sustaining and disruptive technologies have shed new light on how discontinuities happen. However, it is still a bit unclear how this framework fits with the nature of digital technology. The dynamics of digitization have often been described in terms of a rapid increase in performance along with declining prices. For instance, Intel's other co-founder, Gordon Moore, predicted in 1965 that the amount of transistors that could be crammed onto an integrated circuit would double during every 18-month period.[10] This prediction has often been referred to as Moore's law and can be thought of as a description of the rapid development of digital technology. While it is clear that digital technology has often brought some ancillary attributes to the market, it has usually, as Moore's law would suggest, started off with poor performance and a high price. Consequently, it has in many cases initially prospered in very advanced segments which are not sensitive to prices, e.g. in military or scientific applications.[11] Therefore, it is not obvious in what way Christensen's framework, which focused on low-end applications, is compatible with the economics of digital technology. Christensen showed how the disk drive manufacturers were displaced when entrants introduced smaller drives, targeted low-end segments, moved up market and removed incumbents. Thus, it is not apparent whether this pattern is compatible with the growth of digital technology. By studying how and why digital imaging emerged in Hasselblad's segment, this article will argue that digital technology is substantially consistent with the notion of disruptive technology, albeit in a way that is different from what has been suggested previously.

Hasselblad and the early versions of digital cameras

Hasselblad became a dominant player in the medium-format segment of the camera industry during the time after the Second World War. This small segment of the camera market used larger film than the normal 24*36mm format and was aimed for professional photographers with high demands on image quality. One reason for Hasselblad's dominance was that its cameras were compatible with a wide range of lenses which were manufactured by Carl Zeiss, film magazines and other accessories that were used by photographers. Hence, a photographer who used a Hasselblad camera had great flexibility, but Hasselblad did not develop these products itself. The company became world-famous in 1969 when Neil Armstrong took the first photos on the moon with a Hasselblad camera. During the 1980s, the firm had about 500 employees in total and an annual turnover of

approximately 600 MSEK. The company showed relatively high profitability in these years, delivering annual profits of 50-60 MSEK. However, the medium-format segment decreased by about 40 percent from 1981 to 1985, mainly since small-format cameras became better and better.[12] Despite this reduction, Hasselblad managed to sustain its revenues and profits in these years, mainly thanks to its strong brand.

The camera industry had reached a mature phase towards the late 1970s. By that point, Japanese firms like Canon, Nikon, Olympus and Fujifilm had entered the scene and captured market shares primarily from European companies like Leica and Rollei. Technologically speaking, the industry had reached a point of saturation. Rolls of silver-halide film in various formats were used in cameras that were essentially based upon precise mechanics. Though the first digital camera which used a Charge Coupled Device (CCD) had been exhibited in 1975 by Kodak, it had not caused any panic among the established firms.

The entire camera industry was instead shaken in 1981 when Sony introduced its Mavica, the first fully electronic, non-film-based camera. The camera stored images on floppy disks instead of on film. It was presented as a still-video camera; images were captured by a CCD chip, transformed into electric signals which were handled by processors inside the camera, and thereafter stored on a floppy disk. 50 photos could be taken and viewed on a TV screen later.

Many Japanese companies became concerned that this new technology would eventually replace their current products. A few years later, Canon, Fuji, and several other firms had developed their own versions of the Mavica which they exhibited at the annual Photokina fair. Photo journalists argued by that time that the camera industry would become computerized at the same pace as the calculator and watch industries had been during the preceding decade.

At Hasselblad, the company's CEO Jerry Öster tried to figure out how this potential threat should be handled:

"I met with Sony's CEO and the person behind the Mavica project. It soon became clear to me that the technology had so many drawbacks and limitations that it would not become a commercial success."

After having consulted Hasselblad's R&D manager, Lennart Stålfors, Öster concluded that several technological breakthroughs were needed before the Mavica concept could threaten analog photography. Öster and Stålfors also agreed that digital imaging would have a future and that the company ought to learn more about the new technology.[13]

Hasselblad's attitude toward digital imaging in the early 1980s is well captured by the following quote from Jerry Öster:

"Even though I did not believe in the Mavica concept, I was convinced that the photo chemical film would in the future be subject to serious competition from electronic photography and would eventually be replaced by this technology."[14]

Hasselblad Electronic Imaging

Instead of trying to develop a digital camera, Hasselblad started to explore the new technology through various applications. Lennart Stålfors had a background in electrical engineering and had previously been working on adding electronic features to the Hasselblad system. Among other things, he had been involved in a development project together with SAAB and a professor at the Royal Institute of Technology in Stockholm, which concerned a machine for image analysis. The final product was named OSIRIS, and was primarily intended for digital analysis of images taken by aircraft and satellites. In the end, the project became a commercial failure – the price was too high and the image quality too low. After two years, Hasselblad therefore left the project in 1982.

The insights Stålfors gained from this project made him realize that the technology for telephoto transmission, i.e. the sending of images over the phone line, was underdeveloped. Images lost considerable amounts of quality when being sent over the phone line. Consequently, photographers had to bring with them darkrooms in order to finish photos and send them. The equipment weighed 10-12 kilos, which in combination with the darkroom became a heavy burden for photographers. The analog technology also implied that small amounts of noise over the phone line would generate significant distortions of the images. Could Hasselblad perhaps use digital technology in order to create a telephoto sender that was faster and offered superior image quality? Such a product would clearly make the everyday life of the photographer much easier.[15]

Jerry Öster thought that this was a good idea and Hasselblad now started to look for a potential partner. Lars Falén at Expressen – one of Sweden's dominant newspapers by that time – was contacted. Hasselblad wanted someone to start using their coming product and thereby create attention around it. Falén thought that such a telephoto transmitter would be interesting to use during the Olympic Games in Los Angeles 1984. He explained that the newspaper only had 30 minutes until press stop after the last finals and he needed a product which would enable the last photos to be included.

The development work started towards the end of 1982 and about five persons were involved at Hasselblad. With these scarce resources and a sharp deadline 18 months away,

the team worked very hard and eventually two functioning prototypes of the *Digiscan* joined when Expressen went to Los Angeles in July 1984. The name was an abbreviation of the *Digital Scanner* which could digitize film and offer 1-megapixel resolution of the scanned film. The images were sent via modem, directly from the Olympic stadium to Stockholm, Sweden. By doing so, the photographer gained about 40 minutes and obtained much better image quality.[16]

The Digiscan became a great success for Expressen since the newspaper could get pictures in print faster than its competitors. The news agency Agence France Presse (AFP) became interested in the product and offered Hasselblad a visit to Paris in order to discuss a potential collaboration. The two parties agreed that Hasselblad would develop Digiscan further provided that AFP bought 40 of them, for 120,000 SEK each. AFP signed and paid one third of the sum up front, and this led to the development of the *Dixel*.

Hasselblad's work had initially started off as an ambition to learn more about digital technology and turned quickly into a business opportunity. The company now had to decide how the digital development should be organized. Digiscan had been developed by Hasselblad's R&D department. It had taken some of the key staff into account and moreover, this project had been fundamentally different from the daily development work at Hasselblad. Jerry Öster thought that digital development should be put outside the parent company and therefore started the subsidiary Hasselblad Electronic Imaging AB (HEIAB) in 1985. The former R&D manager, Lennart Stålfors, became the CEO of the new company. Jerry Öster and Hasselblad's CFO Bengt Ahlgren were also members of the board. In the annual report from 1985, Öster wrote: "The Dixel 2000 is a natural link for Hasselblad between the traditional chemical photography and tomorrow's electronic image technology".[17]

Initially three employees worked at HEIAB. The ambitions were not very high in the beginning and the subsidiary was often regarded as an attempt to create knowledge rather than profits. The subsidiary had only six employees in 1986, but grew rapidly over the coming years. The Dixel was launched on a much bigger scale than the Digiscan and the demand for it grew quickly. During 1987, it was used at many large sports events, for instance the global athletics championships in Rome. As sales grew, HEIAB became increasingly profitable. The subsidiary had only cost 3.5 MSEK before it reached break-even in 1988.

Over time, several other products related to digital transmission and handling of images were developed. By the early 1990s, HEIAB's turnover had grown to about 50 MSEK and showed good profitability. In 1990-91, 20-25 percent of the company's total profits came from an organization that had only existed for a couple of years.[18]

	Turnover (MSEK)	Profit (MSEK)	Profit Margin (%)
1985	0	0	0
1986	4	0	0
1987	11	0	0
1988	20	2,5	12,5
1989	30	5,6	18,7
1990	48,6	11,6	23,9
1991	60	11	18,3
1992	48	3,5	7,3

The table above contains financial data about Hasselblad's subsidiary, Hasselblad Electronic Imaging, during the years 1985-92.[19]

The work at HEIAB generated valuable knowledge and created a new source of profit for the company.[20] In the 1980s, the medium-format segment of the camera industry became increasingly saturated and was even subject to negative growth. Hence, the profits that came from HEIAB were needed in the mother company since it was hard to find new sources of growth within the core business.

By the late 1980s, the uncertainty regarding digital imaging was still very high. Both Canon and Fujifilm had tried to launch their own versions of digital cameras without any success. Many electronic still-video cameras had been shown on camera exhibitions during those years. They all had two things in common: poor image quality and a high price. Since the early 1980s, photo journalists had claimed that analog photography would become history within the coming 2-3 years. Parallels were often drawn to the instant digitization of calculators and watches during the 1970s and early 1980s. By the end of the 1980s it was obvious that the same thing had not happened yet in the camera industry.

The parallel to watches and calculators was in fact not entirely accurate. The most notable difference is that the digital technology in a calculator or a watch does not have to be light-sensitive. In the cases of watches and calculators, electronics displaced discrete mechanical parts inside the products. Cameras, however, were different. Both analog and digital cameras contain large amounts of optics, chemistry, precise mechanics and electronics. Moreover, the fact that an image sensor has to be light-sensitive implied that the demands upon digital technology were significantly higher within the camera industry. For instance, by the late 1980s, Nikon launched a still-video camera with 0.6 megapixels. A photo taken with an analog Hasselblad camera would correspond to about 36 megapixels whereas a photo with small-format film would be similar to 10 megapixels.

Summing up, Hasselblad changed during the 1980s from having been a manufacturer of mechanical cameras to a company that also works with various elements of imaging. The scope of Hasselblad's business had been extended and digital technology was the main ingredient in this change.

"We should not become a new Facit!"

"Hasselblad's long-term survival may depend upon how much resources we invest in the development of a new digital camera."
CEO Jerry Öster at a board meeting, 10 February 1994[21]

As was concluded above, HEIAB became a great success. At its peak, the subsidiary had 43 employees in 1992, but the times were about to change. Much of HEIAB's success could be attributed to the telephoto transmitter Dixel. However, in 1992, Nikon launched a telephoto scanner which revolutionized the industry. It was better than the Dixel in all respects and consequently, sales diminished rapidly for Hasselblad. Responding to such formidable competition was not an option for a small niche player like Hasselblad, and therefore HEIAB instead focused on software over the coming years. Nikon's hardware and HEIAB's software came to dominate the market for a few years, but nevertheless, HEIAB had reached a dead end around 1993-94.[22]

Another important change was also taking place in these years. After 16 years as CEO, Jerry Öster now left the company. Before leaving Hasselblad, he pointed out that the long-term survival of the firm would to a large extent depend upon how much resources the company spent on digital imaging. Incentive, the owner of Hasselblad, listened to this advice and started to look for a CEO who could take Hasselblad into the digital era.[23] Eventually they recruited Staffan Junel. He had a background as an engineer in computer science, with many years of experience from the telecommunications company Ericsson, and had long experience of working with digital technology. One of the first things he did as CEO was to gather the top management and all expert engineers in order to discuss the long-term prospects for the company. Junel recalls:

"We tried to look into the future and understand where the company would be in 2010. This question inevitably drew us to the issue of the substitution of film by digital imaging. We agreed that 50 percent of our market would be digital somewhere around 2005."[24]

While some of the electronic engineers thought that this would happen even earlier, others argued that it would take more time. But they all agreed that digital technology in the long run posed a serious threat to the established camera industry. Junel thought that it was important for Hasselblad to develop its own digital products in order to obtain

knowledge that would be needed in the future. The board agreed that it was time to invest more in digital imaging. Therefore, a new division called digital photography was started inside the parent company in autumn 1993.[25] The initial purpose was not to develop a digital camera, but rather to learn more and follow the development, especially in the area of image sensors.

Junel recalls how top management kept repeating that "Hasselblad will not become a new Facit". Facit was a Swedish manufacturer of mechanical calculators that collapsed in 1971-72 due to the rapid shift to electronics. Ever since, Facit had been regarded as an infamous example in Sweden of what happens to firms when they oversleep technological shifts.

The new division was headed by the former CEO of HEIAB, Lennart Stålfors. Since HEIAB was now in sharp decline, many engineers from the subsidiary moved to the digital photography division. After some time of knowledge development, Stålfors argued that the improvements in the area of image sensors had been so rapid that it was now time for the company to start developing a new camera system. Junel explained this to the owner and asked for more resources. Incentive wondered whether Junel was willing to terminate the analog development activities at this point. Junel argued that development of the analog system was still needed, but that it did not have to take place with the same intensity as before. The conflict between analog and digital development would become much stronger over the next years. However, Incentive agreed with Junel at this point and provided some more resources. Even though the company spent about twice as much on analog development, this should still be regarded as a major step into digital imaging for a small company like Hasselblad. After all, digital imaging would in many ways render the existing skills in precise mechanics obsolete. The company therefore sought to renew its competence base at an early point. Additionally, from 1992 and on, Hasselblad sought to make their cameras compatible with digital backs. In 1994, several cameras could use digital backs, which enabled the photographer to see the images directly after they had been captured.[26]

'Crystal Ball' – development of a digital camera

It soon became clear that digital imaging had properties which made it significantly different from analog photography. For instance, at this point it was virtually impossible to photograph moving objects when using a digital camera. Even though the image quality was surprisingly good at this early point, it did not correspond to what Hasselblad's film-based images could offer. For decades, Hasselblad had relied upon superior image quality in their marketing activities. Additionally, image sensors were very expensive. However, digital imaging had other characteristics that could make it

attractive. For example, images could be viewed instantly, and could be copied, sent and manipulated in a more convenient way. Moreover, an infinite amount of images could be captured at virtually no cost. In photography segments such as photo journalism, many images were digitized sooner or later, and digital imaging could remove one step in this process.

These properties implied that the company had to look for niche applications where digital imaging could create more value than analog technology, despite its lower image quality and higher price. After having performed some market research, Stålfors and his colleagues thought that studio photography would be such a niche.[27] In this segment, customers could be willing to trade off some image quality in order to capture, duplicate, manipulate and send images at a much lower cost. The fact that such a camera had to be big and stand on a tripod would not be a problem for this customer segment. The idea was to start off with small volumes, charge a lot of money (about 50,000 USD for a camera), then make incremental developments of the system and lower the price over time. It would initially be targeted at large studios, catalogue and product photography, and later on enter Hasselblad's mainstream segment of wedding and portrait photography.[28] The project was pursued under the name 'Crystal Ball', for two reasons. Firstly, the product would in the end look like a crystal, and secondly, one hoped that it would guide the company into the future just like a crystal ball.

The engineers made sure to create a modular system in order to enable future improvements of each component. While the ambition was to create a commercial product, the main purpose was not to dominate the market with it. Rather it was an attempt to establish Hasselblad as a digital actor and have a system to start with for further development of different cameras. At its peak in 1996, the project involved more than 20 people at the company.

As mentioned above, the image quality was relatively poor for a long time. However, in 1993-94 one could obtain up to 16 megapixels by using several sensors or letting it slide over the object. But in order to launch a commercially viable product it was necessary to develop a sensor that had the right size and price. Therefore Hasselblad initiated a collaboration with Philips which resulted in a 6-megapixel sensor at a reasonable price. By that time, most image sensors had the shape of a square and were 2000*2000 pixels big. A 2000*3000 sensor would thus give a 50 percent better image quality, but since most images are cropped into a rectangular shape, the difference was in reality around 100 percent, or more.[29] For several years, Hasselblad was the only company that had access to this sensor, which of course gave them a competitive advantage around 1995-97. Several firms were interested in using the sensor – for instance, discussions were initiated with Agfa who wanted to buy the rights to use it.[30] Moreover, this sensor offered perhaps

the best price/performance ratio on the market in those days.[31] Philips was keen to collaborate with Hasselblad due to its strong brand and, in total, Hasselblad only had to spend about 2 MSEK on this project. This figure is about 60 percent lower than what Philips would have demanded from other actors. From this work, it would also have been possible to develop a 3*4 sensor of 12 megapixels later on. Hence, while being a collaboration where both parties contributed to the technical development, the project was very favorable on Hasselblad's behalf.

In parallel with the development of a digital studio camera, some minor changes were made to the analog system. A couple of models were developed and Hasselblad sought to diversify its system a bit. By offering a couple of models at a lower price, more photographers could use the Hasselblad system. But no major changes were made in the camera system during these years. At this point, Hasselblad had essentially sustained the same system for more than 40 years. Consequently, it had become very complex due to all small improvements over time. Competitors like Mamiya, Pentax and Contax were now introducing autofocus in their cameras, something that Hasselblad lacked and could not integrate into their current system. Hence, the need for a new camera system became more important over time and the analog development team grew increasingly frustrated over this fact. The development of a completely new camera system was considered in the late 1980s and early 1990s, but management hesitated and eventually decided not to do so at this point. One reason for postponing this work was that they believed it would become too expensive for a small player like Hasselblad.

Consequently, the company became more polarized in the mid-1990s. Digital technology had been controversial when HEIAB was founded in the 1980s, but it became even more sensitive when it came to developing cameras. Hasselblad had been split into two camps – one analog and one digital. They competed for the same pool of resources within the company and had fundamentally different ideas about what Hasselblad was, and what it was going to be.[32] Under these circumstances, the company was bound to be a place with a lot of conflicts and fierce arguments. The project manager for Crystal Ball, Lennart Stålfors, thought that "I had to spend a disproportional amount of time defending the project instead of working with development activities."[33] But this was just the beginning.

The 'Big Berta' camera and private equity

"By the year 2000 digital cameras may replace film photography for most uses"
MacWEEK 13th of May, 1994[34]

Towards the end of 1995, Incentive changed its scope of ownership and decided that it was time to sell Hasselblad. During the years that the company had owned Hasselblad,

large amounts of resources had been spent on digital technology. In that respect Incentive had maintained a long-term scope of ownership. However, once it had been decided that Hasselblad should be sold, the owner made sure to get as much as possible of the cash that had been accumulated in the company over the last decades. The firm had been very well capitalized, partly in order to be able to pursue one analog and one digital development project in parallel. This opportunity was lost through the dividends that were taken by Incentive before selling the firm.[35]

Incentive sold its shares in Hasselblad to UBS Capital, the private equity branch of the Union Bank of Switzerland, to the British private equity firm Cinven and to Hasselblad's management. Since UBS controlled 55 percent of the shares, the fate of Hasselblad was now in the hands of a Swiss bank. At Hasselblad and in the local media, people were concerned that the new owner lacked a long-term scope of ownership. UBS had declared from the beginning that they did not intend to own the company for more than 3-7 years. Moreover, UBS intended to do a leveraged buyout, i.e. to buy an asset with borrowed money, increase its value, sell it and thereby obtain a high return on equity. Hasselblad was therefore acquired partly by borrowed money, which was brought into the company that now had to pay off those interest rates. Hence, within only a few years the company went from being very well capitalized into being severely under-capitalized. Needless to say, this had a large impact on how Hasselblad could handle the shift from analog to digital photography.

