Dancing with Up-stream Directives in the Supply Chain: Suppliers‘ Innovation Performance

Abstract

This study contributes to the innovation management literature by clarifying suppliers' innovation and performance antecedents in supply chains. Suppliers are highly important as they trigger innovations in supply chains. Suppliers have to cope with upstream directives which manufactures impose on them to improve the coordination of several suppliers' innovative modules to the product concept. This study of 193 IT suppliers finds that suppliers increasingly encounter upstream directives in high uncertainty environments. Upstream directives promote radical innovation and business performance, yet negatively affect incremental innovations. Suppliers can cope with upstream directives through planning approaches. The deliberate planning approach is found complementary to upstream directives. Uncertainty moderates the effectiveness of the emergent planning approach: it increases a supplier's performance under high uncertainty while reducing it under low uncertainty.

Key Words: Supply Chain Management, Innovation, Planning

1 Introduction

Firms in many of the most innovative industries, such as automotive and IT, have an established supply chain management (SCM) that coordinates up- and downstream relationships with suppliers and customers in order to increase value at less cost to the supply chain as a whole (Christopher, 1998; Jüttner, Christopher, & Baker, 2007). Supply chain partners are increasingly interested in innovation investment (Gilbert & Cvsa, 2003) and have extended their new product development (npd) activities across organizational boundaries (Quinn, 2000; Wagner & Hoegl, 2006). Past research indicates that innovation does not originate from the seller or manufacturer alone (Roy, Sivakumar, & Wilkinson, 2004). The involvement of upstream partners in innovation generation is attributed as a source of sustainable competitive advantage of manufacturers (Dyer & Singh, 1998; Johnson, 1999; Wagner et al., 2006). A cross-national study of 29 npd projects showed that the Japanese advantage in concept-to-market time can be attributed to supplier involvement in the npd process (Clark, 1989). Burt (1989) stresses that the potential impact of suppliers on quality and cost of new products cannot be overemphasized. Firms who are not self sufficient with regard to their resources (Pfeffer, 1982; Sheppard, 1995) can improve innovation processes up- and downstream in the supply chain by utilizing the specific expertise of supply chain partners. The inclusion of partners across the value-stages permits appropriate and timely feedback to the product design that allows the innovation process to increase both in speed and market success. Even though there is increasing evidence that the integration of suppliers in innovation processes is important, firms have to be aware that not all such efforts are successful (Wagner et al., 2006).

Innovation activities of suppliers particularly are confronted with manufactures' precepts related to product and process objectives, frame specifications, and target prices. These can range from more informal and flexible suggestions to tight and formal precepts on upstream suppliers. We refer to the latter as upstream directives. Upstream directives results from the manufacturers' need to manage the integration of numerous components from different suppliers to a coherent innovation. Upstream directives manage the resource interface and interdependency with suppliers (Pfeffer, 1982; Sheppard, 1995) and help to coordinate the multi-supplier innovation process. The increased coordination through upstream directives facilitates the integration of innovations delivered by several firms into a manufacturer's product concept. The innovation then provides benefits along the entire supply chain (Gilbert et al., 2003).

The product development in the supply chain can be improved by increased information transfer across supply chain partners. An important class of information relates to customer expectations. The upstream transfer of customer expectations increases the market success of innovation. Manufactures can include information about customer expectations in upstream directives. The innovations suppliers then developed aide the fulfilment of customer expectations and thus innovation performance. Upstream directives further force suppliers to accept responsibility for development, design, integration, manufacture, qualification, delivery, target performance and quality of their particular systems, subsystems or airframe items according to the targets (Wagner et al., 2006). However, when suppliers perceive upstream directives it can hinder their unleashed idea generation, expertise, and experimentation activities. This can be dangerous as firms in the supply chain need more than mere innovation, they need qualitatively good innovations, which rely on encouraged members in the innovation supply chain for their generation (Desbarats, 1999). However, prior research has neglected the existence and the effects of upstream directives on suppliers.

We argue that, when pursuing innovation across the supply chain, suppliers have to cope with upstream directives. Suppliers need knowledge of how to manage their innovation process when confronted with upstream directives.

Planning can help suppliers manage this contingency. Firm level planning processes were the focus of extensive debate in the eighties. From about ten schools of though (Mintzberg & Lampel, 1999), two schools stand out and oppose each other (Brews & Hunt, 1999): the deliberate planning school and the emergent planning school. The deliberate planning approach is "rational" (Idenburg, 1993) and includes in-depth analysis of markets and implementation alternatives as means (Cohen & Cyert, 1973; Fredrickson & Mitchell, 1984; Guerard, Bean, & Stone, 1990). In contrast, emergent planning specifies simultaneous or intertwined means and ends (Fredrickson & Iaquinto, 1989; Fredrickson et al., 1984). The firm level planning processes also inspired research on innovation through management of npd projects (Eisenhardt & Tabrizi, 1995). Past research on firm level planning and of npd project management (Fredrickson et al., 1984) shows mixed results on the relationship between planning and performance under high levels of uncertainty (Pearce, Freeman, & Robinson, 1987a).

Although past research indicates that a) deliberate and emergent planning processes are important for firms' success, b) supplier relationships have received great attention in the past research, and c) the importance of innovation across the supply chain has been stressed (Gilbert et al., 2003; Roy et al., 2004; Wagner et al., 2006), we find that performance effects of planning and upstream directives in supply chains have not been examined.

This research aims to explore the effects of upstream directives on suppliers' innovation and performance. We argue that in an environment of upstream directives, set by manufacturers, suppliers have at least two planning opportunities. Suppliers can integrate the externally set upstream directives into their deliberate planning to achieve a coherent innovation management. Alternatively, suppliers can find the upstream directives too limiting for their innovation processes and compensate the discouraging elements of upstream directives by using emergent planning processes. This study achieves new insights on these relationships from a survey of 193 suppliers in the IT industry. Since many firms in this industry face high uncertainty, our study highlights effects under both high and low uncertainty.

Our study delivers several new insights on a topic that has previously been neglected. Major findings relate to high uncertainty. Results show that suppliers increasingly face upstream directives under high uncertainty. We find that emergent planning increases performance in a high uncertainty environment and reduces performance in a low uncertainty environment. We further find that deliberate planning contributes to performance when upstream directives are set. Finally, upstream directives directly promote radical innovation.

2 Theory

2.1 Innovation in the Supply Chain

Processes in the supply chain include those involved in producing a final product or service by suppliers and delivering it to manufactures, distributors, and consumers. The supply chain aims for increased value at less cost to all participants (Christopher, 1998; Jüttner et al., 2007). Innovation generation in a supply chain involves changes in product, process, or service (Makhija, 2003; Roy et al., 2004). Within the idea of supply chain management, consumer expectations define the activities of design, re-design, and innovation along the supply chain (Christopher, 1998). Recent research shows that innovation in supply chains is increasingly based upon suppliers' activities (Huemer, 2006). Innovation performance in the supply chain hinges on the supplier's resources and capabilities as well as the relationship and coordination between firms (Wagner et al., 2006). With the integration of suppliers into the innovation process, innovation improves through sharing of from technological expertise and timeliness of information. Innovations are usually defined according to their degree of novelty (Dewar & Dutton, 1986; Ettlie, Bridges, & O'Keefe, 1984; Shenhar & Dvir, 1996). Upstream manufacturing sections of the supply chain can generate both incremental and radical innovations. Incremental innovations include less fundamental change such as quicker delivery periods, reduction of material cost, changes in the material thickness, updated versions of processes and products, or extensions of current products (Dewar et al., 1986; Ettlie et al., 1984). Radical innovations are the development and application of new ideas and novel technologies resulting in novel products, processes, and services (Dewar et al., 1986).

