Supply chain related decisions in product development projects: Insights from the industry

Emine Zehra Yurtkulu Akgün (emine-zehra.akgun@jth.hj.se)
School of Engineering, Jönköping University

Per Hilletofth
School of Engineering, Jönköping University

Glenn Johansson
School of Engineering, Jönköping University

Abstract

The purpose of this study is to investigate supply chain related decisions that are considered in product development projects, product development related decisions considered in product development projects that have an impact on supply chain performance, and supply chain related decisions that are missing in product development projects. Identified decisions consist of strategic level decisions and tactical level decisions. The findings indicate that the supply chain functions have significant desire to get their decisions involved in product development projects. On the other hand, product development functions feel less pressure regarding how product development decisions affect supply chain performance.

Keywords: Supply chain management, product development, collaboration, decision-making

Introduction

Collaboration between supply chain management and product development has captured the attention of operations management scholars during last 20 years. The issue has been analysed from different angles such as supplier involvement and concurrent engineering. These types of collaboration lead to better resource utilization, increased capacity for innovation, and development of inter-firm coordination skills (Petersen et al., 2005). In addition, by reviewing supply chain related decisions in product development projects, companies can identify and mitigate the supply chain related risk factors in advance (Chiu and Okudan, 2014). The increased supply chain complexity and its critical position within the company signify the need for rethinking about the rationale of supply chain operations in product development projects (Van Hoek and Chapman, 2006; Marsillac and Roh, 2014). Existing studies focus on the topic from the perspective of external supply chain actors (i.e., supplier involvement). Still, the role of internal supply chain actors (i.e., supply, sourcing, packaging and transportation) and the decisions that they make for contributing to the product development have been discussed narrowly from decision-making perspective (Krishnan and Ulrich, 2001; Chiu and Okudan, 2011).

In order to enhance the knowledge and the understanding of supply chain related decisions in product development and the role of supply chain functions while making the decisions, this study seeks to identify decisions in product development projects that focus on supply chain related issues or have an impact on supply chain performance. In the context of this study,

supply chain performance include indicators such as time to market, product availability, flexibility (ability to respond to supply and demand variations and performance indicators in manufacturing as well as suppliers), as well as adaptation to the new products, markets and competitors (Beamon, 1999; Gunasekaran et al., 2004). In order to accomplish the purpose of this study, following research questions have been formulated: (1) 'Which supply chain related decisions are considered in product development projects?' (2) 'Which product development related decisions, considered in product development projects, have an impact on supply chain performance?' and (3) 'Which supply chain related decisions are missing in product development projects?'

This paper is organized in four sections. The first section reviews the literature on how supply chain involvement in product development are motivated and discussed within the existing literature. The second section presents the research method where the case study approach is emphasized. The third section presents identified supply chain decisions, factors influencing the decision-making process among different internal stakeholders. The findings section is followed by the discussion based on the reported findings. In the fourth section, various points have been spotted for future research.

Literature review

Companies can gain significant benefits from having collaborative relationships with suppliers and customers in product development projects, such as shared burden of development (Cadden and Downes, 2013), better understanding of market trends and customer needs, shorter time to market, and better ability to generate new innovative ideas (Lau et al., 2007; Laage-Hellman et al., 2014). This external integration with suppliers and customers is rooted in the strong internal collaboration among different functions within a company (Huo, 2012). According to Wong et al. (2011), internal integration leads companies to remove barriers between different functions, which enables collaboration. Joint product development is stated as one of the most important dimensions of internal integration (Koufteros et al., 2010). Krishnan and Ulrich (2001) define product development as a joint activity, which refers to a deliberate process that consists of various generic decisions. Looking at product development as a collection of decisions increase the possibility of generalization because the methods can vary from one company to another. But the companies still need to make decisions on the similar concepts, such as cost, lead-time, make-or-buy, location selection, and product architecture (Krishnan and Ulrich, 2001).

Companies tend to react upon technological advancements and market changes immediately by developing new products. This does not guarantee survival in the market by it selves since companies also need to consider supply chain requirements for bringing the products to the market as effective and efficient as possible. The supply chain constitutes a significant share of the total cost and the market price of the product, including sourcing, manufacturing, materials handling, packaging, warehousing, and distribution (Appelqvist et al., 2004; Petersen et al., 2005; Rungtusanatham and Forza, 2005). Thus, companies need to be open-minded and change their ways of working (Khan et al., 2012). Decision perspective, which recognizes including particular supply chain related decisions in product development projects has received limited attention in the literature but the attention is increasing. Current studies in this research stream focus on the decision concepts to point out the areas where involvement of the supply chain decisions takes part in product development. Petersen et al. (2005) investigated implications of supplier involvement while coordinating supply chain decisions with product development decisions. Their findings indicate that the engagement of suppliers can provide alignment between supply chain and product development decisions.