The new owner now had to make up its mind regarding the Crystal Ball project. Towards the end of 1995, a prototype was almost ready and the board was keen to see what progress had been made. As mentioned earlier, the camera had been developed in order to suit studio photographers. It was a very odd product and did not look like anything Hasselblad had offered previously. The camera could not be carried to the boardroom; instead, the board had to come to the room where it was standing in order to see it. The product looked more like a computer than a camera, stood on a tripod and was connected with wires to a computer where the images could be displayed. Afterwards, people at Hasselblad referred to the camera as 'Big Berta' since it was clumsy and had the same shape as the golf club with that name.[36]

The new board became skeptical when they saw the prototype. One person who attended the meeting recalled that the product "was gigantic and did not even look like a camera."[37] Other people had a different point of view:

"Those who understood the niche for digital technology saw its advantages and realized that the camera had a potential. But the board related it to the analog technology and therefore dismissed the camera."[38]

All in all, it was not an easy task to convince a financially oriented investor that this camera was the right way to a successful leveraged buyout. The digital development team tried to underline that this was just a prototype and that it would only require an additional 13 MSEK or so before it could reach the market. Moreover, they tried to explain that a camera aimed for studio photography and catalog production did not have to be light and portable or offer stunning image quality. It was enough that plenty of images could be captured rapidly at a low cost and then be handled in a much more convenient way. Furthermore, the image quality was relatively high and pictures could be enlarged up to 0.5 square meters without any problems. Hence, the customer utility was in fact large, yet different from what Hasselblad had offered their customers previously. However, it should be underlined that the studio photographers at IKEA who saw the first prototype thought that it was too big and clumsy for them. Even within this segment it was after all important to move the camera, if only just slightly.

Despite the above-mentioned advantages, the board remained very concerned after having seen 'Big Berta'. The new owner thought that such a product could harm Hasselblad's brand and its image of being a high-end camera. Another issue that was raised at this point was the fact that digital technology had started to prosper in Hasselblad's market segment in the shape of digital backs. A digital back was a component that could be added to an analog camera by removing the film magazine. The back contained an image sensor that captured the pictures electronically. Those backs were primarily manufactured by entrant firms such as Leaf Systems, Imacon and Phase One, but Kodak had also developed some products in this area. UBS appointed Andersen Consulting to perform an investigation into these issues during the end of 1996. They concluded that the industry would be subject to fierce competition once it became digital, and recommended Hasselblad to develop a solution based upon digital backs.[39]

After having received more resources for many years, Stålfors and the digital development team were now suddenly in a lot of trouble. Questions were raised regarding why so much money was spent on things that were outside the company's core competence. Moreover, the board had become increasingly frustrated over all deadlines that had not been met. Staffan Junel was a firm believer in digital imaging and kept trying to persuade the new owner that it was worth pursuing the initiated project. He failed, and eventually left the company since he could not enact a strategy he did not believe in.

The division for digital photography made one last attempt. Since the board had concluded that the digital back solution was preferable to 'Big Berta', the electronic engineers sought to develop a digital back in a very short period of time. The 6-megapixel image sensor was now built into a digital back, which had circuits pointing out

on both sides and was nicknamed ‘Mickey Mouse’ since it looked like the head of the same Disney character. The digital back was brought to the board meeting where it was going to be decided what should be done with digital photography. Stålfors and his colleague Carl Henrikson attached ‘Mickey Mouse’ to a Hasselblad camera, took photos of the board and showed it to them on a computer screen during the meeting. This little prank was not appreciated by the members, who remained firm in their decision to stop all internal development of a digital camera. The new board motivated their decision by saying that Hasselblad’s customers did not demand a digital camera.[40] These turbulent events were very briefly summarized in Hasselblad’s annual report from 1996:

"The board also decided that the digital activities should be changed towards a focus on marketing and sales”.[41]

After this decision had been made, almost the entire digital development team had to leave the company. Only 3 persons were invited to stay in order to keep the company updated and pursue collaborations instead of developing products and technologies. Needless to say, the electronic engineers were very disappointed about this decision. In one internal discussion, the following statement was made on an overhead slide:

“If the chemical waste from film processing could be turned into beer – film would have a bright future!”[42]

Hasselblad had basically laid off all its digital capabilities, an asset that had been developed for almost 15 years in different ways. The company also lost its exclusive access to the image sensor that was co-developed with Philips. Contax tried to use the same sensor when developing a digital single reflex camera in the early 2000s, but eventually failed to launch a viable product. The decision to stop all digital development was made public in early 1997. A press release to Dagens Industri contained the following text:

“The costly development of a new digital camera has been sold…the optimal digital camera will thereby have to be developed by someone else. By doing so, the company saves 15-18 MSEK…that can be invested in development of conventional cameras as well as adapting them to digital technology.”[43]

Göran Diedrichs, UBS’ representative, defended the decision:

“Digital technology is still in its infancy. When it has been developed further we will of course enter and then we need to have a strong financial position.”

In the same article, Diedrichs stated:

"We have been a technology driven company up until now. We have to develop products that are interesting for the market."[44]

The description of the company's history above suggests that Hasselblad had been a very market-oriented company over a long period of time. Over decades, the firm had succeeded in charging premium prices by relying upon clever marketing and sustaining its legendary brand. With the exceptions of HEIAB and the digital photography division, Hasselblad had not really pursued any development activities for many decades. Its analog camera system was essentially the same as it was in the late 1950s. The problems that Hasselblad would encounter over the coming years were largely related to the fact that the company had been too "market-oriented" over a long period of time.

The shift to digital imaging

The fact that Hasselblad had postponed all analog development activities and never created a new camera system in the early 1990s meant that the firm now started to lose market shares to its competitors. While the brand helped the company to keep its market in the short term, inferior products eventually resulted in lower volumes. Hasselblad therefore lost market shares to its competitors in 1997-1999.

Consequently, it became more and more urgent to develop a new camera system. Therefore, the H1 project was initiated in 1998 with the purpose of generating a completely new system. The idea was to create a hybrid camera, one which would be compatible both with film and with digital backs. Moreover, the system would incorporate many new features such as autofocus. The company had not done anything of this magnitude since the 1950s, and this was one of the reasons why the project was severely delayed and in the end cost 320 MSEK. However, 50 percent of it was in fact funded by Fujifilm who, among other things, developed the lenses that were specified by Hasselblad and in return got the opportunity to launch the same camera in Japan under its own brand.[45] The new system was not launched at full scale until late in 2002. During the period 2000-2003, Hasselblad suffered severely from a sharp decline in their analog sales. Professional photographers were rapidly changing to digital camera systems, primarily from Canon and Nikon. For decades, Hasselblad had dominated the segment of wedding and portrait photography. This part of the market was now lost within only a few years, to companies which had not been Hasselblad's competitors previously.

When the H1 finally arrived, it was not really a digital camera. While compatible with digital backs, it was delivered with a film magazine and therefore never really perceived

as a digital system. The freedom to shoot either analog or digital turned out to be of little use for photographers, who were instead frustrated by the fact that they had to buy digital backs separately. Moreover, such a system would cost about 100.000 SEK more than Canon's or Nikon's high-end cameras and, in the end, many photographers were not willing to pay that much for a Hasselblad system. Advanced Digital Single Reflex cameras which were smaller and cheaper, and offered sufficient performance, started to displace Hasselblad's high-end products. Therefore, the H1 did not become the expected success and it could not really compensate for the rapidly declining analog revenues.[46]

In November 2004, Hasselblad laid off 50 percent of its work force and balanced at the brink of bankruptcy. By that time, the company had gone from having about 500 employees to around 75 in less than ten years. After having invested in digital imaging more than two decades earlier, Hasselblad was now about to repeat the infamous "Facit story", even though its former managers had sworn that this would not happen.

The company eventually survived through yet another ownership change and a merger with Imacon, a Danish manufacturer of digital backs. In 2005, Hasselblad could for the first time deliver a complete digital camera system on its own and became even more of a high-end company than before. The H system was very expensive and offered such extreme performance that it is primarily used today in very special applications. In the following years, the company made some upgrades to its new system and kept delivering profits until the recession in 2008. Since then, a couple more layoffs have taken place.

Discussion and conclusion

The story of Hasselblad's long and troubled journey from analog photography to digital imaging provides some interesting evidence regarding how industries are digitized, and what challenges companies face in such shifts. One main challenge seems to have been that Hasselblad's skills related to precise mechanics were to some extent rendered obsolete. In this sense, the shift to digital imaging was competence-destroying.

Digital imaging also possessed some disruptive characteristics. It initially offered worse image quality, as well as some new performance attributes such as the ability to take an infinite amount of photos at a very low cost. However, it did not prosper in a low-end segment or in a new market as Christensen's disruptive innovation framework would suggest. Instead, it grew in Hasselblad's high-end segment in the shape of digital backs from the early 1990s onward. The main reason for this seems to be that digital technology could simplify the daily work for studio photographers. This description is partly inconsistent with the disruptive innovation framework, which posits that technologies with the above-mentioned attributes prosper in low-end segments or in a completely new

market. Hasselblad's customers did in fact demand the new technology, and thus the main managerial challenge was not related to a lack of financial logic as stated by Christensen.

The main problem seems rather to have been that digital imaging started to prosper around a new way of creating value, and Hasselblad was not used to delivering this kind of value to its customers. The market organization and the mechanical engineers thought that this technology was incompatible with Hasselblad's brand, which could be regarded as its most important complementary asset. For a financially oriented owner with a short-term scope of ownership, it was easier to focus on the core business of Hasselblad and develop the H1, which was a sustaining innovation in the sense that it resembled what the company had offered its customers previously.

The typical "Christensen effect" of attack from below and a displacement of firms which listened to customers instead happened when the company lost market shares to Canon and Nikon. When combined with a digital back, the H1 offered superior image quality, but most photographers still preferred a smaller, cheaper DSLR camera which offered sufficient image quality.

This pattern of disruption from below via a continuous miniaturization and decreasing prices can be seen in several industries which have been digitized. The first transistor radios were primarily targeted at the military and were very expensive. When the price levels declined and the performance improved, smaller and simpler versions of the same technology could be sold to consumers.[47] Electronic calculators followed a similar pattern. They were first introduced in price-insensitive segments such as the military and scientific laboratories.[48] In the mid-1960s, they entered the office machine segment and started to displace mechanical calculators. When prices had declined even further, small and cheap pocket calculators were introduced to the consumer market, and these products eventually turned out to be good enough for many professional applications as well. The description of how digital imaging initially prospered in Hasselblad's high-end segment in the early 1990s can be regarded as another illustration of how digital technology grows in high-end segments by bringing new performance attributes to the market. As image sensors became smaller, cheaper and better, the dominant design for professional digital cameras shifted from medium-format cameras with digital back to high-end Digital Single Reflex cameras. Hasselblad chose to stay in the medium-format segment and consequently experienced declining sales in recent years. Few photographers are willing to pay so much more in order to get a camera which is bigger, heavier and offers a great image quality.

This pattern can be regarded as an effect of Moore's law, i.e. the rapid decline in prices and increasing performance over time. Digital technology starts off as big, expensive and often with poor traditional performance such as image quality. However, it often brings a new value proposition to the market which still makes it attractive for high-end segments. As the performance of digital technology improves, it can eventually be miniaturized and enter lower segments, where the smaller versions eventually displace the bigger digital calculators, radios, cameras and disk drives. The process of low-end disruption as described by Christensen can therefore be thought of as a consequence of Moore's law and the continuing decline in prices and improvement in performance. While the technology initially prospers in sophisticated segments, as was illustrated in the Hasselblad case, the low-end disruption happens later on.

Summing up, Robert C. Noyce unintentionally managed to make a somewhat accurate description of Hasselblad's fate, about 25 years before the company balanced at the brink of bankruptcy. Digital technology has created a lot of industrial turbulence, often by displacing precise mechanics, and established firms have struggled to survive those technological shifts. Hasselblad and the camera industry were no exception to this pattern. In 2004, the CEO of Hasselblad, Lars Pappila, stated that "the shift to digital technology was much more dramatic than we had expected".[49] Hasselblad was not the first, nor the last, company to end up in this way, despite all its efforts over several decades.

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Paper III

High-end Disruptive Technologies with an inferior performance

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Abstract: The literature on disruptive technologies has previously stated that those innovations often emerge in low-end segments or in new markets and as the performance improves it eventually displaces the old technology. This article aims to explain how and why a technology may prosper in high-end or mainstream markets despite its initially lower performance and does so through three in-depth case studies. The findings suggest that those technologies may compensate the inferior performance by simplifying and removing work for customers. For instance, digital imaging emerged in high-end segments since these customers were willing to trade off the initially lower image quality in order to remove the usage of film. Based upon these results, the paper concludes that the literature on disruptive technologies needs to maintain a more nuanced view of value and how it is created and distributed inside the customer's organisation.

Keywords: Disruptive technologies, high-end, inferior, performance, Hasselblad, high-end, Facit, digital imaging, IP video surveillance

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1 Introduction

For many decades, scholars have primarily looked inside the firm (e.g. Tushman and Anderson, 1986) in order to explain why established companies tend to encounter difficulties in the face of technological shifts. Christensen (1997) brought a different perspective upon this issue by looking at the firm's external environment and argued that those technologies which initially underperform according to the demands of mainstream customers tend to be problematic for established firms. Christensen and Raynor (2003)

claimed that there are two forms of disruptive technologies, namely those which emerge in low-end segments and in new markets.

Other scholars have stated that previous literature has largely overlooked the issue of high-end disruptive technologies (e.g. Govindarajan and Kopalle, 2006). However, it is not entirely clear how and why a technology with lower traditional performance would emerge in a high-end application or in a mainstream market and more empirical evidence on this phenomenon is needed.

This article explores how and why disruptive technologies may prosper in high-end or mainstream applications despite their inferior performance. It is done by conducting a detailed multiple case study of how three such technologies have emerged in high-end or mainstream segments in different industries.

The remainder of this paper is organized as follows. The next section contains a theoretical exposition whereas the subsequent section provides a description of the methods used in this paper. Then the case studies are presented and analysed. The final part contains a discussion and some managerial implications.

2 Theoretical Exposition

It is well documented today that established firms may encounter difficulties in the face of discontinuous innovation (e.g. Utterback, 1994). A discontinuous innovation can be defined as a major change, related to either a technology or a business model (Veryzer, 1998). Incumbent companies are usually good at innovation under steady, stable circumstances, but when technologies shift or new business models are introduced they can all of a sudden become vulnerable. Frequently, established firms struggle to survive these changes; they lose market shares and are displaced by entrants.

Answers to this puzzle have often been sought by looking at supply-side factors and the firm's existing resource base (Cooper and Schendel 1976; Henderson and Clark, 1990). For instance, Tushman and Anderson (1986) wrote about competence-enhancing and competence-destroying innovations. They argued that innovations which destroy the value of a firm's existing competencies are very difficult to manage, because established firms are bound by traditions, sunk costs and internal political constraints.

Christensen (1997) rejected previous explanations of incumbent failure which had primarily looked inside the firm. Instead, he drew upon resource dependence theory (Pfeffer and Salancik, 1978) in order to explain the decline of established firms. This theory suggests that a firm's freedom of action is in fact controlled by actors outside the boundaries of the company. Since customers and owners are the key stakeholders that provide a firm with resources, they also impose a great indirect control of the decisions that are taken and how resources are allocated. In addition to this, Christensen applied the concept of value networks defined as "the context within which the firm identifies and responds to customer's needs, procures inputs and reacts to competitors" (Christensen and Rosenbloom, 1995, p. 234) when explaining incumbent failure.

Bower and Christensen (1995) argued that a key determinant of the probability of survival for an incumbent is whether the new technology addresses the preferences of actors in the existing value network. From this theoretical base, they explained the pattern of incumbent failure by making a distinction between sustaining and disruptive technologies. Sustaining technologies have in common that they improve the performance of established products along the dimensions that existing customers value. Disruptive

technologies on the other hand, initially underperform along these dimensions and at the same time bring new, ancillary technological performance attributes to the market. According to Christensen (1997) they are typically simpler and cheaper than the sustaining technology. The lower traditional performance and the higher ancillary performance create a large market uncertainty and make it difficult to find a financial logic in entering the new technology. At the same time the established firm finds it irrational to abandon its current, profitable customers in order to aim for a new market and an initially inferior technology. Incumbent firms are therefore "held captive" by their most profitable customers and as the performance of the disruptive technology increases it begins to attract customers and eventually displaces the former technology.

Christensen and Raynor (2003) developed this theory further and suggested that there are two forms of disruptive technologies, namely those which emerge in new markets and those that prosper in low-end segments. The same authors also extended the theory by introducing the concept of disruptive business models, i.e. business models that target low-end customers or new markets, can be carried up-market and displace incumbents later on. Ryanair and the concept of low cost airlines can be regarded as one illustration of this notion.

While Christensen's work has shed new light upon the issue of incumbent failure, this theory suffers from a lack of clarity in the used terminology and several scholars have called for a more precise definition (e.g. Danneels, 2004). Govindarajan and Kopalle (2006) provided an expanded conceptualization of this notion when they suggested that a disruptive technology is a novelty that introduces a different set of performance and price attributes relative to existing products. These characteristics make it unattractive for mainstream customers and as the technology improves along certain parameters it eventually displaces the former product or technology. This definition is broader and could also include disruptive technologies which initially prosper in the high-end or mainstream segments of the market. The authors argue that there are several reasons why high-end disruptive technologies may create a dilemma for established firms. Mainstream customers may not value the new performance attributes, it may have an insufficient initial traditional performance, the market niche is too small and therefore it may not result in any significant profits. However, given its initially lower traditional performance it is not yet entirely clear how and why such a technology would emerge in high-end or mainstream segments (Danneels, 2004). There seems to be confusion in the literature regarding the seemingly paradoxical issue of high-end and mainstream disruptive technologies. The article aims to fill this gap by answering the following research question: how and why do disruptive technologies prosper in high-end or mainstream segments of the market, despite its lower traditional performance? Before presenting the illustrative case studies, some literature on value and business models is presented, along with the methodology employed in this paper.

2.1 Value Creation, appropriation and business models

Economists often refer to utility theory when trying to understand value. Total utility refers to the satisfaction that comes from the possession of a good (Bowman and Ambrosini, 2000). Several scholars have pointed out the subjectivity of value, i.e. a good can be of great value for one individual or firm and be of no use for another one (e.g. von Mises, 1963). In line with this, Menger (1950) made a distinction between use value and

exchange value. The exchange value is the paid price whereas the use value is the economic value that the buyer obtains from using the product. A positive difference between these two measures is regarded as a consumer surplus. Given that buyers may use a product for different purposes their use value differs and consequently they are willing to pay different prices.