2.2 Upstream Directives

Innovation in the supply chain strongly advances through information exchange across the new product development stages and well coordinated contributions across firms to develop superior novel products and to reduce concept-to-market time (Clark, 1989). Manufacturers are generally closer to downstream partners and consumers than suppliers and therefore conceptualize product designs. Even though suppliers have expertise and give inspiration for new technology, most often a manufacturer's product concept guides the formulation and selection of components delivered by suppliers. When bridging innovation components across organizational boundaries, manufacturers have to synchronize the inputs from different suppliers.

The definition and coordination of novel components delivered to the product design is fraught with uncertainty (Fynes, de Búrca, & Marshall, 2004; Miller, 1987; van der Vorst & Beulens, 2002; Wilding, 1998). Organizational thinking distinguishes between certain, predictable, well-understood, and routine or unpredictable, intractable, and uncertain situations (Burns & Stalker, 1961; Galbraith, 1973; Scott, 1992). Uncertainty is the result of the inability to predict future outcomes and "the difference between the amount of information required to complete a task and the amount of information already possessed" (Galbraith, 1977; p. 5). In supply chains, uncertainty propagates throughout the network and may lead to inefficient processing and non-value adding activities (van der Vorst et al., 2002). Within supply chains, in particular in the automotive and IT industry, innovation generation is technology laden. Innovations frequently rely on the implementation of emerging and new technologies which are not fully known and tested and are thus confronted with uncertainty (Fynes et al., 2004). New technologies account for rapid change in firms; they further are expected to benefit from supply chain management (Slater & Narver, 1994). As firms strive to master new features, tools, devices, or techniques they are confronted with changing technology (Galbraith, 1977). Manufactures encounter uncertainty and dependency when they coordinate technological advancements developed by various suppliers. Therefore, manufacturers strive to control suppliers upstream in their supply chain (Pil & Holweg, 2006).

Resource-dependence theory views governance across firms as a strategic response to uncertainty and the dependency on external resources (Pfeffer, 1982; Pfeffer & Salancik, 1978). Manufacturers have established formal or semi-formal links to their suppliers to better predict and control resource flows and therefore manage self-sufficiency (Stock, 2006). When improving upstream innovation and seamless fit, manufacturers exert precepts such as objectives, orders, and guidelines related to technology, design, interfaces, and product logics to their suppliers. We refer to tight and formal precepts as upstream directives. The upstream innovation process includes pre-contract meetings (Dwyer, Schurr, & Oh, 1987) in which directives are set. Manufacturers translate the latent or virulent expectations of consumers into a product concept that is decomposed and integrated into upstream directives. Through the definition and contracting of upstream directives manufacturers coordinate each supplier's and sub-supplier's contributions to the innovation more easily and re-integrate information from downstream supply chains. Further, components by suppliers can be organized according to and around components developed by manufacturers. The corridors or targets set up through upstream directives help to line up and synchronize the technological developments from several suppliers. Summing up, upstream directives regarding innovation particularly allow technological uncertainty to be handled and help to coordinate the multi-supplier innovation process that requires innovative inputs of several suppliers to the product design.

Hypothesis 1: Suppliers are subject to stronger upstream directives under high uncertainty than under low uncertainty.

2.3 Innovation Impact of Upstream Directives

Upstream directives can restrict and narrow a supplier in his pursuit of technological breakthroughs thus limiting the exploitation of their technological development expertise and in turn reducing the likelihood of achieving radical innovation. The perception of upstream directives can also generate a climate of domination and distract suppliers from their creative processes. Creativity has been described as the cornerstone of organizational change and as a key to organizational effectiveness (Amabile, Conti, Coon, Lazenby, & Herron, 1996; Woodmang, Sawyer, & Griffin, 1993). Suppliers that obey upstream directives also have to invest time and resources to closely follow the precepts that deviate from the cornerstone of innovation activities.

Despite those disadvantages for the generation of innovations, upstream directives might give direction to suppliers' technology development. When following upstream directives suppliers can bundle their strength and straightforwardly integrate their components in manufacturers' products designs reducing unnecessary sidetracking and cost. Upstream directives increase the coordination of tasks and innovation modules across several suppliers. As such innovation targets can be dissected into modules and gain from coordinated expertise of different sources. Upstream directives allow a supplier's employees to develop new ideas from associations based on former stages or ideas. Upstream directives can transfer information about customers' expectations. This enhanced information augments the likelihood that the innovation is a success in the market. Innovations by suppliers that address customer expectations more strongly will be more highly valued by manufacturers. As such, suppliers that encounter and accept strong upstream directives will face lower demand uncertainty.

The increased coordination and concentration of resources might be particularly important when firms target radical innovations as their high level of technical uncertainty environments force suppliers and manufacturers to use upstream directives as instruments to manage their interdependency (Pfeffer, 1982). Radical innovations are confronted with high ambiguity and business inexperience (McDermott & O'Connor, 2002). Harmonized tasks and procedures, planned suitably in advance and within the whole supply chain, will increase the achievement of radical innovations. This also allows suppliers to focus their resource allocation. By specifying targets to suppliers as well as defining the design and functionalities of innovation modules of several suppliers and the modules’ dependency, manufacturers can coordinate parallel and sequential efforts towards radical innovations across people and suppliers. This helps to speed up the innovation process and to increase success of the suppliers’ novel products, services, and processes. Improved guidance within the different stages of the innovation process promotes a supplier’s buyer orientation and helps to meet producers’ targets on radical innovations.

The fundamental change associated with radical innovations requires a large amount of resources to develop, re-adjust, test, and launch the innovation. Manufacturers who search novel components for their product concept will tend to buy radical innovations from suppliers who follow their upstream directives. Radical innovations will then face less demand uncertainty. Increased likelihood of market success will also motivate suppliers to undertake further investments in technological development necessary for the generation of radical novelty.

Even though at first glance upstream directives might generate a climate of domination and limit a supplier’s creativity and technological enhancements, we argue that upstream directives trigger radical innovations as the selection and organization of resources is more focused and the chance of novel results being sold to manufacturers and appreciated by consumers is greater.

Hypothesis 2: Under high uncertainty, stronger upstream directives increase suppliers’ radical innovations.