In order to understand why disruptive technologies may prosper in high-end or mainstream segments it becomes important to look more precisely at what use value they create for customers. Some of the recent work in this area has focused increasingly on the role of the market and the customer. Adner (2002) pointed out that the structure of demand needs to be addressed in order to clarify the nature and effect of disruptive technologies. Furthermore, Adner used the notion of thresholds, defined as critical performance levels that must be met. The functional threshold of a product is the minimum performance that the customer can accept whereas the net utility threshold also takes price into consideration. Slater and Mohr (2006) identified parallels between the work by Christensen (1997) and Moore's book *Crossing the chasm* (2002) and underlined the importance of finding a nursing market for disruptive innovation.

Though the abovementioned work has contributed to an increased understanding of how disruptive technologies create value this issue needs to be further addressed. One potential drawback of existing literature is that it has with few exceptions regarded customers as single entities in the value network, with one specific interest, rather than as organisations which comprise several actors with dispersed utility functions. Many technologies are developed for industrial customers rather than individual consumers and hence, innovations are often sold to organisations which can be regarded as value networks of their own. Therefore, it may be beneficial to look further into the customer's organisation in order to understand how disruptive technologies create value and prosper in high-end or mainstream segments.

Given that a disruptive technology brings new performance attributes to the market and that value creation is distinct from value appropriation (Chesbrough and Rosenbloom, 2002), the new value may need to be appropriated in a different way. The business model can be regarded as a construct which addresses how a firm creates and captures economic value (Chesbrough and Rosenbloom, 2002). Hence, a better understanding of how disruptive technologies create value is also needed in order to understand the challenges they impose upon incumbent firms and existing business models.

Summing up, while several important contributions have been made by addressing the impact a new technology has on the value network of a firm, more needs to be known regarding how and why disruptive technologies may prosper in high-end or mainstream segments. This in turn calls for a better understanding of how such technologies create economic value. The article addresses this issue by investigating what traditional and new performance attributes the studied disruptive technologies brought to the market and how this new mix created value for customers.

3 Method and Research setting

This article is based upon three case studies of technological shifts that have or are currently taking place. Given that the presented research is of an exploratory nature seeking to understand an issue which has been insufficiently addressed by previous

literature, the method is deemed to be suitable. Moreover, the chosen method enables the kind of detailed descriptions that are required in order to address an issue which needs to be better understood (Yin, 1994). Case studies imply a limited generalisability from the findings (Eisenhardt, 1989). However, the article does not attempt to provide an exhaustive set of answers. Rather, it seeks to explain how and why disruptive technologies with a lower traditional performance may still prosper in high-end or mainstream market segments.

The cases come from the calculator, camera and video surveillance industries and they are all related to a displacement of analogue or mechanical technology by microelectronics, i.e. digital technology. The industries and corresponding companies were targeted since they all have in common that the technology had disruptive characteristics (see table 2 for further information), but did not prosper in low-end segments or in new markets as predicted by the disruptive innovation framework (Christensen and Raynor, 2002). The first electronic calculators, as well as the first successful applications of digital imaging and IP-based, digital surveillance (IP video) all emerged in either the mainstream market or in high-end applications. Additionally, these technologies had an inferior performance along those dimensions that have been valued historically by mainstream customers. Digital imaging initially offered a lower image quality, electronic calculators started off as bigger and more expensive and IP surveillance had a lower image resolution and a higher price in the beginning. Hence, these shifts offer an opportunity to understand how and why disruptive technologies may prosper in high-end or mainstream applications, despite a lower traditional performance. Another reason for choosing these cases is that incumbent firms have struggled in these transitions, despite the fact that their customers initially demanded the technology. Hence, the pattern of displacement is different in these cases from the one described by Christensen (1997). Therefore they present an interesting opportunity to address how and why a disruptive technology does not initially prosper in low-end or new market segments as postulated by previous theory.

In these three different industries, one corresponding company has been targeted. This was done in order to obtain insights into how these technologies have been commercialized in their early phases and how those firms tried to overcome the problem of offering a product with lower traditional performance. All the targeted firms were operating in high-end or mainstream segments. Table 1 below provides a summary of the gathered data.

Table 1. An overview of the data used in the different cases

Company and industry	*Interviews*	*Secondary data*
Hasselblad and the shift to digital imaging.	30 interviews, follow-up questions and discussions of in total about 100 hours.	Minutes from board and top management meetings 1989-1995. Internal PMs, strategic documents and mail conversations.
Facit and the displacement of mechanical calculators.	Six interviews, totalling about 20 hours.	All minutes from board and top management meetings during 1964-1972. PMs, internal investigations and reports from this period.
An entrant firm that has driven the shift to IP VIDEO.	7 interviews of in total about 15 hours.	None.

Former CEOs, R&D managers and people in charge of commercialization have been approached with open ended and semi-structured interview questions. Since these companies have been public, CEOs and people with strategic responsibility could be identified. A snowballing technique was used in order to find additional respondents. Given that two of the cases (digital imaging and electronic calculators) are historical studies, it was possible to identify people who had experienced the entire process of emergence and eventual dominance of the new technology. The shift to IP-based surveillance is currently taking place and hence, the same historical perspective could not be adopted. However, as the technology has been adopted by about 20 percent of the market and it has been around for more than ten years, it is still possible to study how and why it has emerged in the mainstream of the market. A large majority of the interviewees can be said to have had direct insight into commercial, technological and strategic issues related to the technological transition. The information retrieved from the other respondents should rather be regarded as important background knowledge.

The questions concerned how the technology prospered and how it performed compared to the established technology along both the traditional dimension and the new attributes that were brought to the market. Additionally, questions were asked regarding how these innovations created value for customers and why they adopted it, despite the lower traditional performance. The respondents also described the challenges that were encountered when trying to develop and launch a technology with the properties mentioned above and how those were handled. While all of the collected secondary data did not directly concern the disruptive technology, additional information should still be regarded as vital since it provides important contextual information. The interviews and the collection of data were conducted from mid 2007 until late spring 2009.

Collecting data by performing interviews may imply a biased interpretation (Yin, 1994). This potential drawback was taken care of by approaching many respondents. Several follow-up interviews were conducted and compared with the written sources that have been accessed. In those cases when the sources contradicted each other, further interviews were performed. By doing so, the collected data has been triangulated. Moreover, the Hasselblad case description has been read by many of the interviewees and hence been further validated.

4 Results and Analysis

This section contains a presentation of the results and an analysis of how and why disruptive technologies may prosper in high-end or mainstream markets. Table 2 on the following page provides an overall description of the studied companies and the disruptive technologies, their respective properties and how they created value for customers.

Table 2 An overview of the investigated companies and how the disruptive technologies created value

Disruption	*Studied firm*	*Time period*	*Traditional Performance*	*Price*	*Ancillary Performance*	*Value Proposition*	*Changes in the value network*
The displacement of analogue video surveillance by digital, internet cameras (IP video).	A European entrant firm which has driven the shift and grown rapidly over the studied time period.	1996-2007	For a long time, the new technology offered worse image quality in terms of resolution and displayed images per second.	Network cameras have up until 2005 with few exceptions been more expensive.	Easier installation since fewer wires are needed. The cameras can be made more intelligent.	Improved video surveillance at a lower total cost of ownership.	IP Video is sold to the same customers, but to IT departments instead of security departments. Thus a change inside the customer's organisation has taken place.
From film-based photography to digital imaging.	Hasselblad, a high-end incumbent firm which is famous for outstanding image quality.	1990-2005	Hasselblad's analogue photos corresponded to about 36 megapixels, the first digital versions in the mid 1990s offered 4-6 megapixels.	Digital cameras were significantly more expensive up until the late 1990s.	Simpler production of pictures. Images could be viewed instantly and captured at no cost.	A simplified workflow enabled an improved handling and images that are good enough.	Sold initially to Hasselblad's traditional high-end segment of studio photography.
The substitution of mechanical calculators by electronic calculators.	Facit, a Swedish manufacturer of office furniture, typewriters and mechanical calculators.	1964-1973	Electronic calculators offered similar computing capabilities initially, but became better towards the mid 1970s.	In 1966, electronic calculators were about twice as expensive, but the price went down rapidly during the studied period.	From the late 1960s and on pocket calculators introduced portability and simplicity as new attributes.	Similar up until the rise of pocket calculators. Then factors like simplicity, price and portability were introduced.	Electronic calculators were sold to the same customers up until the rise of pocket calculators. Those were instead sold via bookstores and retailers in order to generate larger volumes and reach mass markets.

4.1 *How high-end and mainstream disruptive technologies prosper*

The case studies presented in this article offer some interesting evidence regarding how disruptive technologies create value for high-end or mainstream customers, despite their lower traditional performance. Generally speaking, it seems that they emerge in market segments where the ancillary performance compensates the lower traditional value to such an extent that customers are willing to buy it anyway. In two of the three cases, the main reason for this was that the disruptive technology could remove work in the customer's process and thereby lower their total cost. Hence, the technology created value on a more systemic level rather than on the level of each individual product. This is illustrated by the cases of digital imaging and IP video below.

4.1.1 Hasselblad and digital imaging

Over the last 15 years the camera industry has undergone a shift from film-based photography to digital imaging. The sales of digital cameras grew rapidly from the late 1990s and on when cheaper and better cameras were launched at a high pace. Prior to this remarkable growth and the eventual displacement of film, digital imaging prospered in Hasselblad's medium format segment of professional photography were a digital back could be attached to medium format cameras. These digital backs were primarily manufactured by entrant firms such as Leaf Systems, Phase One, Imacon and Jenoptik and were expensive complements to the dominant analogue technology. The main customer segment for these backs was studio photographers. Digital technology enabled these customers to view images instantly and removed the costly and time-consuming process related to using film. Additionally, those images were often scanned and digitized later on anyway and hence, digital imaging made the production of images much cheaper and simpler. Studio photographers were willing to trade off some image quality and pay a higher price since it could save days of downtime waiting for the transparencies to be finished.

With these attributes in mind, Hasselblad sought to develop a new camera system in the mid 1990s which was based upon a 6 megapixel sensor that had been co-developed with Philips. The camera was intended for studio photography, a high-end niche which would hopefully be willing to pay a high price and trade off some image quality in order to remove film. Hasselblad was not used to offering this kind of value proposition and thus, the project met a lot of resistance inside the firm. The person in charge of the project, Lennart Stålfors, recalls that he "had to spend an un-proportional amount of time defending the project instead of working with development activities."

The project was eventually stopped in 1996 when a new owner changed strategy and decided to develop a new camera system that was compatible with both film and digital backs. When the shift to digital imaging came into full motion from 1999 and on, Hasselblad's semi-digital medium format cameras were displaced primarily by Canon and Nikon who introduced advanced Digital SLR cameras which were simpler, lighter, cheaper and offered an image quality that was sufficient for most applications.

4.1.2 IP-based video surveillance

IP video surveillance was introduced by the studied firm in the 1990s. CCTV had for a long time been film-based and analogue. IP video is instead based upon digital technology using sensors, so the material is stored as digital files and not on video tapes.

Another difference is that digital cameras have an IP-number and are connected over the internet, instead of via cables. While the analogue technology is still dominating the market, digital video surveillance is growing rapidly and the studied firm is an entrant and one of the actors driving the shift from analogue to digital technology. About 20 percent of the market is now based upon IP video solutions and this figure continues to grow.

Over the last decade, IP video has improved significantly in terms of image quality and with the rise of megapixel cameras it has now outperformed analogue CCTV along this dimension. However, the technology was growing rapidly before reaching these performance levels. One of the main reasons for this is that they are much easier and cheaper to install since the cameras are connected over the internet. This implies a lower total cost for owning and maintaining a system. The studied firm seeks to communicate the benefits of IP-based surveillance by focusing on the total cost of ownership rather than the price of one single camera.

Additionally, IP video has implied that surveillance has become both an IT and a security issue. One person in charge of technology development at the studied company states that installations of IP cameras are mainly performed together with the IT integrators and departments instead of with security departments. Thus, a shift has occurred inside the customer's organisation and the value proposition has changed with the new technology. It has also turned out that IT departments are more easily convinced by the total cost of ownership argument and that they are more willing to use IP cameras since they understand the technology in a better way.

So far, the incumbent firms have failed to dominate the new technology in the same way as they did with CCTV. Whether the established firms will survive this disruptive technological change or not remains to be seen. According to respondents at the studied firm, one reason why the incumbents have so far lagged behind in IP video appears to be that they do not know how to approach customers with it. The logic of selling to IT departments is new to the industry and the analogue players are not used to doing so.

4.1.3 The creation of new value inside the customer's organisation

The cases of digital photography and IP video have in common that they created value in a new way inside the customer's organisation, primarily by simplifying the work process and removing labour. Hence, it seems that the net utility threshold for a disruptive technology (Adner, 2002) can be lower in high-end or mainstream segments since these customers can use the technology in order to lower their overall expenses. While the price was higher and the technology was inferior in many ways, its ancillary performance attributes created a higher consumer surplus that could motivate the investment. The case of IP video also suggests that this threshold is different depending upon which actor is targeted inside the customer's organisation. When selling to IT departments, the overall cost of owning a surveillance system could be lowered and this value creation compensated the higher price as well as the lower traditional performance in terms of image quality.

This explanation of why a disruptive technology prospers in high-end or mainstream markets suggests that previous literature on this topic has maintained an over-simplified view of the customer and value creation. The framework developed by Christensen (1997) draws upon diffusion models such as the one stipulated by Rogers (1995). Those models assume a normal distribution of customers and an epidemic diffusion of

innovations. The case studies in this paper indicate that while such models highlight many important aspects of innovation diffusion, they may hamper the understanding of how and why some disruptive technologies succeed since they do not assume any heterogeneity inside the customer's organisation. The IP video case illustrates that the forces of resource dependency can be imposed by different actors within the client organisation. The dominant analogue players in the CCTV industry are used to targeting security departments with another value proposition and they may therefore be "held captive" by one actor inside the customer's organisation since security departments do not appreciate or understand IP video in the same way. This finding suggests that previous literature on disruptive technologies has not yet addressed the subjectivity of value (Menger, 1950) to a sufficient extent. While the use value differs between different customers, it can also differ *inside* the customer's organisation and this creates a problem for incumbent firms. The consumer surplus is higher for clients if IT departments are involved in the installation of IP video systems and this is one of the main reasons why the technology could prosper in mainstream segments despite its higher price and initially inferior traditional performance. Therefore it seems to be suitable to apply more of an adopter perspective and look further into how disruptive technologies actually create value inside the customer's organisation. Consequently, the concept of value networks needs to be nuanced within the field of disruptive innovation.

4.2 Why Technologies with lower performance emerge in high-end segments

The case studies presented above suggest there are several reasons why a disruptive technology does not prosper in low-end segments or in new markets, but rather in mainstream and high-end segments. As was described earlier, it seems that those technologies may simplify and remove a lot of labour for the customer and that this can compensate the lower traditional performance and the higher price. Customer segments which have a more labour intensive business such as studio photographers or installers of video surveillance benefited extensively from this. Another important reason seems to be the high price that was associated with the technologies initially which made it impossible for low-end customers to afford them. The price parameter seemed to be the most important determinant of why electronic calculators initially emerged in high-end segments and later on entered lower segments as well as created new markets.

Electronic calculators that are based upon transistors were first introduced in the early 1960s. Those were mainly used in order to perform advanced calculations in very specific military and scientific applications. As the technology became cheaper and smaller over time it entered Facit's office machine segment in 1964-65. Since Facit's competence base was related to mechanics, the company decided to collaborate with Sharp and thus bought their calculators and gave them a Facit design. The electronic desktop calculators that Facit sold from 1966 and on had similar computing capacity as the mechanical calculators. Therefore, they could simply replace the mechanical calculators at this point since the product offered similar performance and consequently also prospered in the same value network as the former technology. This strategy prevented Facit from loosing market shares initially. However, when integrated circuits were introduced in calculators from 1968 and on the pace of development was increased to such an extent that it wasn't possible any longer to re-badge calculators from another company. Moreover, the rapid development of integrated circuits implied a rapid decline

in prices and a miniaturization of the products that later on made them appealing to consumers. At this point, Facit's business to business sales model was rendered obsolete since calculators could be bought anywhere. Göran Arvidsson, who was a member of the top management group by that time said that the entire office machine industry suffered due to these changes. The established firms had built strong relations with their customers and had their own sales offices. With the shift to electronics both the technological competence and the sales model were rendered obsolete. Consequently, Facit suffered from severe losses in 1971-72 and was eventually acquired by another company in late 1972.

This case provides a compelling description of how important the price parameter is and it suggests that the literature on disruptive technologies ought to treat this dimension more carefully than just stating that a disruptive technology is 'typically cheaper' (Christensen, 1997). While the diffusion approach to disruptive technologies failed to explain how and why digital imaging and IP Video prospered in high-end applications, it seems to be valid in the case of electronic calculators. Electronic calculators followed a more linear diffusion pattern since it did not create any new value inside the customer's organisation initially and did so in a top-down way due to the rapid decline of prices and increased performance over time.

The case studies above give a further confirmation that disruptive technologies may initially prosper in high-end or mainstream segments. These observations also suggest that the extended definition provided by Govindarajan and Kopalle (2006) is therefore more suitable since it includes events that would have been disregarded when using Christensen's (1997) original definition.

5 Discussion and managerial implications

While Christensen (1997) illustrated how difficult it is for incumbent firms to enter lower segments and commercialize an initially inferior technology, it seems to be equally tricky to approach existing customers, even though they would benefit from adopting such a technology. The case study about Hasselblad provides evidence on how firms struggle when bringing a new value proposition to existing customers. It indicates that companies need to experiment with new business models in order to succeed with disruptive technologies since they bring a new value proposition to the market. Lennart Stålfors, the R&D manager in charge of digital imaging at Hasselblad recalls how the issue of digital imaging tended to create tension and conflicts inside the company. The market organisation was reluctant to bring an initially inferior image quality to their customers since it could harm the brand of the company. Given that there was in fact a demand for this product, the challenges were not primarily related to resource dependency as stated by Christensen (1997). Rather, the disruptive technology was problematic since it was not compatible with the value proposition Hasselblad had previously offered. Hence, firms seem to struggle when developing disruptive initiatives because they break the existing linkages between the technology and the business model.

Trying to renew an established business model is therefore not only a matter of finding a customer which demands the technology. It is also an issue related to political power both inside the firm and inside the customer's organisation. If value is created on a different level and the disruptive technology prospers in another part of the organisation,

some actors may lose influence at the expense of others. For instance, when IP video is sold to IT departments this reduces the status of security departments and a political barrier to adoption may occur. The disruptive innovation theory could therefore benefit from maintaining a more nuanced conceptualization of value networks. The case of IP video indicates that there are several different actors inside the customer's organisation who may block the adoption of a disruptive technology. Given the subjectivity of value (Menger, 1950), these actors need to be mapped and understood in terms of their incentives and activities. Finding a business model that aligns different incentives within the customer's organisation therefore seems to be a key success factor.

One of Christensen's (1997) most influential recommendations is that in order to succeed with a disruptive technology it is necessary to launch an independent organisation which can prosper in a different value network. However, it is far from obvious that this can be done when addressing existing customers like Hasselblad had to do. Since the technology emerged in the same segment as analogue photography the company became reliant upon the established market organisation and it turned out that they were reluctant to bring a technology to the market which did not offer the superior image quality that was associated with Hasselblad's brand.