2.4 Planning Schools

Suppliers striving to increase innovations and performance in an environment of upstream directives might benefit from an appropriate choice of planning approach. Planning procedures and the planning process at firm level have been the focus of many studies in the eighties (Fredrickson, 1983). As planning relates to project management in the supply chain and to product development management in npd-projects, we can also consult empirical results of research into project planning styles (Brown & Eisenhardt, 1995; Lewis, Welsch, Dehler, & Green, 2002). We find two different schools of thought that stand out and oppose each other: the deliberate and the emergent planning school (Brews et al., 1999; Mintzberg et al., 1999). While the labels might differ (i. e. deliberate, formal, or rational school (Ansoff,

1991) versus the emergent, flexible, jazz (Kamoche & Cinha, 2001), or incremental school), their ideas are essentially the same. As we assume that externally set upstream directives adhere to firm or business level planning, we primarily follow the literature on firm level planning.

Deliberate firm and business level planning includes the in-depth analysis of markets and implementation alternatives as means (Cohen et al., 1973; Fredrickson et al., 1984; Guerard et al., 1990). In contrast, the emergent planning school neither concentrates on formal analysis nor explicit objectives; instead it builds upon informal structures and a flexible approach that "muddles through by trail and error" (Idenburg, 1993; p. 136). Emergent planning specifies both means and ends (Fredrickson et al., 1989; Fredrickson et al., 1984) and promotes creativity, flexibility and employees' improvisation (Moorman & Miner, 1998a). Both approaches will have specific performance and innovation effects relevant to suppliers.

Deliberate Approach

The flexibility of the emergent approach can contribute to competitive success (Sawhney, 2006). Yet it has been argued that it cannot be utilized to take advantage of planning gains and cost targets. Ansoff (1991; 1994), a strong proponent of the planning school presumes that a rational and deliberate strategy planning process is necessary to achieve performance. Formality in planning was found to have positive relations to sales growth, stock prices, earnings per share, profits, and R&D expenditures in the chemical industry (Herold, 1972). It also increases financial success of banks (Wood & Laforge, 1979) and financial performance of manufacturing firms (Pearce, Robbins, & Robinson, 1987b). A meta-study of 14 empirical papers concluded that deliberate planning contributes to firms' growth and profitability (Miller & Cardinal, 1994). Formal analysis, the setting of objectives, and centralized authority improves implementation and keeps the project on the right path (Wheelwright & Clark, 1992). Deliberate planning links the sub-targets of projects and innovation processes to wider organizational goals (Burns et al., 1961; Lewis et al., 2002). Similarly, the deliberate approach to npd-projects prescribes disciplined planning as a way to speed up project efforts (Zirger & Modesto, 1990) and to squeeze product development time (Gupta & Wilemon, 1990). The planned style of npd projects was similarly identified to enhance project efficiency, its principle objective (Shenhar et al., 1996). Managers seek to ensure that teams have sufficient support and remain on track. Formality was found to increase the predictability of new product or innovation development as extended planning improves the understanding of the development process and therefore its rationalization (Eisenhardt et al., 1995). The schedule- and budget-based milestones of a formal project management approach keep teams aware of their scarce resources (Lewis et al., 2002).

Yet, several studies do not confirm the advantages of deliberate planning, e. g. the meta study by Pearce et al. (1987a) on 18 empirical studies of the planning-performance link highlights inconsistencies of findings and weak results of hard, deliberate planning performance relationships. The studies on planning processes by Fredrickson (1983; 1984) specifically indicate that deliberate planning only contributes to performance in stable environments where people can plan and organize their activities and rely on routines and bureaucracy (Galbraith, 1973) and achieve benefits from the implementation of deliberate planning tools (Fredrickson, 1983; 1984). While some degree of freedom and flexibility seems to be an essential ingredient to the relative speed and success, participants are also free to wander off-strategy, pursue design options that exceed the firm's competencies or resources, engage in endless partisan debate and run behind schedule or over budget (Bonner, Ruekert, & Walker, 2002). This in turn might reduce performance under high uncertainty.

Even though the positive effects of deliberate planning are only widely accepted for stable environments, we argue that suppliers might take advantage of deliberate planning under high uncertainty. The goal orientation, environmental analysis, and improved forecast of the deliberate approach will contribute to fulfilling the expectations of manufacturers and in turn the success of suppliers. For supply chain innovation through decreasing compatibility risks, harmonization of defined targets for sub-tasks, and correspondence to wider internal and external goals, deliberate planning is congruent with manufactures' upstream directives and in turn increases performance of suppliers. High levels of uncertainty will increasingly force suppliers to ensure that directives are met as growing uncertainty of technology is associated with high risks of development failure and incompatibility. Extending Hippel's (1990) assumptions to the supply chain, upstream directives force suppliers to focus on their task. The output will comprise the intended project output when tasks and their interrelation pre-defined. Eisenhardt (1995) showed that planning can reduce misunderstandings and time-consuming coordination problems because participants can refer to the plan for common language and understanding. Increased planning improves the forecast of opportunities of innovation and thus the resource allocation and the integration of manufacturers' upstream directives. Suppliers will be able to focus their resources and follow a coordinated approach and implement manufacturers' upstream directives in their innovation process. When suppliers use deliberate planning, upstream directives will complement the implementation of analytically derived strategies and the attainment of objectives. Deliberate planning will advance the achievement of specifications set by manufacturers and thus reduce the risk of demand uncertainty related to innovations. Deliberate planning will additionally expand innovation success through improved coordination of scarce resources within and across suppliers.

Hypothesis 3: The positive relationship between upstream directives and performance under high uncertainty is mediated by the deliberate planning approach: Following a deliberate planning will positively channel and exploit the performance enhancing focus provided by directives.

In contrast to radial innovations, incremental innovations include smaller changes of components delivered to the manufactures. These small changes might force manufactures to adjust their coordination pattern and to initiate alterations in components or modules from other suppliers. Changes introduced to task specifications after work is under way are costly as they diminish the value prior achievements and/or may degrade the solution ultimately arrived at. Project participants often strive to rescue the work already done by making suboptimal adaptations (von Hippel, 1990). Regardless of whether or not suppliers apply deliberate or emergent planning, the incremental innovations that capture small changes of components will cause further modifications of the manufacturer's product concept. This leads to additional adjustment costs that most likely will not be compensated by the additional value for the customer. Thus, manufacturers in the supply chain will value incremental innovation less and exclude those issues in their up-stream directives. Incremental changes do not pay off the costs associated with their planning. As such, deliberate planning will regularly leave out issues of incremental innovation. Therefore the indirect effect by directives and the direct effect through deliberate planning will negatively influence incremental innovation.

Hypothesis 4a: Upstream directives and the deliberate planning approach will have a negative effect on incremental innovations under high uncertainty.
Hypothesis 4b: Upstream directives and the deliberate planning approach will have a negative effect on incremental innovations under low uncertainty.

Emergent Approach

The importance of flexibility can be traced back to Burns and Stalker (1961). An emergent approach to planning allows firms to be more experimental, flexible and even improvisational (Scott, 1992). Sawhey (2006) assumes that high levels of flexibility are positively related to achieving a competitive advantage. When following the emergent planning approach, new ideas and decisions can be carried out quickly without trying to integrate them into an overall strategy (Fredrickson, 1983). Barrett (1998) explained that, whether a team is engaged in product development or not, a fluid and spontaneous approach to management sparks creativity. Ettlie et al. (1984) find that more aggressive strategies, informal approaches and unique structural arrangements are more beneficial towards achieving novel solutions than traditional structural arrangements, formal approaches, and market orientated strategies. Projects teams with less formal shackles discover new opportunities and challenges as managers encourage members to monitor their evolving understanding, gather information from diverse sources, and/or experiment with new designs as needed (Lewis, 2002).

Rooted in the point of view that product development is inherently ambiguous, Moorman and Miner (1998b) note that the primary goal of the emergent approach is to facilitate improvisation. The emergent approach is seen as particularly favourable under complexity and in unstable environments (Lindsay & Rue, 1980). Under high uncertainty deliberate planning is associated with strong effort and failure: high uncertainty brings high risk, which ultimately translates to a highly unpredictable process. This context suggests that the development process needs to allow flexibility during project execution to allow suppliers to adjust to emerging needs of the project and to take advantage of increasing knowledge about the nature of the innovation and also for mistakes or unexpected outcomes (Perks, 2005). Under high uncertainty the increased autonomy and new idea generation will be advantageous for achieving performance by encouraging employees to seek information from multiple sources and experiment with new design in projects (Lewis, 2002). It has been stressed that npd-projects under unstable conditions require that managers are able to apply improvisation, co-adaptation, experimentation, and time-pacing to improve performance (Macintosh & Maclean, 1999). The imposition of formal control mechanisms by upper manager can have detrimental effects on project performance, associated with delays, cost overruns, and lower product performance. Studies in the npd-field explicitly suggest that project uncertainty moderates the relationship between project management and performance (Eisenhardt & Brown, 1998; Moorman et al., 1998a; Shenhar et al., 1996). In organizational design, authors describe that conditions of low uncertainty are best suited to bureaucratic or mechanistic organizations, while more flexible, adaptive, and organic organizations are appropriate in conditions of high uncertainty (Burns et al., 1961; Galbraith, 1973; Lawrence & Lorch, 1967). Assuming that these contingencies have a similar effect in supply chains, we argue that suppliers can benefit from emergent planning only in high uncertainty environments. The greater openness of the planning unfreezes experimentation and creativity and will increase the novelty of components received by manufacturers in a high uncertainty context.

Hypothesis 5: Uncertainty moderates the relationship between the emergent approach and performance: Under low uncertainty, the emergent approach negatively affects performance; under high uncertainty, the emergent approach positively affects performance.

Nevertheless, it is not clear if the advances of the emergent approach under high uncertainty hold in the supplier-buyer relationship in which a supplier's creativity can clash with a manufacturer's formally set upstream directives. Gilson et al. (2005) find that consumers prefer services that use standard procedures. By following upstream directives, suppliers will face a reduced risk of complicated planning processes that may lead deliberate planning under high uncertainty in wrong directions. Nevertheless, the translation of upstream directives into suppliers' internal emergent planning is problematic. Firms which generally do not implement deliberate planning will experience resistance from participants when trying to follow and integrate upstream directives that have many formal elements. Suppliers following emergent planning procedures will find it difficult to integrate the targets and the content of the directives in their emergent processes. Decentralized and participative decision processes, a minimum reliance on formal rules and procedures oppose the implementation of formal directives. The incompatibility of formalization and emergence will negatively affect the innovation outcome of suppliers when confronted with directives. As such we expect that the positive relationship between the emergent approach and radical innovation is likely to weaken when suppliers perceive high levels of up-front directives.

Hypothesis 6: The positive relationship between the emergent approach and radical innovation under high uncertainty is mediated by upstream directives.

3 Methodology

3.1 Sample and data collection

The population for the survey consists of supply companies operating in the German IT industry. We selected this particular industry for several reasons: it is a fast moving industry in which firms have to be continuously innovative; product life cycles in the IT industry are becoming shorter and firms have to provide incremental or radical innovations in decreasing intervals to sustain their competitive advantage; the use of supply chain management is common in the IT industry, so it is predestined for our research.

Prior to the data collection in 2007, we discussed and readjusted our scales on planning and directives in a workshop with 12 academics and 7 supply chain managers. Afterwards, the items were used in a pilot study of 17 executives of small and medium sized suppliers in the IT industry. These steps induced changes of our scale. We then presented our questionnaire to middle managers in the R&D field. We restricted our mailing to small and medium sized IT suppliers developing Hard- and Software. Service firms in the IT industry were included. After we received responses from R&D middle managers, we asked the respondents about second informants in their firms knowledgeable of the firms' performance, typically senior executives. Not every firm answered to our second request. From our initial 241 responses we could only use 193. Those firms had an average sales volume of 39.545.798 Euro.

3.2 Measures

Upstream directives

Manufacturers have to set upstream directives such as targets, frame specification, objectives and guidelines to ensure the fit of the supplier's input to the final product. Therefore we were interested in how much the supplier's scope of action would be limited by the manufacturer's upstream directives. Due to the lack of research on upstream directives in the supply chain management we created new items in the expert workshop. We pre-tested these items in a pilot study to check their content validity and terminology. The final 3 items refer to the amount of determination of a) the design, b) the technical functions and c) the whole concept of the product.

Planning

We refer to deliberate and emergent planning as distinctive constructs and base our measurement on the scale by Bouncken, Koch, and Teichert (2007). As a result of the workshop we readjusted our questions on the acquisition of information, the processing of information, and the evaluation of information and decision making processes.

According to these information processes the deliberate approach is associated with in-depth research of market chances and risks, finding means-end relations and pursuing the investigation of different options. Therefore we measured deliberate planning with the following four items: a) research of market opportunities, b) analysis of rationales of market growth, c) development of different actions, and d) evaluation of actions taken.

In contrast, the emergent approach builds upon intuition and trail and error. We used a) actions and market opportunities are not planned in advance, b) intuition plays an important role, and c) planning emerges by trial and error as measures for emergent planning.

The items on upstream directives and both planning approaches obtained after the pilot study were subjected to a principal component factor analysis with varimax rotation to assess their convergence in and divergence between scales for the current study. The rotated factor loadings show that upstream directives and the two planning strategies loaded on different factors and therefore represent three stable factors. The factors were retained if their values exceeded one. All together the factors explained 68.5 percent of variance in the data. All communalities exceeded 0.6, which indicates that the three factors capture a significant portion of variance in the items.

Incremental and radical innovation

We refer to the prevailing two different categories of innovation: radical vs. incremental innovation (Dewar et al., 1986). In order to measure how strongly a firm achieves incremental and radical innovations, we asked about the percentage of incremental and radical innovation among all products offered by the firm. By asking respondents in the firms, we draw on the majority of research that takes a firm’s perspective when regarding innovations (Garcia & Calantone, 2002). Herein managers are seen as main informants on a firm’s product innovations because they are partly involved in several innovation processes and consequently are able to compare the product innovation across different units.