The case studies about Hasselblad and Facit also illustrate how the value proposition changed over time and how this augmented the difficulties related to surviving the technological shift. The early versions of digital imaging prospered in a high-end, niche segment by removing work as has been described above. However, from 1999 and on, digital Single Lens Reflex cameras started to disrupt Hasselblad's semi-digital medium format cameras for professional photographers. These cameras were simpler, cheaper and offered sufficient image quality. Hence, they attacked from below and disrupted Hasselblad in exactly the way described by Christensen (1997). The same thing happened when the simpler, cheaper and portable pocket calculators disrupted Facit's mechanical and electronic calculators for office use. Thus, the classical low-end disruption occurred after the technology had initially prospered in higher segments. This development over a short period of time increased the difficulties related to surviving the technological shift since the initial value proposition was different from the one that later on came to dominate the market. Working with lead-users (von Hippel, 1988) in the early phases like Hasselblad did with studio photographers is therefore problematic since these customers had preferences that differed largely from the ones in the mainstream market when the technology had matured later on.

5.1 Conclusions and future research

While previous work on disruptive technologies has contributed to an increased understanding of how and why established firms may decline when new technologies are introduced, this stream of literature has so far not succeeded in explaining how and why such initiatives may prosper in high-end or mainstream markets segments.

The abovementioned issue has been addressed in this article both by providing empirical evidence on this issue and by drawing upon literature about value and business models. The cases in the paper suggest that disruptive technologies may prosper in high-end or mainstream segments by introducing ancillary performance attributes that create economic value on a more systemic level inside the customer's organisation, for instance by simplifying and removing time consuming work. This value creation seems to

compensate the lower traditional performance that was associated with the disruptive technology. This finding implies that the literature on disruptive technologies has so far suffered from an over-simplified view of customers and that the subjectivity of value inside the customer's organisation has not been sufficiently captured. Moreover, it has been argued that it is more relevant to look at how value is created, rather than addressing different performance dimensions.

Additionally, the initially higher price that was associated with the studied technologies implied that they could only prosper in such segments and therefore it can be concluded that the literature on disruptive technologies needs to treat the price parameter more carefully than has been done previously.

The findings in this paper seem to suggest that the challenges related to disruptive innovations which prosper in a firm's existing customer segment are different from those described by Christensen (1997). Previous theory on disruptive innovation has stated that the main challenge is related to managing the internal resource allocation process. When a disruptive technology prospers in a mainstream or high-end segment, firms seem to struggle for other reasons, which are primarily related to the new value proposition and its compatibility with the existing network structure in terms of value distribution and systemic changes inside the customer's organization. Therefore, a more nuanced conceptualization of the term value network seems to be needed.

These conclusions indicate that more detailed studies of what effects disruptive technologies have inside the customer's organisation may be one way forward for future research into why technological shifts tend to create such problems for incumbent firms. Furthermore, the findings above suggest that many of the managerial solutions related to disruptive innovation are not necessarily valid when a technology prospers in high-end or mainstream market segments. Little is known about how firms can actually work proactively in order to renew their business models. This article has offered some tentative guidelines for doing so, which are related to mapping, understanding and aligning incentives throughout the value network. More research is needed regarding how firms can actually succeed in changing their business models to match the new value proposition that disruptive technologies tend to create.

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Paper IV

Value, Actors and Networks
– a revised perspective on Disruptive Innovation

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Abstract

The concept of disruptive innovation has received increased attention over the last decade. This stream of literature has increased our understanding of incumbent failure in the face of technological change by looking at the control that profitable customers impose on established firms. However, there are several issues which haven't been sufficiently addressed thus far. This article adds to existing theory on the subject by drawing upon literature on networks and utility theory. Previous literature on the topic has put an emphasis on the different performance characteristics of a disruptive innovation. We shift the focus of attention towards the utility that it creates for customers, and how this is done. Moreover, we adopt a different notion of networks, arguing that an over-simplified view upon customers has been maintained previously. In doing so, we provide an extended and more nuanced conceptualization which reveals a couple of challenges and potential managerial solutions.

1 Introduction

It is well known today that firms can become more innovative by interacting with their surrounding network (Chesbrough, 2003). However, a strong network may also hamper innovation efforts. The theory on disruptive innovation has pointed out that incumbent firms struggle under conditions of discontinuous change since they get stuck in their established value networks (Christensen, 1997).

While this literature has contributed to a better understanding of incumbent failure and the role of networks, there are several elements of the theory of disruptive innovation that have been questioned (Markides, 2006; Danneels, 2004), and these need to be addressed in order to provide a more coherent framework that allows us to understand this phenomenon better.

This article aims to add to existing theory on disruptive innovation and does so by drawing upon different literature streams on networks and utility theory. It starts with an exposition of existing theory on disruptive innovation and moves on to a discussion of issues that this far have been insufficiently attended to. The paper then describes network and utility theory, constituting two bodies of literature that can potentially extend and refine the ideas regarding management of disruptive innovation. This literature is in the subsequent section used in order to address previously identified weaknesses regarding disruptive innovation. Based on the theoretical discussion, some conclusions and managerial implications are given.

2 An exposition of disruptive innovation theory

As mentioned previously, the literature on disruptive innovation has presented new explanations of how and why incumbent firms encounter problems under conditions of discontinuous change. Previous literature had primarily looked at supply-side factors. A prominent example of this literature stream is the work by Tushman and Anderson (1986), who wrote about competence-enhancing and competence-destroying innovations. They argued that innovations which destroy the value of a firm's existing competencies are very difficult to manage, as established firms are bound by traditions, sunk costs and internal political constraints. Henderson and Clark (1990) nuanced those arguments by introducing the concept of architectural and component level innovation. Similar explanations have been provided by Clark (1985), Tripsas (1997) and Cooper and Schendel (1976).

In his seminal work, Christensen (1997) proposed an alternative explanation of incumbent failure. Instead of looking inside established firms, he focused on the external environment, drawing upon resource dependence theory (Pfeffer and Salancik, 1978) and the concept of value networks (Christensen and Rosenbloom, 1995). Resource dependency essentially posits that organizations are open systems which depend on resources from parties outside the organizational boundaries. Hence, a firm's freedom of action is in fact controlled by actors outside the boundaries of the company, e.g. customers and investors. Since the

customers and owners are the key stakeholders that provide the firm with resources, they also impose a great indirect control on what decisions are taken and how resources are allocated. This perspective is manifested in Christensen's research in the concept of value networks, defined as "the context within which the firm identifies and responds to customer's needs, procures inputs and reacts to competitors" (Christensen and Rosenbloom, 1995, p. 234).

Based on this reasoning, Christensen explains the pattern of incumbent failure by making a distinction between sustaining and disrupting technologies. Sustaining technologies have in common that they improve the performance of established products along the dimensions that existing customers value. Disruptive technologies, on the other hand, initially underperform along these dimensions. They are described as normally being simpler and cheaper than the established technologies. Therefore, they are not the demanded initially by the incumbent's customers and thus, the firm fails to invest in disruptive innovations. As the performance of the disruptive technology increases it begins to attract customers from the sustaining technology, eventually displaces it and puts the incumbent in trouble. Christensen referred to this pattern as the innovator's dilemma, arguing that the same management technique which made a firm successful under conditions of disruptive change cause it to fail. Christensen and Raynor (2003) further developed the ideas about disruptive innovation, utilizing the concept of value networks. One important aspect of their framework is the distinction between low-end and new market disruptions. Low-end disruptive innovations evolve in the lower segments of the market, typically by having a business model which enables the firm to offer cheaper products with a performance that initially is inferior. New-market disruptive innovations prosper by approaching customers that have not been addressed previously.

3 Disruptive Innovation – some areas in need of development

While the work by Christensen, and then in particular the ideas about value network lock-ins, has contributed greatly to an increased awareness and understanding of the challenges related to discontinuities, there are still many questions that this far have not been sufficiently dealt with. This section will try to point out some of these outstanding issues, which are primarily related to how such innovations create value and the impact they have on established networks.

3.1 A diffusion approach to innovation

One potential weakness of Christensen's framework is that the theory seems to be based upon a diffusion perspective on innovation. The graph Christensen (1997) uses to explain the pattern of disruption looks at different customer segments. It essentially suggests that a disruptive technology prospers in low-end segments or in new markets and later on invade the mainstream market. Hence, existing literature has to a large extent maintained a

diffusion-oriented perspective on customer attributes such as the one developed by Rogers (1995) and later on used by Moore (2002).

Several contributions to the theory of disruptive innovation indicate that a diffusion approach has prevailed. For instance, Slater and Mohr (2006) identified parallels between the work by Christensen (1997) and Moore's book *Crossing the chasm* (2002) and underlined the importance of finding a nursing market for disruptive innovation. Linton (2002) built upon diffusion forecasting techniques and integrated it with theory on disruptive innovation. Adner (2002) pointed out that the structure of demand needs to be addressed in order to clarify the nature and effect of disruptive innovations. Moreover, Adner used the notion of thresholds, defined as critical performance levels that must be met. The functional threshold of a product is the minimum performance that the customer can accept whereas the net utility threshold also takes price into consideration.

While the diffusion approach has contributed to a better understanding of incumbent failure, we would argue that it is overly simplistic in order to explain the specific pattern of adoption. An over-simplified view of the customer may conceal some important challenges, particularly in business-to-business settings, where the customer is in fact a set of different actors who may have diverging utility functions. Seligman (2006) argues that the adopter is often treated as a black box and that it needs to be understood in a better way. This criticism seems to be valid in the case of the literature on disruptive innovation.

3.2 How do disruptive innovations create value?

The literature on disruptive innovation is also somewhat unclear regarding how the innovations create value for the customer. For instance, Christensen (1997) states that disruptive technologies are typically cheaper and bring new performance attributes to the market, while having lower performance along the dimensions focused on for the established products. But how exactly does a disruptive technology create value and what challenges are related to commercializing such an innovation?

One reason why this question has not been sufficiently understood is that the disruptive innovation theory has a strong focus on performance dimensions, rather than economic value and total utility. An analysis of the market impact of a technology needs to look at the performance of the technology, but should do so in order to identify the value a user obtains from acquiring it. Several scholars have pointed out the importance of both looking at performance attributes and how these are translated into value for the customer (Oskarsson and Sjöberg, 1991; Saviotti and Metcalfe, 1984). Value can be created in several different ways inside the customer's organization. Activities may be changed or removed completely. Moreover, the utility that a disruptive innovation creates can imply a new distribution of value. In a business-to-business setting, these issues would most likely be overlooked when a

diffusion-oriented perspective focusing on performance dimensions is maintained. Hence, the notions of value and utility need to be nuanced.

3.3 Where do disruptive innovations emerge?

Lately, the theory of disruptive innovation has been extended, both in terms of its definition and its applications. Govindarajan and Kopalle (2006) argued that Christensen's original definition was too narrow since it only took cheaper, simpler and initially lower performance products into consideration. They proposed a broader definition, which would also include technologies that initially emerge in higher segments. Utterback and Acee (2005) also called for an expanded view of disruptive technologies. They noted that many technologies such as electronic calculators, fuel injectors and wafer boards were not initially cheaper or simpler than the technologies they later on came to replace. Danneels (2004) asked whether disruptive innovations are never valued by mainstream customers. Govindarajan and Kopalle (2006) provided an extended conceptualization of disruptive innovation when they suggested that a disruptive technology is a novelty that introduces a different set of performance and price attributes relative to existing products. These characteristics tend to make it unattractive for mainstream customers, but as the technology is improved along certain parameters it eventually displaces the former product or technology. This definition is broader and could also include disruptive technologies which initially prosper in the high-end or mainstream segments of the market. The authors argue that there are several reasons why high-end disruptive technologies may create a dilemma for established firms. Mainstream customers may not value the new performance attributes, it may have an insufficient initial traditional performance, the market niche is too small and therefore it may not offer any significant profits.

One consequence of maintaining an insufficiently nuanced view upon customers and the value proposition is that it becomes difficult to understand in what market segments a disruptive innovation may prosper. The question of where disruptive innovations start has up until now not really been adequately answered, and one reason for this may be that a mainstream disruptive innovation could be thought of as a contradiction in terms. Given that resource dependency and the concept of value networks are the main pillars of Christensen's theory, an innovation which prospers in a mainstream market would by definition not be regarded as disruptive. However, given that disruption is a relative phenomenon (Christensen and Raynor, 2003), virtually all disruptive innovations should prosper in a mainstream market for some firm, unless it creates a completely new market. Would those firms which are operating in a segment where the disruptive innovation emerges be better off than others? And if not, what challenges would they encounter when trying to bring a new, potentially beneficial value proposition to an established customer?

3.4 How can incumbents succeed with disruptive innovation?

Christensen's most powerful managerial recommendation regarding disruptive innovation is that such initiatives must be put into an independent organization. By doing so, he argues that these attempts can be protected from the forces of resource dependency, which tend to drain those initiatives since there is no obvious financial logic in pursuing those initiatives.

While this recommendation has turned out to be useful for many companies (Christensen, 2006), more knowledge is needed regarding how incumbent firms can successfully manage disruptive innovations. Danneels (2004) underlined the importance of developing a "customer competence" in order to succeed with disruptive innovation, but did not specify what constitutes such a competence or how firms can develop it.

One main difference between Christensen's notion of disruptive innovation and previous work on discontinuities is that he drew upon a different theory stream, highlighting the importance of firm-external stakeholders and thereby identifying completely new explanatory factors. Having argued that established firms are "held captive" by their most profitable customers, the managerial solution inevitably became related to how the firm's resource allocation mechanisms should be changed in order to overcome this barrier. Hence, Christensen stresses the impact that customers have on the firm's internal organization, but pays limited attention to how firms can actually manage their networks, to the extent that these actually are possible to influence.

3.5 Can business models be disruptive?

Some scholars (Christensen and Raynor, 2003; Charitou, 2001) have taken this even further by addressing the topic of disruptive business model innovation, i.e. innovations which are not technological, but instead change the business models used by firms. Even though this concept is still not particularly well defined, it provides a useful perspective on how firms create and appropriate value. Markides (2006) contested this notion and argued that business model innovation was a significantly different phenomena than the one originally described by Christensen (1997). Christensen (2006) however provided a nuanced and extended argument when he framed the fundamental problem of disruptive innovation as primarily a business model problem, and not necessarily a technological problem. While such a definition may be broader, it arguably also results in some confusion since it would require a more thorough understanding of business models and the related bodies of literature. Moreover, such an extension would also imply several new challenges that need to be faced by management.

Summarizing the above, we can conclude that the by now substantial work on disruptive innovation has shown the importance of looking at the demand side in order to understand the competitive dynamics related to this specific type of innovation. However, we also see that as long as the theory regarding disruptive innovation draws narrowly upon resource

dependency and the concept of value networks, it will most likely not be able to address several of the important shortcomings mentioned above. Consequently, the underlying theoretical framework needs to be modified into a more comprehensive one. It has been argued above that the raised issues can be understood by looking more carefully at the notions of value and networks. Below, a literature review on these topics is provided, which will be applied later in the article in order to generate a potentially improved understanding of disruptive innovation.

4 The network approach

Since the early 1980s, the interaction approach to understanding business-to-business marketing (Hallén, 1982; Håkansson, 1982) has received increased attention. This perspective materialized from a critique of those neo-classical economic models which assumed individual action and independence. These thoughts were later on developed into what is often referred to as the network approach (Håkansson, 1987; Håkansson and Snehota, 1989). These scholars argued that existing literature on market practices missed out on the interdependence that characterized many relations between customers and suppliers. Instead of looking at markets as homogeneous and without any friction, they argued that a market consists of actors that are interrelated and depend upon each other and that this aspect was not sufficiently captured by other theories of the firm (Håkansson, 1990). Networks can be thought of as separated from the more traditional notions of markets and hierarchies.

In order to study how firms interact, network scholars regard companies as actors which employ resources in order to conduct activities. Actors have different objectives, scale and scope and are embedded in a network where they depend upon other actors. However, they should still have some degree of autonomy in order to be regarded as actors. Activities concern the transformation and transaction of resources into interdependent activity cycles and webs of transactions. Resources are also thought of as heterogeneous and can be comprised of tangible assets like capital and land, but also as intangible assets like knowledge, competence and skills (Håkansson & Johanson, 1992; Håkansson & Snehota, 1995).

No single actor can control all the required resources or performs all the related activities throughout the chain of transactions. Hence, resources and activities are interrelated with other resources and activities and therefore, actors also become interdependent and are exposed to uncertainty. These networks are held together by mutual interest, however, there is always a mixture of intersecting and diverging interests present in these relationships (Håkansson, 1989).

4.1 Interdependence in industrial networks

Due to the abovementioned interdependence, network theories of the firm claim that a firm's behavior is largely controlled by other firms and not by internal factors. The main managerial challenge in a network is therefore not the internal allocation of resources, but rather how relationships with other actors can be handled (Håkanson & Snehota, 1989). Ford et al (2003) states: "no company *alone* has the resources, skills or technologies that are necessary to satisfy the requirements or solve the problems of any other".

A network approach to innovation would shift the focus of attention from supply-side issues towards addressing the firm's external environment. Thus, the impact an innovation has on relationships to customers, suppliers and other actors become more important from this perspective (Håkansson (1990). One immediate consequence of such a perspective is that innovations are not primarily judged by their absolute performance, but rather in a relational way, i.e. to what extent it generates support from its surrounding network. Succeeding with innovation therefore becomes a process of adaptation to the network rather than just a matter of strong internal development skills.

Networks tend to be path dependent - they create opportunities but also impose constraints upon attempts to innovate outside an existing trajectory. Therefore, the success of an innovation ought to be regarded as dependent upon economic, social and political conditions. Given that the value of resources exists in a particular context, innovations which are incompatible with existing resources, processes and activities in the network will be difficult to commercialize. The activities of one firm can be thought of as one element in a chain of activities and its resources are elements of a greater context of resources. An innovation will therefore not be evaluated primarily with respect to its performance, but to what extent it is valued in its particular context. The established links between actors may create a resistance to change since the network has evolved over time in order to fulfill certain purposes. Innovations in an existing network will therefore be evaluated with regard to how it fits existing structures and incentives rather than by pure performance. Moreover, due to the high degree of interdependence in an industrial network it may suffice that one actor rejects the innovation to block it completely, even though others demand it.

While the industrial network approach may be very useful when exploring innovation in a better way, several scholars have pointed out that better frameworks are needed in order to look at the dynamics of a network (e.g. Waluszewski, 2004; Dubois and Araujo, 2004). Mattsson (2003) states that this approach could be combined with Actor Network Theory (ANT) and thereby create a better understanding of how business networks evolve over time. ANT will be reviewed in the following subsection.

4.2 Actor Network Theory

Actor Network Theory (ANT) is an approach to social theory which resembles the industrial marketing perspective in many ways. ANT has primarily been developed by Latour (1987, 1993, 1996), Callon (1986) and Law (1999). The most notable difference between ANT and other sociological theories is its insistence upon the agency of non-humans, i.e. technologies, products and humans are regarded as the same when performing an analysis. This idea may seem a bit odd, especially from an ethical point of view. However, proponents of ANT often underline that treating people and objects in a similar way is not an ethical position, only an analytical approach. It may be useful to combine this theory with industrial networks since ANT is explicitly concerned with how human and non-human elements interact in a network.