Following Kimberly and Evanisko (1981), who defines innovation as a broad concept including subtypes, we differentiate between different objects. We start with the a) technological innovation. Garcia and Calatone (2002) note that technological innovation largely captures the essence of innovation. Innovation also comprises inventions combined with the market introduction. The invention has to b) add value in the perception of customers. A further value can be rooted in c) advanced performance or in a new way of solving the consumers problems (Akgün, Lynn, & Byrne, 2006).

Uncertainty

We adapted our measure of uncertainty from Lewis et al. (2002), who measured different classes of uncertainty about technology, market, and employee capabilities. Our measure uses four items of technological uncertainty: a) technological feasibility, b) functionality of products, c) technological qualification of the area, and d) employees' familiarity with the technology.

Performance

A firm's performance is multidimensional in nature and scholars have expressed the need to use multiple measures (Venkatraman & Ramanujan, 1986). For that reason our performance measure focuses on subjective and objective data.

For the subjective performance data we drew on the scale by Deshpandé, Farley and Webester (1992). The senior executives were asked to evaluate the firms' performance for the last three years in comparison to their principal competitors' performance with regard to a) sales volume, b) market share, c) return on investment and d) the whole competitive position. Additionally the executives were asked to give precise quantitative, objective data measured as a) sales, b) growth in sales and c) return on investment. Unfortunately the executives were more open to questions on subjective than specific or objective data. For that reason we tested the model using subjective data of organisational performance derived from the senior executives. Many researchers have found a high correlation between subjective and objective data (Dess & Robinson, 1984; Venkatraman et al., 1986).

4 Results

4.1 Measurement Model

Before we tested our hypotheses, it was necessary to evaluate the measurements of our constructs. The measurement analysis was conducted by confirmatory factor analysis. The data were subjected to a testing process including a series of reliability and validity assessments. Descriptive statistics and zero-order correlations among the variables are summarized in table 1. All correlations between the constructs are below 0.4, so there is no apparent evidence for multi-collinearity. Furthermore we generated the variance inflation factor (VIF). None of the constructs exceeded 1.5, which is well below the accepted maximum of 10 (Freund & Litell, 1991).

Table 1: Descriptive Statistics and bivariate correlation matrix

Variable	Mean	S.D.	1	2	3	4	5	6	7
Deliberate planning	3.66	0.84	1						
Emergent planning	2.95	0.89	-0.183*	1					
Incremental innovation	3.02	1.09	-0.144	-0.151	1				
Radical innovation	3.14	1.11	0.175*	0.095	0.044	1			
Upstream directives	2.88	0.95	0.298*	0.142	-0.71	0.208**	1		
Uncertainty	3.39	0.94	0.219	0.043	-0.007	0.049	0.071	1	
Performance	3.38	0.89	0.059	0.183*	-0.147	0.226**	0.315**	0.135	1

**p < 0.01; *p < 0.5

We evaluated our measurement model using several overall goodness-of-fit indices. In general the overall goodness-of-fit indices are divided in three different groups: absolute measures, parsimony measures and incremental measures (Hair, Black, Babin, Anderson, & Tatham, 2006). Absolute fit indices present the most basic evaluation of how well the model specified by the researcher reproduces the observed data (Kenny, Kashy, & Bolger, 1998). Parsimony fit indices consider the fit of the model specified by the researcher relative to its complexity. Incremental measures provide the assessment of how well a specified model fits relative to the alternative baseline model. The baseline model usually refers to a null model, which assumes that all observed variables in the model are uncorrelated (Hair et al., 2006). We use RMSEA as an index for absolute fit measures. According to the rule of thumb, below

0.08 is an acceptable (Browne & Cudeck, 1993) and 0.05 a good (Byrne, 2001) threshold for RMSEA. The normed χ^2 as index for parsimony fit measures is defined as the ratio of χ^2 to the degrees of freedom. When χ^2 is less than three times the degrees of freedom a good fit exits (Carmines & McIver, 1981). Finally we use CFI as index for incremental fit measure. CFI is the improved version of the NFI (Bentler & Bonett, 1980a), one of the original incremental fit measures. It additionally includes the model complexity (Bentler & Weeks, 1980b) and should exceed the threshold of 0.9 (Bentler et al., 1980a; Byrne, 2001). Altogether the fit measures indicate an excellent overall model fit for our measurement model with RSMEA = 0.032; Normed χ^2 = 1.2 and CFI = 0.973 (see table 2).

Table 2: Overall Goodness of Fit

RMSEA	**CFI**	**NPAR**	**CMIN**	**DF**	**P**	**CMIN/DF**
0.032	0.973	95	274.813	229	0.021	1.2

We rigorously checked discriminant and convergent validity. Discriminant validity covers the extent to which a construct in a model is truly distinct from other construct in that model. It can be tested using procedures outlined by Fornell and Larcker (1981). First, we calculated the Fornell-Larcker-Ratio. It assumes that the average variance extracted of one construct should be greater than the highest squared intercorrelation of that constructs with any other construct in the model. The Fornell-Larcker-Ratio indicates satisfactory discriminant validity by not exceeding the critical value of 1 (Fornell et al., 1981). We then conducted a χ^2-difference test, which is another way of testing discriminate validity. This test is based upon the comparison of two measurement models - one model where the correlation between two constructs is specified as equal to 1 and one model where it is not. That way we test if the items of the two constructs could be combined to one construct. To achieve discriminate validity the fit of the two construct model has to be better than the fit of the one construct model. For our model good discriminant validity is established with every Fornell-Larcker-Ratio not exceeding the critical value of 1 and all χ^2-difference values of the two construct model being significant better than the one construct model.

Convergent validity assumes that the indicators of a specific construct should share a high proportion of variance in common (Hair et al., 2006). There are different ways to estimate convergent validity among items measures. Significant factor loadings higher than 0.4 indicate that the items converge on one common point. Another indicator for convergent validity is the average variance extracted by each factor in the model, which should be higher than 0.5 (Fornell et al., 1981). Also reliability can be used to assess convergent validity. Two measures of reliability are available: Cronbach's Alpha and composite reliability. Both indicate a good reliability and therefore convergent validity when exceeding the critical value of 0.7, with each indicator reliability above 0.5 (Fornell et al., 1981; Nunnally, 1994). We find all standardized factor loadings above 0.4; all respective t-values are above 2.0, indicating that none of the items are to be excluded from the model. Furthermore the average variance extracted for all scales exceeded the threshold of 0.5. Good reliability is established by reaching the recommended value of 0.7 for Cronbach's Alpha and composite reliability. The majority of the items display satisfactory indicator reliability. Consequently our measurement model provides good convergent validity (see table 3).