Latour (1993) argued that reality is often thought of and spoken of in a one-dimensional way where nature and culture, human and non-human are considered as opposites which are never really brought together. Hence, reality tends to be thought of either in terms of social constructivism or realism. The essential idea of ANT is to transcend this separation and look at how these different forces interplay in a network. This interaction is the unit of analysis that ANT explores and by doing so, the proponents of it argue that it is possible to analyze the parallel construction of society, culture and nature. Consequently, ANT scholars argue that sociology's task is to describe these networks in their heterogeneity and analyze how these actors together result in organizations, power structures and how they evolve over time as a consequence of changes among the underlying components.

This theory has often focused on understanding how social networks and power structures emerge, prevail and collapse. The process is thought of as highly unstable and uncertain, given that incentives can be changed and that each actor is subject to power from many different actors at the same time. Actors continuously seek to mobilize the network, bring in new actors and remove others and hence, the network is created and re-created over time. Therefore, it is a relational and dynamic approach, which underlines that the world is under constant change.

The ANT perspective can also explain the various challenges that an actor encounters when trying to order reality in new ways. As an actor seeks to remove others or form new networks, others will have incentives to block or hamper such development. ANT urges scholars to look at controversies and conflicts since they indicate that other actors are influencing something and that the network may change (Latour, 1987). For instance, Law (1992) suggests that building actor networks is primarily an issue of overcoming resistance.

Summing up, ANT has a lot in common with the industrial network approach in maintaining a more relational view upon society. Apart from the obvious difference that ANT is a sociological theory and the network approach is more of a management approach, ANT seems to be more concerned with power, politics and the dynamics of a network. However, these two bodies of literature should still be thought of as similar in many ways. Together

with the subsequent section on economic value and utility theory they will be drawn upon in order to understand disruptive innovation in a better way later in the article.

5 Economic value and utility theory

The previous section reviewed two bodies of literature that may contribute to an increased understanding of the phenomenon of disruptive innovation. This section describes a third body of literature, namely the notions of utility theory and economic value. Economists have often referred to utility theory and marginal utility when trying to understand value. Total utility refers to the satisfaction that comes from the possession of a good (Bowman and Ambrosini, 2000). A basic assumption is that consumers use their income in a way that optimizes their utility. Marginal utility is usually defined as the utility someone gets from obtaining or losing one unit.

Several scholars (e.g. von Mises, 1963) have pointed out the subjectivity of value, i.e. the notion that a good can be of great value for one individual or firm and be of no use for another one. In line with this, Menger (1950) made a distinction between use value and exchange value. The exchange value is the paid price whereas the use value is the economic value that the buyer obtains from using the product. A positive difference between these two measures is regarded as a consumer surplus. Given that buyers may use a product for different purposes their use values differ and consequently they are willing to pay different prices. Moreover, while the use value is a key variable in any purchasing decision, it does not materialize until after the transaction has taken place. Hence, in any transaction there is always a degree of uncertainty or speculation.

Transactions become even more complex and uncertain in a business-to-business setting. Firstly, it is more difficult to establish the use value under these conditions since the acquired good may be used as an input in the customer's production process along with several other inputs. Secondly, an organization is comprised of many individuals, and these maintain their own subjective opinion about the use value. These individuals may also have diverging incentives which complicate matters even further. Thirdly, the use value can be realized for another actor inside the customer's organization. The purchasing organization has an aggregated utility from buying a good, but it is much more difficult to measure it and it may be distributed over many different functions or individuals. Hence, there may be a discrepancy between the purchaser's perception of the use vale and the actual use value.

Given the agency of humans, the situation described above can result in 'the principal-agent problem' (Sappington, 1991). In economics, this notion stands for the dilemma of motivating one actor to act on behalf of another one. It occurs when a principal assigns an agent to perform certain tasks on behalf of the agent and it is difficult to monitor the agent. Under conditions of risk and information asymmetry, the agent is sometimes able to act on its own

behalf instead of the principal's. The solution to this problem is to make sure that the incentives of the agent are aligned with those of the principal.

In a business-to-business setting, this and other dilemmas may arise when a purchaser is assigned to buy goods on behalf of an organization. It is more difficult to establish the use value, the distribution of it is hard to assess and there may be diverging interests inside an organization. Therefore, several inefficiencies, uncertainties and power struggles are likely to influence the transaction at stake in a way that makes it much more unpredictable and difficult to accomplish than when a consumer buys something. It would be difficult to predict the success or failure of a potential transaction if the interacting organizations are regarded as rational, utility maximizing individuals.

6 Value, actors and networks – towards a revised perspective

This section contains a discussion of disruptive innovation informed by the theoretical exposition above regarding networks and utility, in order to address the identified shortcomings of the existing theory on disruptive innovation. We suggest that the existing theory needs to be complemented along two dimensions, namely the ones of *value* and *networks*.

6.1 Towards a more comprehensive view on networks

Hernes (2007) provided a summary of how ANT can be applied to the study of innovation processes. He suggests that networks are created and re-created over time. Moreover, actors can be thought of as outcomes of their relations, which means that this perspective would underline the importance of looking at the dynamic changes an innovation creates in its network. Such an approach would first of all mean that the technology, or the innovation, is regarded as an actor (Callon, 1987). This means that it exerts force, and consequently influences its surrounding network in various ways. Therefore, the successful commercialization of an innovation would be thought of as a relational process, i.e. an interplay between social and physical actors. A critical amount of actors must be mobilized in order to succeed in this continuous process of negotiation, and aspects like power and incentives consequently become important. Value is created in social and economic structures through translation and framing. The introduction of an innovation can be thought of as something that often creates a rivalry between different actor networks who try to expand and invade the other network.

One direct consequence of applying an ANT perspective on disruptive innovation is that focus is shifted from objective performance dimensions towards looking at the political effects it has in an established network. An ANT approach would suggest that the perception of a technology may actually matter more than its performance characteristics. Whether

customers adopt an innovation or not would rather depend on the extent to which different actors inside the customer's organization benefit from doing so. Adoption often involves several different actors and interests inside organizations. A large firm can be considered a political economy where units and individuals differ in terms of power and interest (Benson, 1971). Disruptive innovations may thus create value on various levels and in different places. Consequently, the adoption process is often much more complex than a straightforward diffusion approach would suggest and several challenges related to changes inside the customer's organization need to be better understood.

While the theory of disruptive innovation certainly looks at power and the role of customers, it essentially maintains a financial view upon power. Drawing upon resource dependency theory, it is argued that those customers which provide a firm with profitable revenues also impose a great indirect control over the incumbent firm. In this sense, ANT differs from Christensen's (1997) notion of value networks since it does not only look at power as a financial issue and hence, the unit of analysis becomes different from the one used by Christensen. As has been argued previously, the disruptive innovation theory has maintained a somewhat simplified view of customers, primarily since it is concerned with flows of money rather than power in a sociological sense. An ANT perspective would suggest that there are several actors inside the customer's organization which may be powerful and control the incumbent firm. Thus, it would imply that the demand-side is conceptualized as something more complicated and multi-dimensional than just one distinct end-user, with one specific utility function.

One potentially fruitful way of looking at customers would be to think of them as comprised of *actors*, *resources* and *activities*. Actors in an organization control resources and perform activities. Such an approach would explain why existing structures tend to favor minor innovations, rather than those of a more significant character (Hernes, 2007). An actor network can only prevail by repeated activities over time and a major innovation would by necessity have implications for the network, new actors will obtain more power, others are removed completely and some linkages would change. In line with this reasoning, Håkansson and Waluszewski (2001) claim that innovations must be adapted to existing networks and activities in order to be accepted. Therefore, an innovation that calls for a major change in these structures will be met by resistance. Disruptive innovations which distort existing power structures in terms of resources, actors and activities may thus be blocked from adoption even though established customers would benefit from adopting it.

6.2 From performance to value and utility

The disruptive innovation theory has put a lot of emphasis on the different performance dimensions of a technology. Christensen (1997) made a most significant contribution when looking at performance trajectories and ancillary attributes of a technology. Other scholars, however, have underlined the importance of translating performance attributes into economic

value and utility for customers (e.g. Granstrand, 1994; Granstrand, 1999). As mentioned previously, total utility can be thought of as the satisfaction that someone obtains from acquiring a good or service (Bowman and Ambrosini, 2000). Such a view would differ from Christensen's in the sense that disruptive and sustaining innovations are not compared in terms of technological parameters, but rather in terms of the utility they create and how this is done. A disruptive innovation, i.e. an innovation which has a lower traditional performance while at the same time bringing new performance attributes to the market may therefore create a higher total utility for some customers, despite its lower traditional performance. Moreover, the total utility perspective would also suggest that disruptive innovations do not necessarily have to prosper in low-end segments or in new markets as suggested by Christensen and Raynor (2003). Rather, they should emerge in those segments where it creates an increased total utility for customers and such segments might very well be in the high-end or mainstream of the market. In his review and critique of the disruptive innovation theory, Danneels (2004) asked whether disruptive innovations are never appreciated by mainstream customers. Drawing upon actor network theory and utility theory, we suggest that this might very well be the case, however, given the inertia in existing networks outlined above, there may be good reasons why this is often not the case.

If disruptive innovations prosper in a customer segment where an established firm is present, the challenges are also likely to be significantly different from the ones described by Christensen (1997). Given that the most profitable customers request the innovation, the incumbent is in this case not subject to the forces of resource dependency. However, it would still be dependent upon decisions made by actors beyond its own boundaries, albeit in a different way.

While an adopting organization may be considered to have one single aggregated utility function, decisions are still made by individual actors, who perform activities and control resources. Given the lower traditional performance and ancillary attributes of a disruptive innovation, it may have a considerable impact upon the adopting organization's actors, resources and activities and these effects can result in considerable resistance. Existing networks impose constraints since the value of any resource is defined by its context (Håkansson and Ford, 2002). It can be competence-destroying for some actors, utility can be created by removing activities or by changing the value of resources for actors in the customer's organization and thereby shifting the distribution of value and power inside the customer's organization. Given the subjectivity of value and the potential divergence of incentives, political barriers to adoption are not unlikely to occur. Bearing in mind the interdependence in industrial networks (Håkansson, 1990), incumbent firms may indeed be "held captive" by their most profitable customers, even though these customers would actually benefit from adopting the disruptive innovation. The reason for this paradox is that adoption is not merely a rational decision based upon strict performance criteria, it is also a political decision where actors maximize their own utility and power rather than the utility of

their organization, a dilemma similar to the principal-agent problem described above (Sappington, 1991).

Summarizing the two sections above, we have argued that disruptive innovations can be understood in terms of changes along two dimensions - actors and value. A disruptive innovation creates utility in new ways and may result in a new distribution of value inside the customer's organization. Here, we have shifted the focus from looking at different performance characteristics towards total utility. Secondly, we have argued that this utility must be analyzed in terms of its impact upon the customer's power structures, the actors, resources and activities. In that sense, our approach differs from Christensen's in not only looking at new and old customers, but also at the effects inside the existing customer's organization.

Conceptualizing disruptive innovation along these two dimensions also makes it possible to address some of the previously posed questions regarding whether business models can be disruptive or not. In the same way as a technological shift may induce a change in value or in the network, a business model change may also do so, thereby causing problems for incumbent firms. However, the business model can on the other hand be seen as a design parameter that can make it possible for firms to manage disruptive innovation in a fruitful manner.

6.3 Managing disruptive innovation

In the previous section, we outlined a couple of challenges related to introducing disruptive innovations. It was argued that barriers to adoption may occur even in situations in which such an innovation offers an increased utility for customers. When actors, resources or activities inside the customer's organization are changed or even removed by an innovation, it may in fact be rational for certain individuals to oppose the adoption of a disruptive innovation. How then, can these challenges be managed?

Many authors have pointed out the importance of a customer competence in order to succeed with a disruptive innovation (e.g. Danneels, 2004), but little is known regarding what such a competence looks like. Managing disruptive innovations that distort existing customer structures may be particularly difficult since an innovating firm can only impose a limited, indirect control over matters that take place inside the customer's organization.

Veryzer (1998) argued that the evaluation criteria needed for discontinuous innovation should be less customer driven and more experimental rather than analytical. Callahan and Lasry (2004) found that regarding market newness, customer input was important for new products up to a point and then drops off for very new products, whereas customer input was becoming increasingly important without any drop for products of technological newness. These managerial prescriptions have in common that they essentially underline the importance of not regarding the established actor network as constant but rather try to modify

it in different ways, in that sense contrasting the view of Håkansson and Waluszewski (2001). We therefore argue that a customer competence related to disruptive innovation is based upon an ability to identify critical actors and their incentives, as well as finding new ways to align them in favor of the disruptive innovation.

Any existing network constellation contains skeptical actors, which need to be mapped and understood in terms of their incentives. Therefore, the ANT approach would suggest that all affected actors need to be identified, as well as how they are affected by the innovation and which ones that could be brought into the network. Hence, the innovation must have stabilized slightly before involving users and other downstream actors, otherwise, those actors would resist. Since ANT suggests that a network has to be re-created continuously, actors need to be connected and kept loyal to an innovation over time.

The emergence of an actor network around a new idea therefore becomes a matter of connecting actors and aligning incentives. A disruptive innovation would then sometimes require the mobilization of other actor networks and the design of a new business model which fits this specific network. Firstly, the innovator needs to assess the different incentives that govern the different actors. Secondly, the customer utilities should be investigated, both on an aggregated level and for each of the affected actors. This can for instance be done with existing techniques such as customer utility mapping (Kim and Mauborgne, 2000) and looking at the job to be done, rather than the performance attributes (Wunker, 2005). Thirdly, based upon this knowledge, firms need to find a business model which aligns the different actors' incentives so that they are in favor of the innovation. This once again underscores the necessity to have an adequate understanding of the value created for different actors in the network with the existing solution as well as how it will be influenced by the innovation. With this insight, changes to different business model parameters, such as e.g. revenue model, value chain and value network can be explored.

If the management of disruptive innovation is a matter of identifying value for different actors and aligning incentives throughout a network, then the survival and eventual dominance of entrant firms must also be related to having a better capability to do so. The lack of an established network may in this sense actually be an advantage for entrants, since they would not be subject to the same rigidities as established firms (Leonard-Barton, 1992; Dougherty, 1996). Hence, there seems to be a paradox here in that well established relationships with customers create a competitive advantage in the established operations, while they at the same time hamper experimentation with new value propositions. Given that entrant firms are not to the same extent locked into an established actor network, they should be more able to allow the kind of trial and error approach and technology drift (Burgelman, 1983; Ciborra, 1997) that are needed for succeeding with disruptive innovation.

7 Conclusion

This paper has attempted to add to the existing theory on disruptive innovation, and in particular propose a few developments of key concepts in order to address some present shortcomings and thereby render the theory more comprehensive and useful. Drawing upon literature on value and utility theory as well as two different literature streams focusing on networks, we argued that a disruptive innovation is an innovation that creates utility in new ways and distorts existing networks.

Our conceptualization of disruptive innovation differs from Christensen's in two important ways. Instead of looking at different performance dimensions we have argued that innovations should rather be assessed in terms of the utility that they bring to the customer. By doing so, we have been able to explain how innovations with disruptive characteristics may prosper in mainstream or high-end segments, despite their lower traditional performance.

Secondly, this utility needs to be analyzed in terms of its impact upon the customer's power structures, the actors, resources and activities. In that sense, our approach differs from Christensen's in not only looking at new and old customers, but also at systemic changes inside the customer's organization. Drawing upon literature on industrial networks and ANT, it has been argued that customers do not only control firms by supplying them with resources, but that this control can include other types of power as well. Furthermore, while there is such a thing as a total utility for an adopting organization, the interpretation of it differs among individuals who are in turn governed by different incentives. Based on this, we see that adoption is not merely a financial decision, but also a result of political arguments and power.

Even though established customers benefit from adopting a disruptive innovation, they may not request it due to the changes that it may imply along the value- and network dimensions. Our final contribution is that we have pointed out some ways forward for how incumbents firm can attempt to handle disruptive innovations. We claim that the management of disruptive innovation concerns how actor networks change over time and how companies can find ways of introducing something that is significantly new for several actors. Hence, such notions as incentive alignment, power and uncertainty become crucial for the innovating entity. Firms that aim to succeed at disruptive innovation need to 1) identify all actors in the network 2) map their interests and power and 3) find ways to analyze changes in utility and in the network induced by the innovation, and change business models so that all actors' incentives are aligned. How this can be performed on an operative level has until now only been partially investigated, and this area consequently calls for further research. There is also a need to extend the focus of research on disruptive innovations from a mainly descriptive and problem-oriented stance to also include more proactive work. A first logical step in such a development would be to pay more attention to how firms actually can manage to introduce disruptive innovations successfully, possibly also studying more entrant firms.

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Paper V

Managing Business Model Renewal

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Abstract: It is well documented that firms often need to change their business model when introducing a new product, but more knowledge is needed regarding why they struggle when trying to do so. This paper explores the challenges related to renewing an established business model. Drawing upon a case study and industrial network theory, we argue that business models are difficult to change because they are based upon interdependence throughout a system of interrelated actors. Firms are interconnected with actors beyond its boundaries and thus, only a limited control can be imposed. Our findings also suggest that firms can change their business models by identifying critical actors and by aligning incentives throughout their network.

Keywords: Innovation, Discontinuous, Systems, Business Model, Interdependence, Disruptive

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1 Introduction

For many decades, scholars have primarily looked inside the firm (e.g. Tushman and Anderson, 1986) in order to explain why established companies tend to encounter difficulties in the face of technological shifts. Christensen (1997) brought a different perspective upon this issue by looking at the firm's external environment and argued that those technologies which initially underperform according to the demands of mainstream customers tend to be problematic for established firms. Christensen and Raynor (2003) claimed that there are two forms of disruptive technologies, namely those which emerge in low-end segments and in new markets.

Over the last decade, business models have received increased attention, both by scholars and practitioners. This construct focuses more explicitly on value creation and appropriation than other frameworks in strategic management (Teece, 2009). It is often argued that innovations of a more radical or discontinuous nature need a new business model in order to succeed in the market (Christensen, 2006). New business models can also help firms to appropriate the returns from a new product and to compete in mature industries.

While the concept is clearly of great importance, more work is needed regarding the challenges related to business model renewal. Many authors have pointed out that firms often fail to change their business models (Chesbrough and Rosenbloom, 2002), but these difficulties need to be better understood, both theoretically and empirically.

This paper explores the challenges related to business model innovation. It seeks to create a better understanding of why firms struggle to renew their business models, despite the increased awareness of the imperative to do so. The article also aims to point out some guidelines for how firms can go about when trying to change their business models. This is done by drawing upon literature on industrial networks and by presenting an illustrative case study. The case is particularly interesting since it shows both what the challenges are and how they can be handled.

The rest of the paper is organized as follows. The next section provides a critical review of existing literature on business models. The subsequent section introduces industrial network theory in order to create a better understanding of the challenges related to changing existing business models. The following part presents the methods used in the paper and then the case description is provided. The next section contains a theoretical and managerial discussion and eventually some conclusions are provided.

2 An exposition of the business model literature

As stated previously, business models have received more attention over the last decade. The concept emerged during the dotcom-bubble and consequently lost a lot of credibility when the bubble burst (Magretta, 2002). Ever since, business models have become more important and last year, *Long Range Planning* devoted a special issue to the topic.

There are several definitions of the business model which are similar, albeit not identical. It has been described as a concept which focuses on "the architecture of revenue" and the notions of value creation and appropriation (Chesbrough and Rosenbloom, 2002). Business models have also been depicted as the value a firm offers

to customers, the architecture of the firm, its network of partners, and its way of creating, marketing and delivering this value (Osterwalder and Pigneur, 2003). Zott and Amit (2008) define the business model as "a structural template that describes the organization of a focal firm's transactions with all of its external constituents in factor and product markets" (p.1).

Amit and Zott (2001) explored the theoretical foundations of the business model construct by studying value creation in e-businesses. They argued that none of the established frameworks in strategic management and entrepreneurship could fully explain this phenomenon. The concepts of value chains, Schumpeterian innovation, the resource-based view of the firm, interfirm strategic networks and transaction cost economics could only address different parts of how value is created in e-businesses. Amit and Zott therefore claimed that the business model can be regarded as a more holistic perspective on strategy and value creation which draws upon these bodies of literature.

A growing body of literature has explored the area of business model innovation in detail (e.g. Markides, 1997, 1998; Charitou, 2001). A business model innovation can be defined as a reformulation of what an existing product or service is and how it is provided to the customer (Markides, 2006). Several scholars have pointed out the importance of renewing the business model, both in order to compete in mature industries and to appropriate the returns from a product innovation (e.g. Chesbrough and Rosenbloom, 2002; Magretta, 2002; Zott and Amit, 2008). Others have suggested that changing the business model is particularly important when launching an innovation of a more discontinuous nature. For instance, both Christensen (2006) and Doz and Kosonen (2009) argued that succeeding with disruptive innovation is a business model challenge rather than a technological problem.

2.1 Enablers and disablers of business model renewal

While the importance of renewing existing business models seems to have become increasingly clear to both practitioners and scholars, firms still struggle when trying to do so (Chesbrough, 2009). The literature on business models provides some explanations to why this is the case. Christensen (2006) stated that the conflict between the established business model and new initiatives tend to impede business model innovation. Amit and Zott (2001) offered a similar explanation when arguing that several of the key components of a business model such as novelty, lock-in and complementarities tend to be incompatible with a firm's existing resources and capabilities. Attempts to reconfigure an established business model would therefore be met with a lot of resistance in a firm. Other scholars have pointed out cognitive delimitations among senior managers as a source of inertia (Chesbrough and Rosenbloom, 2002; Tripsas and Gavetti, 2001).

For sure, the abovementioned work has contributed to an increased understanding of the challenges related to changing established business models. However, none of the explanations put forward are specific for business models. In fact, similar arguments have been put forward in the product innovation and technology management literature for a long time. The explanations which focused on incompatibility and tension between old and new business models are analogous with for instance the argument that new technologies may render existing competencies and organizational structures obsolete and therefore cause problems for incumbent firms (Tushman and Anderson, 1986; Henderson and Clark, 1990). Moreover, cognitive barriers are not specific for business

models. Rather, they may impede any kind of organizational renewal or product development efforts (Prahalad and Bettis, 1995). Hence, existing literature has not really identified the specific challenges related to business model renewal. Given that firms seem to succeed with product innovation more often than with business model renewal, these challenges must either be similar, albeit of a different magnitude, or fundamentally different in some way. Such different explanations haven't really been identified by previous literature.

Partly as a consequence of a lack of identified unique business model challenges, the literature on how business models can be renewed is also similar to the solutions offered in other fields of management theory. For instance, Chesbrough (2009) suggested that experimentation, effectuation and organizational leadership may help firms to change their business models. These managerial prescriptions are not specific for business models. Veryzer (1998) claimed that the new product development process is more experimental and open-ended for initiatives of a more discontinuous or radical nature. Effectuation, as opposed to causation, refers to the process of changing the environment by taking action without knowing the outcome, instead of analyzing and trying to control the future (Sarasvathy, 2001). Sarasvathy argued that a key characteristic of entrepreneurial behavior is to pursue effectuation rather than causation. This notion may offer some guidelines for how to go about when renewing a business model, but it is not specific for business models. The same holds for organizational leadership which has been identified previously as crucial in order to succeed with major changes (e.g. Rosenbloom, 2001). Doz and Kosenen (2009) provided further insight into how firms can change their business models when underlining the importance of strategic agility in terms of adapting to the environment and being able to allocate resources to new models. Again, these prescriptions are well elaborated and relevant to managers, but not unique for business models.

Summing up, there seems to be a gap in the business model literature. Several scholars have pointed out that firms often succeed with product innovations but fail to change their business models accordingly. However, the theoretical review above suggests that the literature both on barriers and enablers of business model renewal resembles previous literature on new product development and organizational change in general. Given that it seems to be more difficult to change a business model, we should expect the challenges and managerial solutions to be unique in some way. The article seeks to identify these business model specific challenges and managerial solutions. The next section provides some further elaboration on the business model notion and introduces industrial network theory as a way to approach these issues.

2.2 Business models and industrial networks

Zott and Amit (2009) provide a conceptualization of business models as "a system of interdependent activities that transcends the focal firm and spans its boundaries". This definition is particularly interesting because unlike other depictions, it underlines the interconnected nature of business models. In this sense, business model initiatives are different from the development of new products, which is more of an internal, firm-specific challenge. For sure, product innovation efforts also depend upon linkages with the external environment, for instance when it comes to purchasing critical components. But business models are explicitly concerned with how value is created and captured from actors beyond the boundaries of the firm. The notion of interdependence has up

until now been mentioned in the literature on business models, but not addressed in further detail. Pynnonen et al (2008) presents an exception to this pattern by drawing upon theory on value networks when analyzing business models. We adopt a similar approach but focus more explicitly on the interdependent nature of business models. In order to understand this issue, a more detailed description of industrial networks is provided below.

Since the 1980s, the industrial network approach to business-to-business relationships has received increased interest (Håkansson, 1982). Proponents of this perspective claimed that previous literature missed out on the interdependence that characterizes relations between suppliers and customers. This perspective originated from a criticism of neo-classical economic theory and the notion of homogeneous customers. These scholars argued that a market consists of actors that are interrelated and depend upon each other. Therefore, the term 'network' is often used instead of 'markets', thus underlining the mutual dependence among suppliers and customers (Håkansson, 1989). In this sense, the network concept differs from the traditional dichotomy of markets and hierarchies.

When studying the interaction between firms, network scholars regard companies as actors which employ resources in order to perform certain activities. Firms can be regarded as actors, but individuals and groups can also be thought of as actors. They have different aims, scale and scope and are embedded in a network. Actors perform activities by transforming resources and making transactions with other constituents (Håkansson and Snehota, 1995). It is assumed that no single actor can command all resources or perform all activities throughout a network and therefore, they are interrelated with other resources and activities. Actors therefore depend upon the environment, which is in turn regarded as unreliable. In order to remove this uncertainty, they tend to build relationships with other actors (Dubois, 1998) and thus become interdependent. Networks are held together by mutual benefits, but there's always a mixture of intersecting and diverging interests in these relationships (Håkansson, 1989). Industrial networks are therefore based upon restricted freedom (Ford et al, 2003). This approach has a lot in common with resource dependency theory (Pfeffer and Salancik, 1978), which states that organizations are to a large extent controlled by others since they obtain resources from their environment.

The abovementioned interdependence implies that a firm's behavior is largely governed by actors beyond its own boundaries. This observation has several implications for attempts to change existing business models. Given that firms are interdependent the main managerial challenge is not a matter of resource allocation, but rather how relations with other actors can be handled. In this respect business model renewal is something fundamentally different from product innovation since firms depend upon actors that they cannot control to the same extent. While a firm's relations are the basis of its current success, these relations may at the same time impede attempts to change its business model since networks are conservative to their nature (Håkansson and Ford, 2002). Moreover, the industrial network approach suggests that a network needs to be mapped and analyzed in order to understand barriers and enablers of business model renewal. We discuss how this can be done in the analysis section of the article.

3 Method and Research setting

Along with a more theoretical discussion, this paper is based upon an exploratory single case study, which examines how the studied firm developed, launched and eventually succeeded with a product innovation that required a new business model. According to Eisenhardt (1989) a case study is the appropriate research strategy when little is known about a phenomenon and current perspectives seem inadequate. As stated previously, the business model concept is still relatively new. Furthermore, the theoretical review above identified a couple of issues that have not been sufficiently understood yet. Therefore, we believe that an exploratory case study is a suitable method for addressing specific challenges and managerial solutions related to business model renewal. This method generates the kind of detailed description that is needed in order to explore an issue that needs to be further addressed (Yin, 1994).

Single case studies imply a limited generalisability of the findings (Eisenhardt, 1989). However, as the work presented aims to develop new theory rather than testing existing theory, the method is deemed to be suitable. Thus, the article does not attempt to provide an exhaustive set of answers, but rather to identify some specific challenges and how they can be handled. Moreover, the case study approach enables a rich and nuanced description which is often required in order to understand the abovementioned topic. The authors decided to base the case study upon interview data since this source of evidence generates a nuanced and insightful depiction. According to Yin (1994), interviews may result in a biased description and interpretation of events. This potential weakness was handled by targeting many interviewees and by performing the interviews by a duo of researchers. All interviews were recorded, transcribed and listened to afterwards.

In total, nine employees were interviewed two times, which may seem to be a low number. However, according to Yin (1994) interviews can be quite focused and directly address the topic, hence enabling a rich understanding quite rapidly. Moreover, the interviewees had different roles and insights into the project - six of them worked in the R&D department, either as directors or senior engineers with plenty of experience. The other three persons had been in charge of business development activities related to the studied innovation. Hence, a relatively small sample of interviews could still cover several different aspects of the project. They were targeted with semi-structured questionnaires, asking the respondents to describe the development of the product, what the main difficulties were, and how the product could eventually be turned into a commercial success by renewing the business model. Several interviews were conducted with the person who was in charge of changing the business model. Follow-up interviews were also performed in order to ensure an accurate interpretation of the gathered information. The case study description below emerged from similarities in the responses from the interviewees. It was also read and validated by the innovation manager and the person who had been in charge of the main business model changes that this product had implied. After the termination of the project, a final presentation was given to the company where the main findings and conclusions were communicated. During this session, the general interpretation of the collected data could be validated one more time. Hence, the empirical description in this paper emerged from an iterative approach where the findings have been validated at several points in time.

The present authors maintained a formal research partnership with the studied firm throughout the study and were interacting with it continuously during 2007-2008. This relationship enabled extensive access both to databases and to key employees. Within the scope of this partnership, scorecards have also been sent out regarding the creative climate at the company and the innovative capabilities of the firm. In total, more than 150 people answered these scorecards, giving a total response rate of more than 70 percent. This was done as part of an innovation audit that was performed at the firm. During the audit, interviews were conducted with top and middle management. Moreover, detailed case studies of nine discontinuous innovation projects at the firm have been done within the scope of the research which this paper is based upon. These data should be regarded as important background knowledge for the study described in this paper.

4 Results

The studied product innovation is a diaper for adults, intended to take care of heavy incontinence among elderly people. The product was launched by a company which has been a global player in the personal care industry for several decades, manufacturing diapers, feminine pads and incontinence products. The firm pioneered the incontinence market in the 1970s and is a dominant actor in this business today. Over the years, the company has sought to sustain its leading position by launching innovative incontinence products, whereas it has remained a follower in the diaper and feminine pad markets. Incontinence products are both sold to end-consumers and to retirement homes. The studied product is only sold to retirement homes.

The incontinence diaper was first launched in 2001 and then re-launched in 2002. The technical development started ten years earlier within a concept development project. Initially, the scope was more open, with the purpose of generating new knowledge rather than aiming for a new product. This development eventually resulted in an ambition to launch a new incontinence product, which would be based upon a belt, instead of having a pant diaper or using tape when attaching it. There were several technological challenges in the project. A belt had to be developed, and by that time belts were rarely used in incontinence products. Moreover, both the absorption core and the shell of the diaper had to be improved.

The first attempt to commercialize the innovation took place in 1994. New machines were built and this was done at the same time as the product was developed due to strong pressure from management. Eventually this development turned out to be very expensive and it increased the complexity of the project significantly. Therefore the project was put on hold for some years, but since the firm's products for heavy incontinence became increasingly subject to price competition, the firm decided to re-start the development activities in the late 1990s and thereby replace the 'all-in-one' diaper the firm had been selling previously. *"There was a strong commitment from an early point; management really believed that new products had to be developed in order to survive in the long term"*, one project manager recalls. This time the technological ambitions were lowered. Instead of using a belt, it was decided that the product should be attached with tape, since this would be cheaper. When the product was launched in 2001 it turned out that this tape

made the diaper too stiff and very uncomfortable to wear. Therefore it had to be withdrawn from the market and the brand was severely damaged.

4.1 Barriers to adoption

Despite this failure, management still believed in the product and therefore decided to improve the belt and re-launch it in 2002. Once the diaper had been put on the market again, the sales did not take off, for several reasons. The new design made the product appear inferior, though it was in fact much better, both in terms of absorption capacity and in terms of convenience for the users. More importantly, the price was higher, and thus it was difficult for the sales organisation to justify to the purchasers at retirement homes why they should buy the it. Previously, the firm had mainly offered products which could last longer, thereby lowering the customer's expenses. Though the new product resulted in an improvement along this performance dimension, the main difference was that it enabled cost reductions by decreasing the total cost of incontinence care. The "consequence costs" in terms of unnecessary product consumption, extra work, laundry and skin treatments could be reduced significantly. Up to 10 percent of the total cost could be removed, and since the cost of incontinence products only summed to 1 percent of the total incontinence care cost, this reduction was indeed remarkable and would easily justify a higher price. The main reason for this reduced incontinence care cost was that problems with skin irritation and leakages could be decreased. This improvement was primarily related to the breathable back sheet which enabled air to circulate instead of having the fluid circulating. The back sheet thus helped to maintain a healthier skin while at the same time increasing the comfort.

Hence, the new product resulted in fewer pad changes, less leakage and skin breakdowns, and this lead to a significant reduction of the total incontinence care cost. But since the purchasers at retirement homes were not assigned to handle the total cost of incontinence care but only the costs of incontinence products, they had in fact low incentives to buy this innovation, despite its superior performance. Moreover, the sales organisation preferred to sell the old products since they did not know how to justify the higher price. Thus, the incentives both to buy and to sell the product were initially very low. It also proved difficult for the caregivers to understand how the product should be used. The innovation was easier and more convenient to put on, but how to do so was not obvious, and therefore the product was not really appreciated by the caregivers either, despite being more ergonomic when used correctly.

To sum up, even though the innovation offered increased convenience both for users of the product and for the caregivers, while at the same time creating significant cost reductions for retirement homes, the product was about to become a failure. *"We underestimated the barriers to success and therefore the product was initially a commercial failure"*, one engineer recalls.

4.2 Business model renewal

Despite all the difficulties related to this product, the firm still believed in it since the diaper clearly created an increased economic value for the customer. Therefore the company started to look for new ways of selling it, by focusing on different attributes and sales channels. One major step in this direction was the launch of a service organisation which aimed to take a broader perspective on sales, focusing on total incontinence care rather than just selling products. This can be illustrated by the motto of the organisation, which is *"better care at a lower total cost"*. The new unit sought to communicate these values by performing studies together with customers, which showed the superior performance of the innovation. In one study together with six Danish municipalities it was proven that the customer's total cost for products could be reduced by 22 percent and that leakages could be reduced from 25 percent to 10.6 percent. In another study, they focused on the total cost of incontinence management, illustrating that it could be reduced by 13 percent. Moreover, by using simulations, the service organisation showed to the customers how the "hidden" costs of incontinence in terms of leakages, the required time for pad changes, and skin breakdowns could be reduced significantly.

Apart from focusing on new performance attributes and changing the value proposition, the firm started to work actively with educating caregivers regarding how to use the product. The innovation manager said that *"it was not really intuitive how the product should be put on, but once we showed the caregivers how it is done they found it to be much more convenient than to use the old products"*.

The service organisation also performed a study together with Linköping University, where they could show that the innovation was in fact much more ergonomic for the caregivers. This was an entirely new performance dimension for an incontinence product that the firm was scarcely aware of when the product was first launched, even though this had been a focus area in the development ten years earlier. This attribute implied that the costs related to employee absence due to illness could be reduced, thus lowering the total cost of incontinence care even further. Once these studies had been performed, the sales force felt more confident selling the product. Furthermore, the incentives of the sales organisation were changed so that the employees received their annual bonus based upon how much they sold of the new product.

The sales channel was also shifted towards the management of retirement homes, since they could focus on total incontinence care costs rather than solely the costs for the products. By using advanced statistics and computer simulations, and extending the value proposition, it was proven that the innovation decreased the total cost of incontinence care significantly, and this argument turned out to be more appealing to the managers than to the purchasers.

After having taken these measures, sales eventually started to take off and have been growing in recent years. The innovation manager summarized the story by saying that *"the product would not have become a commercial success if a service organisation had not been created and the sales approach had not been changed."* Moreover, top management had been firmly committed and was not reluctant to cannibalize upon previous products, primarily because the profitability was much higher on the new product.

5 Analysis and discussion

The case description above provides further evidence on the necessity of changing a business model when introducing a product that brings new performance attributes to the market (Christensen, 2006). The studied incontinence diaper created an increased utility for the customer, but did not succeed until the business model was changed. This section provides a theoretical and managerial discussion of business model renewal and synthesizes the case with the previously described literature on business models and industrial networks.

5.1 Challenges related to business model renewal

The literature review in this paper suggested that while several challenges related to changing a business model have been identified, they are not really specific for business models. Indeed, many of them were of a rather general nature and are familiar to scholars in strategic management, entrepreneurship and new product development. The development and eventual success of the studied incontinence diaper sheds some new light on how the business model innovation challenges differ from those related to product innovation.

Starting with the actual product development, it can be seen in the case study that the main challenges were related to patience and being determined to allocate resources to a project that turned out to be very problematic. Hence, the issue was a matter of execution where top management continued to believe in the project, despite the difficulties. As was stated in the case description, this commitment was a key success factor.

Once the product was launched, the firm faced the challenge of appropriating the returns from the created value and changing the business model in order to do so. These challenges were of a fundamentally different nature than those related to developing the product. The product's success in the marketplace could not be controlled in the same way as the development activities. Zott and Amit (2009) suggested that the business model can be regarded as a construct which is based upon interdependence. This definition helps us to understand why business model renewal seems to be so difficult. The case illustrates how several barriers to adoption occurred due to this interconnectedness since the product was incompatible with the existing network constellation of actors, resources and activities. The product required a shift in the activity of changing the diapers. Moreover, the increased value that the product generated was distributed differently. It was spread over the end-users in terms of convenience and reduced skin irritation, the caregivers because the product was much more ergonomic, and the retirement homes by offering a significant cost reduction for total incontinence care. However, the individual purchaser was not assigned to take this value creation into consideration, and this in combination with the higher price per unit created an adoption barrier.

Clearly, these challenges are different from the ones related to developing the product, which were primarily related to top management commitment and experimentation. Drawing upon the industrial network theory outlined previously, we therefore suggest that the challenges which are unique to renewing a business model are

related to *interdependence and systemic changes* in the way that value is *created and distributed among the key actors*. A firm's existing business model is not only controlled by the firm itself, but also by the incentive structure of its surrounding stakeholders, which are beyond direct managerial control. A product which requires a change in the activities, relationships or implies a new distribution of value will meet resistance. As stated before, firms build networks and relationships in order to reduce uncertainty, but as a consequence, they also become subject to limited freedom (Ford et al, 2002) which hampers its attempts to change established business models.