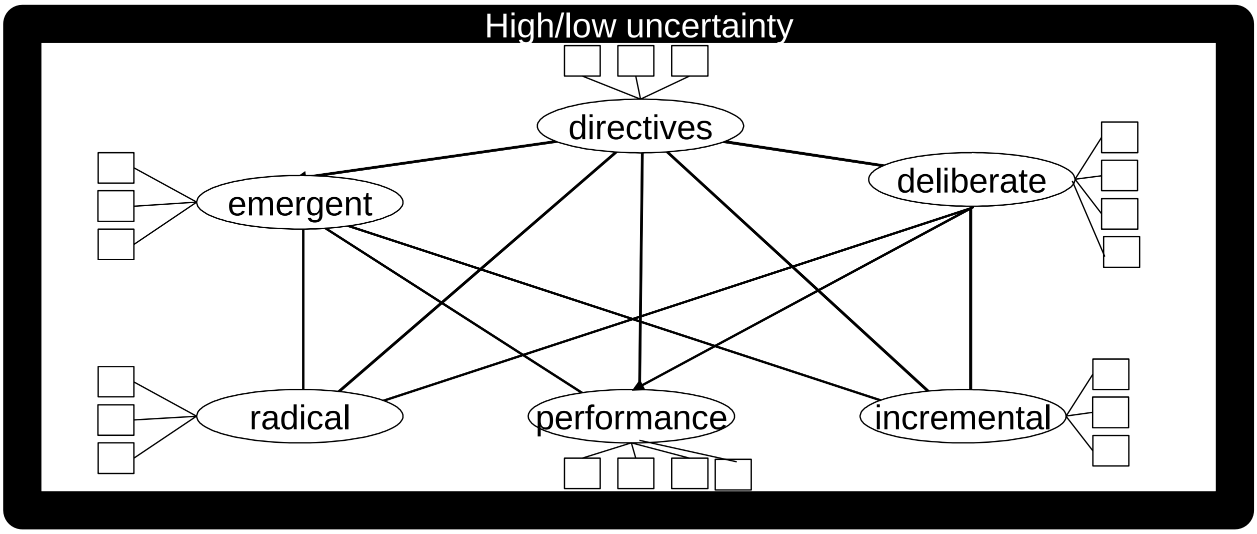
Table 3: Convergent and Discriminant Validity

Construct	**Item**	**Standard. factor loadings**	**Indicator reliability**	**α**	**Composite reliability**	**AVE**	**Fornell-Larcker**

		> 0.4	> 0.5	> 0.7	> 0.6	> 0.5	< 1
Upstream Directives	Customer determines whole concept of product characteristic in detail	0.704	0.495	0.784	0.78	0.55	0.87
	Customer determines design elements in detail	0.868	0.753				
	Customer determines technical functions in detail	0.676	0.456				
Deliberate	Research of market opportunities	0.703	0.494	0.850	0.84	0.57	0.83
	Analysis of rationales of market growth	0.676	0.451				
	Development of different options	0.783	0.613				
	Evaluation of actions taken	0.848	0.718				
Emergent	Actions and market opportunities are not planned in advance	0.650	0.422	0.707	0.80	0.59	0.81
	Intuition	0.522	0.272				
	Trail and error	0.816	0.666				
Incremental Innovation	Technology	0.832	0.693	0.855	0.77	0.52	0.91
	Performance	0.831	0.690				
	Customer value	0.794	0.631				
Radical Innovation	Technology	0.878	0.770	0.828	0.76	0.53	0.90
	Performance	0.774	0.600				
	Customer Value	0.703	0.494				
Techno. Uncertainty	Employees' familiarity with the technology	0.750	0.563	0.840	0.78	0.55	0.87
	Technological feasibility	0.828	0.686				
	Functionality of products	0.753	0.568				
	Technological qualification	0.690	0.477				
Performance	Higher sales volume than competitors	0.765	0.585	0.861	0.86	0.60	0.79
	Higher market share than competitors	0.782	0.611				
	Higher return on investment than competitors	0.692	0.479				
	Better competitive position than competitors	0.815	0.665				

4.2 Results

Figure 1 presents the hypothesized path model to examine our hypotheses. Radical and incremental innovation and performance are explained by emergent and deliberate planning as well as upstream directives.



To be able to test both mediation hypotheses (hypothesis 3 and 6) we calculated correlation between the planning styles and upstream directives. Following this procedure we are able to deal with upstream directives as an independent variable (hypothesis 3) and as a mediator (hypothesis 6) at the same time. We used factor scores of all constructs to verify the hypothesized relationships. We estimated the parameters of the path model with AMOS (Version 7) to test all hypotheses except hypothesis 1. The path coefficient presents the relation between the independent and the dependent constructs. Furthermore to test the hypothesized relationship under low and high uncertainty conditions, we conducted a median split of our data set in order to use the multi-group approach of AMOS. Therefore we checked measurement invariance and found both models to be invariant.

Hypothesis 1 was verified by conducting a t-test for two independent samples. We found that the high uncertainty group experiences more upstream directives than the low uncertainty group. The mean difference was significant on the 0.1%-level (t-value -3.848). Thus hypothesis 1 can be confirmed: Suppliers encounter more strong upstream directives under high uncertainty than under low uncertainty. Hypothesis 2, stating a positive effect of upstream directives on radical innovations under high uncertainty is supported. We found a significant positive relationship (path coefficient) between the two constructs. Thus we find that under high technical uncertainty, upstream directives increase radical innovations of suppliers (0.224, t-value = 2.009). The hypothesized mediator effect of deliberate planning in hypothesis 3 was tested following the 4-step procedure outlined by Kenny and Baron (1986). First we have to test if the independent variable is correlated with the dependent variable to establish an initial effect without the mediator. Thus we have to estimate a model without the planning. Second, we have to check if the independent variable is correlated with the mediator. Third, the mediator needs to affect the dependent variable. And fourth the initial effect should be reduced and/or become non-significant in presence of the mediator. We found a positive path significant on the 10% level between upstream directives and performance calculating our model without the mediator (0.183, t-value = 1.736). Further we found a positive significant correlation between upstream directives and deliberate planning (r=0.368, significant on the 10% level) as well as a positive significant path between deliberate planning and performance (0.208, t-value = 1.856). The initial effect between upstream directives and performance was reduced to a non-significant value of 0.09 (t-value = 0.820). Overall hypothesis 3 can be confirmed: The positive relationship between the upstream directives and performance under high uncertainty is mediated by deliberate planning approach: Following a deliberate planning will positively channel and exploit the performance enhancing focus provided by directives. An overview of the results is given in table 4.

Table 4: Results of the Hypotheses Testing I

Path	**Hypo-thesis**	**Standar-dized Estimate**	**t-value**	**Confirmation (✓) / Rejection (x)**
Suppliers are subject to stronger upstream directives under high uncertainty than under low uncertainty. (t-test)	1	***	-3.848	✓
Measurement invariance across low and high uncertainty (pre-condition)		df = 14; χ^2 = 17.654 p = 223		
Under high uncertainty, stronger upstream directives increase suppliers' radical innovations: up-stream directives → radical innovations	2	0.224*****	2.009	✓

The positive relationship between upstream directives and performance under high uncertainty is mediated by the deliberate planning approach:	3			✓
Model without deliberate and emergent planning:				
▪ upstream directives → performance		$0.183^{\dagger}$	1.736	
- Model inclusive planning				
▪ Correlations across upstream directives and deliberate planning		0.368**		
▪ Deliberate planning → performance		$0.208^{\dagger}$	1.856	
▪ upstream directives → performance		0.090	0.820	
standardized path coefficient significant at ***p<.0001 **p<.001 *p<0.05 respectively †p<0.10				

Hypotheses 4a and 4b addressed the negative total effects that include indirect and direct effects of up-stream directives through the deliberate planning on incremental innovations (see table 5). We ran OLS regressions to calculate the indirect and total effects. We found a negative indirect effect of upstream directives through deliberate planning approach on incremental innovations under high uncertainty (indirect effect -0.082). According to Hair et al. (2006) indirect effects higher than 0.08 are crucial and have to be considered. Additionally we found a negative total effect of upstream directives on incremental innovation (total effect -0.091). Thus Hypothesis 4a can be supported: Upstream directives through the deliberate planning approach will have a negative effect on incremental innovations under high uncertainty. Hypothesis 4b has to be rejected: we can not show that upstream directives through the deliberate planning approach will have a negative effect on incremental innovations under low uncertainty.

We examined the moderator effect of uncertainty in hypothesis 5 using χ^2-difference test. We compared the path coefficient of emergent planning and performance under low and high uncertainty. In the high uncertainty group we found a positive influence of emergent planning on performance significant on the 1% level (Path 1: 0.269, t-value = 2.629). In the low uncertainty group we found a negative influence of emergent planning on performance significant on the 10% level (Path 2: -0.182, t-value = -1.647). Also the difference of the paths was significant on the 1% level (χ^2-difference value = 8.594, p = 0.003). Thus hypothesis 5 can be confirmed: Uncertainty moderates the relationship between the emergent approach and performance: Under low uncertainty, the emergent approach negatively affects performance; under high uncertainty, the emergent approach positively affects performance. An overview of the results of hypotheses testing 4, 5 and 6 is given in table 5.

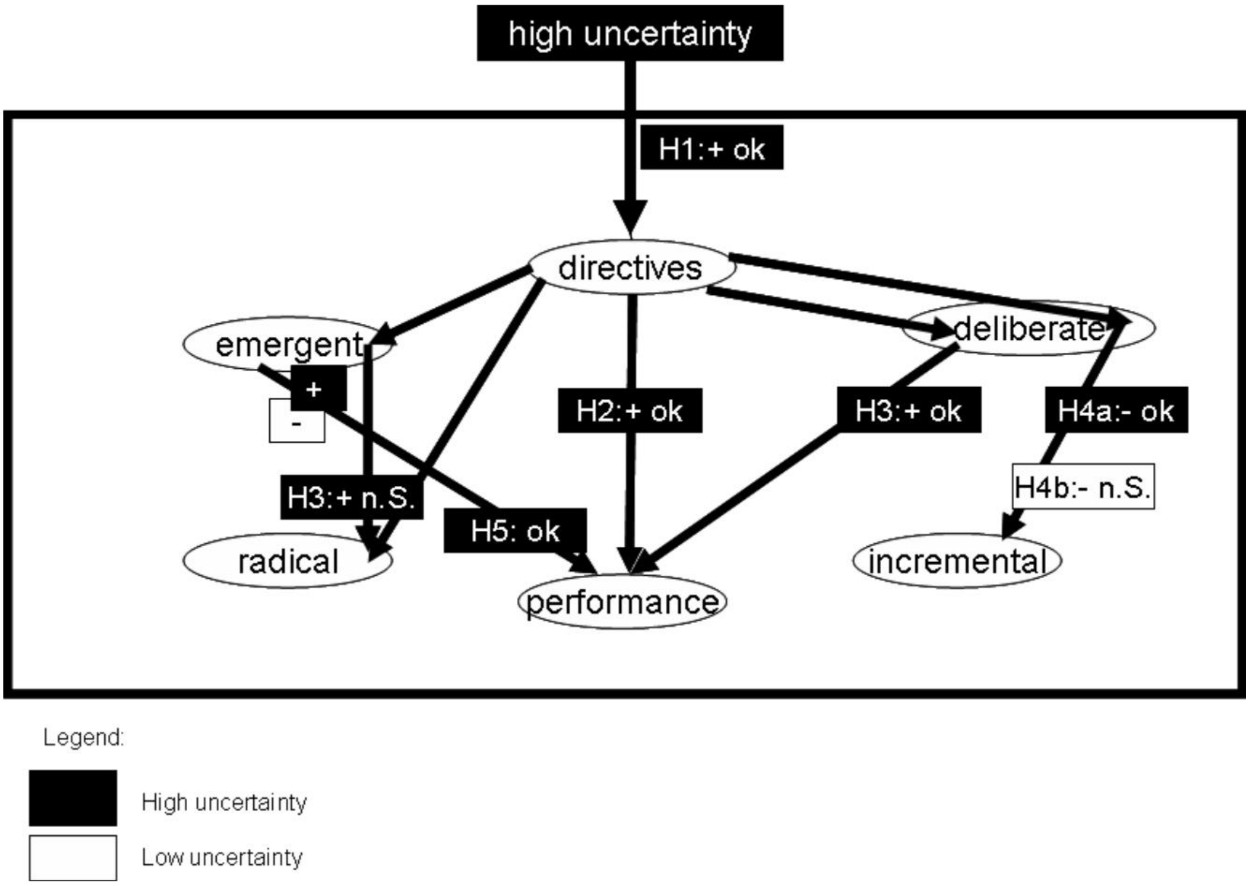
Table 5: Results of the Hypotheses Testing II

Path	**Hypo-thesis**	**Standar-dized Estimate**	**t-value**	**Confirmation (✓) / Rejection (x)**
Upstream directives and the deliberate planning approach will have a negative effect on incremental innovations under high uncertainty.	4a			
direct effects				
▪ upstream directives → incremental innovation		-0.009	-0.071	
▪ deliberate planning → incremental innovation		-0.224†	-1.855	
▪ upstream directives → deliberate planning		0.366***	3.755	
indirect effect				
▪ upstream directives → deliberate planning → incremental innovation		-0.082		
total effect				
▪ upstream directives → incremental innovation		-0.091		✓
Upstream directives and the deliberate planning approach will have a negative effect on incremental innovations under low uncertainty.	4b			
direct effects				
▪ upstream directives → incremental				

innovation		0.137	1.117	
▪ deliberate planning→ incremental innovation		-0.128	-1.070	
▪ upstream directives → deliberate planning		0.183†	1.752	
indirect effect				
▪ upstream directives → deliberate planning → incremental innovation		-0.023		
total effect				
upstream directives → incremental innovation		.1136		**x**
Uncertainty moderates the relationship between emergent planning and performance:	5			
a) Under high uncertainty: Emergent planning→ performance (= Path 1)		0.269**	2.629	✓
b) Under low uncertainty: Emergent planning→ performance (= Path 2)		-0.182†	-1.647	✓
c) Path 1> Path 2		Chi-square difference test: $\Delta\chi^2 = 8.594$ ** (p = .003)		✓

The positive relationship between the emergent planning and radical innovation under high uncertainty is mediated by upstream directives				
- Model without upstream directives				
▪ Emergent planning → radical innovation	6	0.075	0.652	**x**
- Model inclusive upstream directives				
▪ Correlations across upstream directives and emergent planning		0.078		
▪ upstream directives → radical innovation		0.224†	1.845	
▪ emergent planning → radical innovation		0.051	0.440	
standardized path coefficient significant at ***p<.0001 **p<.001 *p<0.05 respectively †p<0.10				

The postulated mediator effect of upstream directives in hypothesis 6 was not supported. We were not able to find an initial effect of emergent planning on radical innovation under high uncertainty as well as a significant correlation between upstream directives and emergent planning. Therefore we failed to meet step 1 and 2 of the procedures outlined by Baron and Kenny (1986). Hypothesis 6 has to be rejected: There is no support for a positive relationship between the emergent approach and radical innovation under high uncertainty which can be mediated by upstream directives. Figure 2 shows all results.