It should be underlined that the case study above concerned a relatively minor shift in a dyadic relationship between a supplier and a customer. A product innovation with some new performance attributes was enough to create systemic changes and resistance inside the customer's organisation. Changing a business model which affects several actors throughout an entire supply chain is therefore likely to be even more difficult. In such a context, an attempt to reconfigure a business model may affect several functions in many firms and due to the aforementioned interdependence, it is enough that one actor blocks the initiative for it to fail (Adner, 2006). As firms are to a larger extent drawing upon external sources in order to innovate and become more interconnected (Chesbrough, 2003), these difficulties will probably increase over time. Bearing this in mind, it becomes easier to understand why many firms struggle to renew their business models.

5.2 Managing business model renewal

The notion that business models are built upon interdependence also reveals how firms can succeed when trying to change their business models. First of all, we observe that the managerial prescriptions related to business model renewal seem to be more applicable to the product development phase in the case description above. Chesbrough (2009) suggested that experimentation, organizational leadership and effectuation were some of the determinants in succeeding with changing a business model. When developing the product, the firm experimented extensively with new concepts and technologies. Moreover, the engineers tried to use their skills in order to reach a goal which was not known beforehand as suggested by Sarasvathy's (2010) notion of effectuation. It is also clear that top management demonstrated organizational leadership in being committed to a project that turned out to be problematic.

These three factors seem to have been less important in succeeding with the actual reconfiguration of the established business model. Given that the success of the incontinence diaper depended upon changes which were beyond the direct control of the firm it had to find ways to align incentives in favour of the innovation. Under conditions of interdependence, leadership, experimentation and effectuation are important, albeit not sufficient criteria for success since the outcome is in fact governed by actors which cannot be managed by using executive power.

The case study provides some evidence regarding how firms can renew their business models. When sales did not take off, the firm sought to understand how all the relevant actors and activities were affected by the new product. A couple of barriers were found, such as the discrepancy between the purchaser's incentives and the overall utility of the

retirement homes and the caregiver's lack of knowledge regarding how the product should be used.

Once these actors and their incentives had been identified, the firm sought to develop a business model that was compatible with this structure. Under conditions of restricted freedom (Ford et al, 2002), firms depend upon its surrounding environment and therefore need to map and align incentives in order to succeed. The studied firm did so by undertaking a couple of measures. Given that the new incontinence diaper created value on a more systemic level for the customer by reducing the total cost, the firm targeted the management of retirement homes rather than the individual purchaser. When doing so, the value proposition was also changed from selling incontinence products towards offering "*better care at a lower total cost"*. Moreover, given that the activity of changing diapers had to be altered, the firm started to educate caregivers regarding how the product should be used.

Table 1. Some managerial guidelines for how firms can renew their business models. The middle column is on a generic level and the right hand column describes how it was accomplished in the studied case.

	Managerial action	*What was done in the studied case*
Step 1	Map all relevant actors in terms of their incentives, resources and activities.	The incentives of purchasers were not compatible with the new diaper. The product required that the caregivers changed their activity of changing diapers.
Step 2	Find out how value is created and distributed among these actors.	The product created value for the organization on a more systemic level – the total cost was lowered while the unit price was higher.
Step 3	Identify actors which are critical for the adoption of the product innovation.	Management of retirement homes needed to be convinced since purchasers rarely took the total cost into consideration. Caregivers had to be re-educated.
Step 4	Design a business model which aligns incentives throughout the established actor network.	The value proposition was changed to "better incontinence care at a lower total cost" and management was targeted instead of individual purchasers. Caregivers were re-educated and a closer relation to customers was developed.

Summing up the above, our findings provide some tentative guidelines for how firms can go about when trying to renew their business models. As stated in the theoretical review, some authors have pointed out the interdependent nature of business models, but little is known about how firms can change their business models under conditions of restricted freedom. From this theoretical standpoint we have contributed to existing literature by pointing out some guidelines as to how firms can renew their business models.

Companies need first of all to identify all actors, resources and activities which are affected or can influence the adoption of a product. It should be pointed out here that those actors can be found inside the customer's organisation as well as in other parts of the firm's network. Secondly, the incentives that govern these actors must be mapped and understood. These conditions are more or less fixed and finding the right business model

is a matter of figuring out how these incentives can be aligned in favour of the product, for instance by helping actors to change their activities or by targeting new actors with a new value proposition.

6 Conclusion and future research

We started this article by observing that while many firms are good at introducing new products, they often fail to renew their business models. Several scholars have pointed out the importance of changing existing business models in order to succeed with product innovations, especially those of a more discontinuous nature (Christensen, 2006). However, more knowledge is needed regarding why this seems to be so difficult and how firms can go about when changing their business models. We have tried to address these two issues by drawing upon industrial network theory and by using an illustrative case study. Our literature review suggested that most of the literature about business model renewal is of a general nature and does not really make a difference between business models and new products. Given that it seems to be more difficult to change a business model than a product, we have tried to identify in what ways these challenges are different, and how they can be handled.

Having paid special attention to Zott and Amit's (2009) definition of business models as being based upon interdependence we went into further detail using industrial network theory. Based upon our case study and theoretical review we conclude that business models are difficult to reconfigure since such a change depends upon actors outside the firm's boundaries and thus, only a limited control can be imposed. One reason why it seems to be easier to introduce new products than new business models would therefore be that a firm has much more control over new product development efforts than business models, which to some extent transcend the boundaries of the firm.

A couple of guidelines regarding how the dilemma of interdependence can be handled have also been presented. In order to renew a business model, firms need to identify all affected actors and activities as well as their incentives. Based upon this input, firms can develop new business models by targeting new actors, encouraging changes in existing activities and aligning incentives throughout the network.

Having drawn upon one single case study and some theory on industrial networks, our conclusions need to be further validated. We therefore encourage other scholars to explore and test our findings, particularly by looking at business model changes throughout entire supply chains. These challenges are likely to be even more complex and difficult to handle since more actors are affected in such a setting.

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Paper VI

Disruptive Innovation as a business model challenge

Mats Magnusson and Christian Sandström

Abstract

It has often been stated in previous literature that disruptive innovation is a business model problem, but few studies have attempted to explain what this problem actually consists of. We address this issue through a multiple case study of how firms have tried to introduce disruptive innovations and sought to renew their business models. Conceptualizing business models as boundary-spanning activity systems, three key challenges are identified. A first challenge concerns how the new value creation associated with the innovation is sometimes incompatible with the existing competences and activities of key actors. Furthermore, disruptive innovations can create a new distribution of value, which in turn may imply that some actors lose their power or status. The third key challenge concerns the fact that firms can only impose a limited control over their business model as it transcends the boundaries of the firm. Subsequently, managerial implications related to disruptive innovation and business models are elaborated.

1 Introduction

Innovation is a fundamental dynamic capability, allowing firms to renew their product and service offerings in order to match, and sometimes even create, market changes. In the field of innovation management, particular emphasis has lately been put on changes of a discontinuous or disruptive nature, as these have been found to generate substantial problems for incumbent firms (Christensen, 1997). Existing literature on the subject has underlined the importance of finding new business models in order to survive and prosper under conditions of disruptive change. Christensen (2006) explicitly pointed out that handling innovations which have disruptive characteristics is essentially a business model problem. However, more knowledge is needed regarding the way in which a disruptive innovation actually constitutes a business model problem.

We address this matter by exploring what business model challenges a firm encounters when trying to introduce disruptive innovations. Five illustrative cases are presented in order to show how and why firms struggle with disruptive innovations and how they can succeed by attending to a number of business model issues. These ideas are based upon both direct empirical observations from case studies and drawing upon an elaboration of complementary theory that can inform and improve the ongoing development of management theory and practice related to the disruptive innovation and business model change.

The paper is organized as follows. The following sections provide a theoretical exposition of literature on disruptive innovation and business models. Next, the methods used and empirical data are presented. Thereafter, a discussion and analysis follow, in which we identify key challenges and provide some managerial implications regarding how business models can be renewed in a way that enables disruptive innovations.

2 Disruptive innovation

It has long been known that established firms seem to encounter difficulties under conditions of discontinuous change (see e.g. Cooper and Schendel, 1976; Utterback, 1994). A discontinuous innovation can be regarded as a step-wise distortion of an established industry or market structure (Hamilton and Singh, 1992). Initially, academic work in this area focused largely on difficulties related to changing firms' resources and capabilities when confronted with discontinuous innovations. Previous work in this area has for instance pointed out that technological shifts which render existing skills obsolete tend to be problematic (Tushman and Anderson, 1986). It has also been argued that changes in the product architecture are difficult to handle due to organizational inertia (Henderson and Clark, 1990).

Christensen (1997) developed a significantly different perspective upon why established firms fail when facing discontinuous changes. Instead of looking at the resource and competence base of incumbents, Christensen explored the role of the market and firms' value networks[1]. He observed that those innovations which are not initially demanded by the existing customers of a company tend to be particularly problematic to handle since the financial incentives to invest in such initiatives are normally absent in the early phases.

Based on these observations, Christensen made a distinction between disruptive and sustaining innovations. Disruptive innovations have in common that they underperform along dimensions which customers have historically valued, while at the same time bringing new performance attributes to the market. Sustaining innovations, on the other hand, are those which a firm's established customers demand, and primarily improve performance along the dimensions already valued by existing customers. Many disruptive innovations tend to prosper in low-end segments or in new markets (Christensen and Raynor, 2003), and as performance of the new technology improves it eventually displaces the former technology. Disruptive innovations tend to be developed by entrant firms, since these companies can more easily create a new value network and grow even in small market segments offering lower profit levels.

[1] A value network can be defined as the "context within which the firm identifies and responds to customers' needs, procures inputs and reacts to competitors" (Christensen and Rosenbloom's, 1995, p. 234)

The theory on disruptive innovation was developed by drawing upon resource dependence theory (Pfeffer and Salancik, 1978). This perspective on organizations contends that the environment imposes a great indirect control over the focal firm since it depends upon resources from the environment in order to survive. Incumbent firms are in this way "held captive" by their most profitable customers and fail to invest in initiatives which are not initially demanded by them.

A key managerial recommendation related to disruptive innovation has been that those initiatives need to be developed in an independent organization. By doing so, these potential products can be protected from the competition for resources inside the firm, which tends to drain the disruptive innovation of funds.

Clearly, the above-mentioned work has put an increased emphasis on the importance of the surrounding network when trying to understand and manage discontinuities. Indeed, Christensen (2006) reformulated his earlier work by stating that disruptive innovation is fundamentally a business model problem. Nevertheless, the bulk of the existing literature has until now largely focused on the focal firm and its internal resource allocation processes. By viewing disruptive innovation as a business model problem, a new research area is opened up, in terms of identifying both challenges and managerial solutions. A first step in this direction would be to clarify the problems. We therefore address the following research question in this paper:

How and why is a disruptive innovation a business model challenge?

Before addressing this question in further detail, a brief exposition of literature on business models is given in the following section.

2.1 Business models

Generally speaking, business models are concerned with how firms create and capture value (Chesbrough and Rosenbloom, 2002). The concept initially became popular during the dotcom-bubble. Companies could find new ways to make profit by using the Internet, and business models thus became increasingly relevant to scholars and practitioners (Magretta, 2002). Some researchers consider the business model to be the mechanism by which firms create and capture value (Shafer et al., 2005), whereas others think of it as a set of business components or answers to certain questions (e.g. Yip, 2004; Osterwalder and Pigneur, 2005). The latter definitions are problematic for a couple of reasons. First of all, it becomes difficult to assess the underlying theoretical concepts. These definitions also seem to be somewhat arbitrary as different scholars use a range of different components. Indeed, Shafer et al. (2005) found 12 different definitions in 1998-2002, which together contained 42 different elements. Clearly, the important concept of business models becomes hard to understand

when there is such a variety in the way that the term is defined. Another consequence of regarding the business model as a broad set of components or answers is that it becomes difficult to develop managerial solutions which are specific for business models.

Some more theoretically grounded works on business models have stated that business models deal with how a firm interacts with its surrounding network. Itami and Nishino (2009) argued that business models can be thought of as two basic elements, a business system and a profit model. They also pointed out that such a system is essentially an interplay between the firm and its surrounding network. A similar conceptualization was provided by Weill and Vitale (2001), who stated that a business model is comprised of participants, relationships and the flows between them. Zott and Amit (2009) developed these ideas further, defining a business model as "a system of interdependent activities that transcends the focal firm and spans its boundaries". In their article, the importance of regarding business models as activity systems, i.e. interdependent organizational activities which are related to the firm as well as its surrounding network, is underlined. Embracing such a perspective, it becomes clear that a fundamental part of the business model is the design of an activity system that captures which activities should be performed, by whom, and how activities and actors are linked together. One advantage of this conceptualization is that it clarifies that business models need to be thought of as systemic and holistic (Zott and Amit, 2009). In addition to this, an activity system perspective allows us to consider not only financial, but also social aspects of a business model. In this article, we will apply the outlined interactive perspective to business models.

3 Methods used

In order to explore the topic explicated above, a multiple case study approach was chosen. This method is often used when looking at a phenomenon that has been insufficiently dealt with in previous literature. When trying to build new theory rather than testing established theory, case studies are often used, since they enable a detailed description which makes it possible to comprehend an issue that has only partly been addressed before (Eisenhardt, 1989). A multiple case study approach was used since the addressed topic can include a wide range of different managerial solutions, given that business models are holistic and cover a wide range of different business functions and means. By looking at how several firms in different industries, both entrants and incumbents, have tried to renew their business models, a broad range of insights could be obtained regarding this phenomenon. The companies approached all had experience of launching products that required changes along one or several dimensions of their business model. Additionally, these companies and their corresponding products were targeted since they had developed products which had some disruptive characteristics, e.g. new performance attributes or a new way of creating value. By necessity, this larger sample implies that the descriptions become more limited in terms of

detail and richness. The advantages of using interview data in terms of obtaining a nuanced account for the different cases are still present, since quotations and illustrative examples are highlighted.

The article presents five illustrative case studies, all of which concern how firms have launched a product or technology with disruptive characteristics and sought to refine their business model to fit with the new value creation and appropriation in the activity system. In order to gather this information, semi-structured interviews were conducted at the different firms. The questions concerned how and why a certain discontinuous innovation imposed a demand for business model renewal, and how the firms proceeded in order to fulfill it. The number of interviews in each firm ranged between two and nine. In the cases where fewer interviewees were involved, those interviews were specifically targeting persons who had key roles in developing the new product and/or the business model. By doing so, key information could be obtained despite a relatively small amount of interviews (Yin, 1994). Each interview lasted for about 90 minutes. Notes were taken by the researcher and the interviews were also recorded in order to allow for subsequent validation of the notes. Several interviewees have read the interview documentation and been asked to confirm the interpretation of the data. Table 1 contains further information about the performed interviews.

Firm	**Number of interviews**	**Interviewees**
Video surveillance firm	8	Managers of R&D and people who have been in charge of business development for a long time.
Floor coatings firm	4	Manager of one division, the former director of sales and marketing, the manager of R&D, and one engineer.
Health care firm	2	Director of marketing, and the engineer who was the champion behind the studied product.
Incontinence diaper firm	9	The person in charge of renewing the business model with regard to the studied product, the innovation manager, and 7 other persons involved, primarily engineers.

Table 1 Information regarding the respondents that have been interviewed in the study.

4 Results

This section contains a presentation of the results. A brief summary of the cases is provided in Table 2, and the following sub-sections give a more detailed description of relevant aspects of each single case, with an emphasis on how the business model was changed and the critical activities related to this shift.

Product / Technology	Studied firm	Key product characteristics	Main business model challenges	Overcoming the challenges
Digital, Internet-based video surveillance.	A European entrant firm which has driven the shift towards digitalization and grown rapidly over time.	More scalability and integration with other systems such as the intranet. Easier installation and increased intelligence.	A lack of IT competence among key stakeholders in the value network related to security.	The firm has sought to communicate the new value proposition that is brought to the market. It provides training to customers and system integrators, and has tried to target new actors inside the customer's organization.
Water-based coatings for wooden floors.	A firm which pioneered the use of water-based coatings back in the early 1980s and has grown a lot over these years.	Waterborne coatings are more environmentally friendly, it took less time to finish a floor for the craftsmen who used them, and they did not contain carcinogens like the former products.	Convincing the craftsmen of the importance to stop using solvent-based products and shift to waterborne coatings which were installed in a different way.	Training activities like seminars and training centers launched in many countries. The firm offered good margins to its distributors in order to make them promote the products.segment
UV-based coatings, for manufacturing wooden floors.	The same firm as in the previous case.	An initially lower durability, but also a significant simplification of the customer's manufacturing process.	While the manufacturers of wooden floor benefited from using the product, the end user did not do so due to a lower durability.	UV finishes were initially sold as a complement and a waterborne coating was also used once the floor had been installed.
The first hydrophilic catheter, launched in 1983.	A European firm which has grown significantly over the last decades thanks to this product.	Enabled patients to use a catheter on their own, without help from healthcare staff.	The product required a different form of treatment of patients.	Informed physicians sought to identify key 'opinion leaders', performing clinical trials and influencing the public reimbursement system.
The first incontinence diaper that used a belt, launched in 2002.	A large European manufacturer of diapers, incontinence products and feminine pads.	Reduced leakages, less skin irritation and a more ergonomic product to use for caregivers. Decreased the total cost of incontinence for the customer's organization.	Higher price per piece, but reduced overall costs for incontinence care. The economic value was created on a new level and caregivers did not know how to use the product.	The firm started to work more proactively with its customers, informing and training them. The value proposition was changed and new actors were targeted inside the customer's organization.

Table 2: An overview of the investigated product innovations, the main business model challenges and how the firms handled them.

Case 1 – IP-based video surveillance

The video surveillance industry is currently experiencing a shift from analogue to digital, IP-based cameras. For a long time, IP video offered a lower image quality, but lately it has surpassed analogue technology along this dimension with the rise of megapixel cameras and HDTV quality. At the same time, the technology has brought several new performance dimensions to the market. For instance, IP video is easier to integrate with other information systems, it is much easier to expand the system, and images can be viewed from any place that has access to an Internet connection. This technology has grown rapidly in recent years and the analogue incumbents have so far failed to dominate the technology.

While entrant firms like the one studied in this paper have grown significantly, they have encountered several challenges over this time. When installing an IP-based system, surveillance becomes more of an IT issue than a traditional security matter. Historically, the security industry has been characterized by a business logic that is very different from the logic in the IT industry. The security industry used to have limited price transparency throughout the supply chain and people who worked in the industry often had a background in the military or in the police. These actors have been used to doing business based upon strong relations. Integrators and distributors of IT products, on the other hand, are used to higher price transparency and weaker ties between the actors. Additionally, security people do not command the new technology since the competence related to installing and maintaining an IP system is significantly different. Another problematic issue has been the fact that security managers lose power vis-à-vis IT managers inside the customer organizations and therefore they have been reluctant to adopt the new technology.