5 Conclusion

Suppliers are regarded being influential on manufacturers' innovation. This paper intended to bring light into the black box of suppliers' performance within supply chains. Specifically, we aimed to disentangle how upstream directives set by original equipment manufacturers, the buyer, influence planning as well as innovation and performance of suppliers. We worked towards giving answers about how useful buyers' upstream directives are on suppliers' performance. We also investigated how suppliers can cope with upstream directives through internal planning, the emergent or the deliberate approach. The starting point of our results concerns the intensity of upstream directives that are set up by manufacturers to coordinate contributions of their numerous suppliers. We refer to upstream directives when manufacturers set up tight deliberate targets and objectives.

Our results show that suppliers increasingly encounter upstream directives under high levels of technical uncertainty. Suppliers and manufacturer can decrease uncertainty and improve the coordination of different modules provided by several suppliers to a consistent end product.

Upstream directives and their effect on suppliers' planning approaches and performance then are of greater interest under high levels of uncertainty. Interestingly, radical innovations increase while incremental innovations decrease when suppliers encounter greater upstream directives. In analogy to Roy (2004) we reason that suppliers aim toward radical innovation hoping that the buyer will continue to offer future business once the innovation is fruitfully. Suppliers will be highly motivated to prove themselves. Radical innovations are suppliers' business model and might give them the chance to continuously operate in supply chains. We also reason that suppliers acknowledge the high obstacles manufactures find due to changes the product concept which are less worthy for incremental than for radical innovations. Incremental innovation will cause adaptations of each of the components delivered by several suppliers. As such incremental innovation causes costs of adaptation. At the same time, customers do not value incremental innovations as much as radical innovations. The novelty of radical innovations attracts customers and allows higher prices.

For suppliers it also is important how they can internally react through planning approaches upon upstream directives. The two planning approaches that have been highlighted by prior research as opposing each other have in our research on suppliers different as well as equal outcomes.

Our results are consistent with Hippel's (1990), suppliers can focus through upstream directives on their tasks and increase performance through deliberate planning. When suppliers generally use deliberate-formal planning, upstream directives will complement the implementation of analytically derived strategies and the attainment of objectives. The output will meet intended goals when tasks and their interrelation defined while the innovation generation proceeds. Deliberate planning can limit misunderstandings and reduce time-consuming coordination problems, because participants can refer to the plan for common language and understanding, which was shown for teams (Eisenhardt et al., 1995). Increased deliberate planning improves the forecast of technical opportunities of innovation and thus the resource allocation and the integration of manufacturers' upstream directives and achievement of their expectations. Suppliers can bundle and focus their resources and follow a coordinated approach and implement upstream directives of manufacturers in their innovation process.

To our surprise, upstream directives do not promote radical innovation through an emergent planning approach. Instead, we find a negative effect on radical innovation through the deliberate planning. This had been stressed by several studies in the field of npd projects looking on unstable conditions (Brown et al., 1995). Being consistent with the critique of the proponents of an emergent npd project style on the planned style in unstable conditions we with these findings extend prior research on the nature of innovation in a supply chain context.

The emergent approach reduces performance under conditions of low uncertainty. A negative performance impact also results from being exposed to upstream directives and following an emergent planning approach under low uncertainty. Yet under conditions of high uncertainty the emergent planning increases performance. We find uncertainty a moderator on the emergent planning performance relationship: A greater appliance of the emergent planning approach in conditions of high uncertainty increases performance and in conditions of low uncertainty decreases performance. However, our results indicate that the emergent planning approach is not related with increasing upstream directives under high uncertainty. Yet emergent planning can contribute to performance under high uncertainty. As such suppliers can achieve higher performance through emergent planning and are unaffected by upstream directives. We reason that high performing suppliers have greater autonomy and high quality components to their clients. The novel components are attracting clients that then try to implement them into their product concept.

Summing up, this research brings across many new aspects interesting for research and for practice in supply chains. When manufacturers or suppliers inquire about the advantages of upstream directives or planning we provide evidence under different circumstances and outcome targets. Generally and simplifying our results, suggestions strongly depend on the innovation type pursued and the level of technical uncertainty.

Incremental innovations are not the type of innovation important for suppliers in supply chains. We reason that the changes necessary in the total product concept are too costly. As such suppliers have to be aware that radical innovations are their business model. In the pursuit of radical innovations suppliers have to follow upstream directives of their clients. Internal planning then has no effect. It is important to follow the pre-settings announced by clients. In the pursuit of higher performance suppliers have to alternatives. A) suppliers can follow upstream directives and implement deliberate planning. B) suppliers can implement emergent planning process and develop and deliver high quality components to clients.

As all empirical studies ours has some limitations and might inspire future research. This study is directed on the environment of innovation generation in the supply chain. We did not control about the interaction quality between suppliers and buyers. This would be an avenue for further research on upstream directives and suppliers’ performance. In particular a climate of domination and upstream directives might be disadvantageous when firms follow the integrated product architecture. In the integral product architecture components are very complex and physical coupled i.e., many functional elements are implemented by more than one physical component and several physical components implement more than one functional element (Ulrich, 1995). In supply chains the development of components is divided among the focal firm and various suppliers. When highly intertwined the change of one component requires the change of other physical components across the supply chain (Schrader & Göpfert, 1997; von Hippel, 1990).

Even though the upstream directives and deliberate planning both include deliberate guidelines we do not know to which extend the deliberate planning mirror upstream directives of buyers. A dyad research on both suppliers and manufacturers will help to clarify this.

Future research might direct the question if upstream directives are associated with documentation standards. Thereof both suppliers and buyers can more easily track the different stages of development. This might reduce uncertainty and time for future changes of the product, service, or process.

Future research might investigate if suppliers and manufactures establish joint and even co-located innovation teams. Pinto and Prescott (1988) stress that innovation strategy and business goals are among key factors of performance. Also studies have stressed that the innovation outcome is a result of careful staffing of functional and cross-functional teams (Sherman, Souder, & Jenssen, 2000), the manner in which innovation teams are structured (Cooper & Kleinschmidt, 1995), and led (Hirst & Mann, 2004; Keller, 1992). Performance differentials were also found to be affected by the monitoring of the project process (Lewis et al., 2002). As such the existence, the staffing and project management of such inter-firm teams might deliver factors that improve innovation and performance of both suppliers and manufacturers interesting for further studies.

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