Initially, the studied firm sought to handle this conflict between IT and traditional security by building separate channels according to the logic described above. They even sought to communicate the different logic by selling black products in the security channel and white or light grey products in the IT channel, as these colors are usually associated with the different industries. But at that point (1999-2001) the technology was still inferior in many respects, and hence the security industry saw little benefit in adopting the new technology. The IT industry, on the other hand, had been hit by the dotcom-bubble in 2001-2002 and there were plenty of skilled persons who looked for jobs. The studied firm has therefore chosen to focus on an IT channel approach, and has grown significantly by doing so. As the technology has evolved, the traditional security industry has become more interested in IP video and come back to the firm. But when doing so, they had to follow the IT logic, based upon weak ties and price transparency.

The power and knowledge of security managers has continued to be a challenge for the studied firm. The firm has undertaken a couple of measures in order to deal with this issue. For instance, it has to a large extent targeted IT managers. One company representative said: "*It was easier to find an IT manager with an increased need of security than a security*

manager with an increasing need of IT". Additionally, the firm has sought to create a broader interest for IP video inside the customers' organizations by being involved in many different marketing activities. It has put advertisements in the security industry press, released white papers and approached the managers of the security managers. The studied firm does not normally know exactly how and where decisions are taken inside the customer organizations, and has therefore chosen to target a wider set of actors, thereby hopefully creating an internal pressure to go for an IP-based system. It often tries to get the IT and security managers to attend the same meeting and reach an agreement between themselves. Additionally, the firm educates installers and customers in how IP video is used, by offering training sessions. "*They won't know everything about IP surveillance from a one-day session, but they know much more and can learn more*", a company representative recalls.

The firm's business model is based upon a couple of common denominators. It doesn't sell directly to end users and works together with many different partners, who integrate systems, act as distributors, develop software and sell various services. The business model seems to be very flexible – the firm makes money primarily on hardware but also to some extent on video management systems. The partners in its network are free to develop their own ways of making money using both the company's products and its competitors'.

Case 2 – Waterborne coatings for wooden floors

Until the late 1970s, coatings for wooden floors were based upon chemical solvents. These smelled substantially, and later on it was also proven that many of the solvents in the coatings were carcinogenic. Additionally, it took a long time to coat a floor using this technology. The studied firm launched the first waterborne floor coating in the late 1970s. It offered several advantages – no smell, no carcinogens and it enabled the craftsman to finish a floor in one day instead of three.

Nevertheless, the firm encountered several problems when trying to commercialize the technology. Even though the benefit of shifting to water-based coatings was significant for the craftsmen who used them, many craftsmen had used solvent-based coatings for several decades and were used to working with these products. Furthermore, putting on a waterborne coating was a slightly different activity from using solvent-based products and the users did not really know how to use the waterborne finishes. Since the firm sold its products via distributors, it had to convince both the end users and the distributors about the benefits of using this product. The company sought to do so by offering better margins to its distributors, who thereafter started to promote the product more. Additionally, the firm started to inform and educate the market about the advantages of its product. The former director of the market organization remembers how the firm on average arranged one seminar per day somewhere in the world during the 1980s. He wanted people to get to know the company and its products by demonstrating and training them regarding how the coating should be used. The company

had training centers throughout the world. These seminars and trainings were often arranged together with a distributor, and the firm regarded this as an activity that was needed in order to make profits on its products, even if the seminars and training sessions barely covered their costs.

Case 3 – Industrial coatings for wooden floors

In the late 1960s, industrially produced wooden floors started to enter the market. These products were both industrially produced and coated with a solvent-based coating. The industrially produced wooden floors were often installed in newly built apartments and houses. The process of manufacturing these floors was very sensitive and risky. The chemical compounds implied a great risk of fire which in turn resulted in high insurance premiums. The production sites smelled, were harmful and dangerous for people working there, and generated high levels of pollution. A manufacturing line for industrial coating and production was about 100 meters long. The floors needed to be dried in large ovens which consumed a lot of energy.

Since the studied firm was primarily selling floor finishes to craftsmen, its directors realized that industrially coated floors could have an impact on the core business. The firm therefore sought to develop products which could be sold to these manufacturers. Instead of focusing on solvent-based products, the engineers developed a UV-based coating. This product was radically better for the manufacturers of wooden floors. The production line did not need to be longer than 10 meters, no ovens were needed, and consequently the energy savings were huge. The customers could now manufacture 20-25 meters of floor per minute instead of 2-3 meters. Additionally, all the smell, the great risk of fire and the toxicity were removed.

The producers benefited extensively from adopting this technology and did not hesitate to do so, despite the fact that they had to exchange a large part of their installed machinery. The final outcome, however, was in many respects quite poor. UV coating initially offered a significantly lower durability, and could even be scratched away from the surface. In many cases, it was therefore used as a complement to traditional coatings. The performance of the products was increased over time and UV coating now has performance similar to more traditional coatings.

Case 4 – A hydrophilic catheter

In the early 1980s, the studied firm launched a catheter which had a hydrophilic surface. The hydrophilic surface enabled people to use these products on their own, without needing any help from a nurse or a doctor. The product was safer and easier to use than previous catheters, which had high friction.

The engineer who developed the concept and has worked with the product for the last 25 years stated that the main challenge associated with commercialization was that another kind of treatment was required. The firm basically had to educate the entire market for the first decade. It sought to do so by interacting extensively with physicians and nurses who were specialized in urology. Seminars were arranged, demonstrations were given and several clinical trials were conducted in order to prove the benefits of the product. Since doctors and nurses are the ones who teach a patient how a certain treatment should be undertaken, they had to be convinced and trained. The firm tried to make explicit the increased value of the new product, by estimating to what extent the quality of life was improved for the end user as well as pointing out the reduced costs associated with the fact that people did not need a nurse to help them when going to the toilet.

Today, hydrophilic catheter treatment is considered to be the European standard in the industry. However, while the firm has enjoyed considerable growth in Europe, it has been more difficult to succeed on the American market. The main reason for this appears to be that the public reimbursement system for these products has not been as generous. An additional reason seems to be that the system is much more complex in the United States where there are more different actors, such as insurance companies, hospitals, government programs, state and federal governments. It has also turned out to be more difficult to align the many different actors in the United States, arguably blocking the adoption of the innovation there.

Case 5 – An incontinence diaper with a belt

This case concerns an incontinence diaper for adults, which is primarily sold to elderly homes and hospitals. Unlike its predecessors, this product used a belt-like solution for fastening the diaper, an innovation which had many implications. It resulted in fewer leakages and problems for patients, while at the same time being more ergonomic to put on for caregivers, resulting in decreased sick-leaves. Hence, the total cost for incontinence was reduced significantly with this product. Despite this, sales of the product did not take off when it was launched in 2002. First of all, customer purchasers found it hard to justify the higher price associated with the product. Secondly, the caregivers did not really know how to put on a diaper that had a belt. Thirdly, while the created value by far motivated the increased price, it was not very visible, since costs were reduced in a more systemic way.

The studied firm sought to overcome the mentioned barriers by undertaking a couple of measures. It started to train the caregivers in how the product should be used. Moreover, the firm performed a couple of studies in which it was shown how much the total cost of incontinence was actually reduced when using this product. After having done so, the value proposition was changed from selling incontinence products to selling *better incontinence care at a lower total cost*. Since the purchasers were not assigned to take these factors into account, the firm started to target the management of hospitals and elderly homes instead. It

turned out that they were more easily persuaded by this argument. After having made these changes, sales eventually started to take off.

5 Analysis and Discussion

In the literature review above, it was stated that business models concern how a firm creates and captures value from its surrounding network. In this section, we will try to explain in what way a disruptive innovation is a business model challenge by pointing out a couple of key obstacles. After doing so, we discuss how these findings differ from previous literature. Subsequently, some managerial implications are offered.

5.1 From performance to value

Our empirical observations suggest that one key business model challenge with regard to disruptive innovation concerns how the innovation creates value. While previous literature on the subject has focused largely on how different performance trajectories match the demands of existing customers or not, it is perhaps more important to translate this performance into value and utility for customers (Lindmark, 2006; Oskarsson and Sjöberg, 1991). Several of the case illustrations show that the disruptive innovation could prosper among established customers despite a lower traditional performance. The key obstacle was rather related to the way that this value was created.

Economists often consider value to be subjective (Bowman and Ambrosini, 2000), i.e. some actors may regard specific goods or services as valuable and others may have a different opinion. This subjectivity can be explained by the fact that actors have diverse perceptions of an offering. Moreover, value can be thought of as a positive difference between the obtained benefits and the required sacrifices related to adopting an innovation (Monroe, 1991). Whether value is created or not therefore depends upon the context of the concerned actor, the sacrifices it has to make and the benefits that it obtains.

As different actors perform different activities and control different resources (Håkansson, 1989), they are also subject to different tradeoffs. The empirical data provide some illustrations of this issue. In the case of IP video, the studied firm faced several actors with diverging incentives, both in the downstream network and inside the customers' organizations. Integrators of traditional CCTV did not command IP video, and security managers were largely hostile towards the new technology. While the new technology offered an increased performance in many respects, several actors were still hostile towards it since they perceived the sacrifices to be bigger than the benefits due to a lack of competence related to the technology. Similar issues could be identified in the incontinence diaper case, the hydrophilic catheter case and in the case of waterborne floor finishes above. Critical

actors lacked the competences required for the realization of the potential value associated with the innovation.

5.2 The distribution of value

Another key issue related to business model renewal seems to be how the created value is distributed across the actors in the network. As an innovation may generate an increased economic value by destroying value elsewhere, the distribution of value needs to be analyzed. Actors who are subject to such changes which reduce their importance may have clear incentives to block an innovation. On the contrary, others may be in the opposite situation and gain from the adoption.

In some of the cases reviewed above, critical actors felt threatened by the disruptive innovation since their power or status could potentially be reduced by the innovation. The case of IP video presents an illustrative example here. When security becomes more of an IT issue, security managers lose some of their status and power vis-à-vis other actors inside the customer organization, and they therefore had clear incentives to block the adoption. Hence, a disruptive innovation became problematic to introduce when it had a negative impact upon actors with the possibility to influence whether it should be adopted or not.

In the incontinence diaper case, the product's ancillary performance characteristics created value which was more widely distributed inside the customer's organization. This in turn resulted in a barrier to adoption, as the purchaser was not assigned to take this more systemic value creation into account.

In other cases, adoption was rather quick despite the initially poor performance of the innovation, mainly since the key actors benefited extensively from adopting it. In the UV-based coatings case, manufacturers of wooden floors were willing to trade off some performance for the end customer in order to save money in the production process. Hence, they were affected positively by the innovation, partly at the expense of the end customer, making it possible for the technology to reach the market despite its inferior performance. While end customers and users in other cases could influence the network, this was not the case in the specific situation. Clearly, this underscores that the relative power of different categories varies between different industries and innovations, and that these power structures need to be understood to avoid unexpected resistance to change. The case of industrially coated wooden floors therefore suggests that one main determinant of success is how critical actors are affected by an innovation.

5.3 Interdependences leading to restricted freedom

While the key adoption barriers seem to be related to how value is created and distributed, our observations also suggest that trying to change a business model is difficult since firms can only impose a limited control over it. If a business model is something that transcends firm boundaries and concerns the established network constellation (Zott and Amit, 2009), the concept is fundamentally about interdependences between actors. This would arguably imply that firms are only to a limited extent able to change their own business model, since it by definition involves other actors, their activities, and preferences. Put briefly, firms which operate in a network are bound to act under conditions of restricted freedom (Håkansson and Ford, 2002).

Several of the described cases illustrate the problematic issue of trying to change a network constellation. In the IP video case, the studied firm became reliant upon issues beyond its direct control, such as the conflict of interest between the IT and security functions inside the customer organizations. The incontinence diaper could not be adopted until different actors such as the purchasers, caregivers and managers had coordinated themselves differently and developed new skills. Similar challenges could be identified with the hydrophilic catheter, which could not be realized until several key actors had changed their opinion and altered their activities. Whether these required changes will be made or not is an issue that the focal firm can only influence to a limited extent. Put differently, firms struggle to renew their business models with regard to disruptive innovations since business models span the boundaries of the firm and are therefore based upon interdependence, which can be defined as follows:

"Any event that depends on more than a single causal agent is an outcome based on interdependent agents. (…) Interdependence exists whenever one actor does not entirely control all of the conditions necessary for the achievement of an action or for obtaining the outcome desired from the action" (Pfeffer and Salancik, 1978. p. 40).

The empirical illustrations suggest that this interdependence exists between the firm and the concerned actors as well as between different actors in the network. A disruptive innovation seems to distort or modify the network, and some actors may have incentives to block it due to the new distribution of economic value, while others may be incapable of realizing this potential value due to a lack of relevant competences.

5.4 Disruptive innovation as a business model challenge

The key obstacles identified above stand in contrast to those that have been identified by previous literature on disruptive innovation. This stream of literature argued that the main difficulty was related to how existing customers control the resource allocation process of firms, by rejecting innovations that did not meet certain performance requirements

(Christensen, 1997). Our observations rather indicate that different performance levels need to be translated into how value is actually created and distributed throughout the network. By doing so, a more nuanced view of the incentives of different actors emerges, and thereby also a clearer picture of the potential obstacles to adoption.

Our findings also suggest that it is important to look at the impact an innovation has on different actors. It has been shown how actors both inside the customers' organizations and throughout the network may have diverging incentives since they control different resources and perform different activities. Instead of arguing that a disruptive innovation is problematic since established customers do not demand it, we would claim that these innovations are problematic because they are sometimes *not demanded by certain actors* in the firm's established business model. The main reasons for this appear to be that the creation and distribution of value are sometimes incompatible with the incentives and competences of certain actors. The interdependences among these actors and the focal firm in turn make it difficult to change the network.

5.5 Managerial implications

While previous work on disruptive innovation has argued that the key challenge is related to the environment and how it controls the focal firm, surprisingly little attention has been given to how firms can actually manage the environment. Previous work has instead focused largely on how firms can manage their own resource allocation process. One reason for this could be that existing theory on the subject has conceptualized the environment in a rather simplistic way. It has been assumed that customers do not demand an innovation unless it offers a certain performance. Our findings rather suggest that disruptive innovations sometimes cannot be realized since actors lack the required competences, and that they at times may block an innovation as it would bring about a new distribution of value that would not be positive for them.

Having developed this more nuanced conceptualization of value and networks, it also becomes possible to identify how firms can actually renew their business models. While it is clear that the aforementioned interdependences impose constraints on managerial action, several scholars have argued that it is still possible to influence a network in one's own favor (e.g. Knight and Harland, 2005) and our empirical evidence points to some ways of handling this dilemma. Doing so seems to be largely related to the alignment of incentives, a matter that lately has been emphasized in the abundant literature on supply chain management (Lee, 2004). As a disruptive innovation changes the way value is distributed throughout an activity system, modifying the business model so that it aligns the different actors' incentives with the new value distribution constitutes a significant challenge.

A resulting key issue concerns which actors the firm should try to target and which ones to avoid. As illustrated above, some actors have a direct interest in adopting the innovation whereas others may have an interest in blocking it. For instance, IT companies and IT managers had incentives and competences which were aligned with IP video, whereas the traditional security industry initially had little interest in adopting it. The studied firm therefore chose to approach actors who commanded the technology, i.e. developed a sales channel based upon IT integrators and IT managers. In the incontinence diaper case, it turned out that individual purchasers had no incentives to buy the product, since they were not assigned to take the more systemic value creation of it into consideration, but merely the purchasing cost of the products. This company therefore decided to shift the target to the management of retirement homes, who could easily grasp the benefits in terms of improved healthcare quality.

Given that value is something context-dependent and largely a matter of perception, firms can try to influence these factors in order to facilitate the realization of value. This was the case with healthcare staff and hydrophilic catheters, caregivers and the incontinence diapers, integrators and IP video surveillance, and with craftsmen and waterborne floor finishes. These actors were critical for the adoption of the product since they were either the ones using it or were influencing the decision to adopt it. The studied firms therefore decided to target these actors, and took explicit actions to influence their viewpoints, for instance through marketing and training.

Several of the studied firms engaged in more general, broader marketing activity in order to influence and put indirect pressure on the more skeptical actors. This was the case with both the hydrophilic catheter and IP video. In the first case, the firm actively sought to influence key opinion leaders such as physicians and scientists, who in turn could speak favorably about the product and treatment. In the IP video case, the studied company engaged in a wider range of different measures, which would make different actors more receptive to the technology, thereby putting indirect pressure on more skeptical actors like security managers. For instance, they did so by publishing white papers on the technology and by pointing to the advantages of IP vis-à-vis traditional CCTV.

As pointed out previously, some innovations may also destroy the competence of established actors. If these actors are anyhow crucial for adoption, the innovating firm needs to influence and encourage them to change their activities. Several of the studied firms have undertaken such efforts. Training sessions were arranged where these actors were informed about how the product or technology should be used and the benefits of it. In many cases, this was not a profitable activity, but something seen as necessary in order to build relations and help others to renew their competences. These activities could also have a positive effect on the incentives of the involved actors, since the value of the innovation could be communicated more clearly in these sessions.

Other cases illustrate how firms explicated their value proposition differently in order to mirror the new value creation and distribution, making it more appealing for certain actors and thereby reducing resistance to adoption. In the incontinence diaper case, the value proposition was changed from selling incontinence products to providing *better incontinence care at a lower total cost*. The managers of retirement homes and hospitals were more concerned with the total cost of incontinence care than the purchasers were, and as a result this communication turned out to be more effective.

Summing up, when redesigning a business model with regard to a disruptive innovation, firms need to analyze their surrounding network of actors and the innovation's impact on each one of them, in particular in terms of changes to value creation and appropriation of value, and the resulting incentive structures. It should here be pointed out that these actors should be looked for both inside different firms in the network and in other parts of the value network. Of great importance throughout this work is the application of a clear systems perspective, since there are many different actors which are intertwined in exchanges of goods and services.

6 Conclusions

More recent literature on disruptive innovation has increasingly argued that this issue is fundamentally a business model problem (Christensen, 2006). Our literature review suggested that more knowledge is needed concerning in what way this is actually the case.

We have addressed this topic by drawing upon evidence from several case studies. Our findings suggest that disruptive innovations may distort established business models by creating and distributing value in new ways. The different creation of value may not be compatible with established competences and activities, and thus a barrier to adoption occurs. Moreover, a different distribution of value may result in hostility towards the innovation, as some actors would lose their power or status.

With special attention to Zott and Amit's (2009) definition of business models as interdependent and boundary-spanning activity systems, we would like to stress that it is sometimes difficult to change a business model as such a change tends to involve actors beyond the boundaries of the firm. Attempts at business model renewal therefore often take place under conditions of restricted freedom, where solutions based on having direct control are simply not feasible.

Clearly, the interdependences in question impose constraints upon efforts to change the business model. Our empirical illustrations nevertheless show that networks can be changed, by attending to a few critical tasks. The different actors involved need to work in the same direction for the innovation to succeed, but they may be unwilling to do so for several

reasons. They may simply have no real incentives to do so, or may lack the required competences. When analyzing the network it is particularly important to look at the changes implied for value creation and distribution by the innovation, as well as capturing the impact on existing knowledge and power structures throughout the network. Moreover, as a network is comprised of many different and interconnected actors, it is important to maintain a systemic view of the network. In those cases when the innovation required a change in the established competences of important actors, several firms tried to help these actors to change by offering training sessions and information. In other cases, firms have changed their value proposition, engaged in broader marketing activities and aligned incentives by offering good margins to key actors.

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