Two other concepts discussed in this research stream are supply chain configuration and product architecture. Product architecture and supply chain configuration are two strongly related concepts since product architecture decisions influence decisions related to outsourcing, supplier selection, location of supplier base, production, and warehousing operations (Zhang et. al, 2008; Salvador et al. 2002). In addition, the choice of product architecture influences many actions taken by different supply chain functions. Product development needs to be aware of its own influence, capabilities and the constraints of different supply chain functions (Dowlatshahi, 1996; Hatch and Badinelli, 1999; Klevås, 2005). For example, product development, while

making architecture related decisions, need to consider the importance of particular supply chain decisions, such as potential stocking points, number and capacity, facility and process conditions. Such considerations are crucial to avoid an inefficient material flow, backlogs, and inflexibility due to insufficient inventory (van Hoek and Chapman, 2006). Another concept discussed in this research stream is supportability. Supportability refers to an overall philosophy, which requires designing the products in a way that they will not cause serious breakdowns in the supply chain system throughout the product life cycle (Dowlatshahi, 1996; Dowlatshahi, 1999). Product development needs to consider during the product design and development.

Another concept discussed in this research stream is packaging. According to Klevås (2005), the packaging design is not considered until the product design is fixed and restraining factors of packaging in the transportation, materials handling, and manufacturing often is neglected. However, supply chains have some requirements for instance efficient material handling, transportation and communication among different parties. These requirements can be satisfied by minimizing damages and providing accurate information, security instructions as well as tracking information (Klevås, 2005). The risks that may arise from unmet requirements can be mitigated by the product development functions, if they consider these requirements and risks during packaging design. A final concept discussed in this research stream is transportability. Transportability refers to the ability to transport the product with in the supply chain, inside a facility and between them. The transportability is strongly connected to product design, packaging, and supportability (Dowlatshahi, 1996). Product development needs to consider the fact that the physical properties of the product as well as dynamic and environmental limitations affect the ability of the supply chain systems to transport and store product in an effective and efficient manner.

Research Design

This research is conducted as a single case study within the telecommunication industry in Sweden. Previous studies have started to conceptualize the topic by motivating the reasons of why supply chain functions need to collaborate with product development functions. In addition, these studies have proposed guidelines on how to achieve collaboration between these types of functions. However, there is still a need for further exploration of the phenomenon in a real life context in order to improve the understanding. The case company has been chosen from the telecommunication industry and runs in a business-to-business (B2B) fashion. One reason for this choice is that the existing studies tend to focus on the business-to-customer (B2C) market but B2B companies get limited attention. The case company is a manufacturer of technology-intensive and innovative products with considerably wide variety. The company has a global supply and demand chain network covering different continents. This case study is explorative in nature and the aim is to uncover the areas and look up the unknown that remains unexplored so far (Voss, 2009; Streb, 2010). As a result, it is expected to generate more research questions that will be pursuable in the future.

Multiple methods were used for data collection. To begin with, twelve semi-structured interviews were completed in two facilities within the company. The respondents either was involved in product development (e.g., mechanical designers, product development managers, supply-product managers) or in some supply chain function (e.g., project sourcing managers, supply chain managers, inbound supply preparation leaders, supplier developers, purchasers and demand planners). The respondents were asked four groups of questions: (1) Role within the company, (2) General applications and alterations in the product development projects, (3) Structure of supply chain organization, and (4) Role of supply chain functions in the context of product development decision-making. The last group also included questions related to product development's effect on supply chain decision-making. All interviews were recorded and each author reviewed the transcriptions to avoid subjective interpretation. In addition, company-specific documents (i.e., presentations and annual reports) and notes from two meetings, which were organized in the initial stages of the empirical study, were used.

The data analysis was completed in two steps. In the first step, all the statements that were raised as decisions during the interviews were extracted. In the next step, the extracted decisions

were categorized into three groups: (1) Supply chain related decisions considered in product development projects, (2) Product development related decisions considered in product development projects that have an impact on supply chain performance, and (3) Supply chain related decisions missing in product development projects. The decisions were also coded based on different decision-making levels (e.g., strategic and tactical levels). Microsoft Excel was used to document and code the extracted data. In addition, to the identification of these decisions, other facts, which established a base for making the particular decision, were identified. These other facts consists of motivation factors and conflicting objectives of different functions, which trigger the decision making process within the company.

The case study protocol ensures the reliability of this study as it consists of the questions that allow the objective data collection. Validity of the study is also ensured by not only relying on data from the interviews but also from annual reports, company presentations and notes from meetings. In addition, different patterns have been identified during the data analysis and they have been matched while analyzing the data and constructing a purposeful discussion. For instance, in order to understand the meaning of a particular decision, it is crucial to understand the factors that lead the decision-makers to that decision.

Findings from the case study

The findings of this study highlights the emphasis within the case company, struggles when identifying and including critical supply chain decisions in product development projects and when evaluating product development related decisions that have an impact on supply chain performance. The findings are reported in three sections: (1) Supply chain related decisions considered in product development projects, (2) Product development related decisions considered in product development projects that have an impact on supply chain performance, and (3) Supply chain related decisions missing in product development projects.

RQ1. Which supply chain related decisions are considered in product development projects?

The case company's supply chain organization is divided into two main divisions: (1) Inbound supply and (2) Outbound distribution. Under each division, there are different supply chain functions that are involved in product development projects in various extents and they are heavily influenced by the decisions made in the product development projects. The respondents represent functions on different decisions making levels in the case company. The spectrum of identified decisions covers both strategic level and tactical level decisions. The strategic level decisions are divided into two categories. The first category is related to the identification of market needs and evaluation of the internal capabilities (denotated as SC-STRA1). The second category focus on make-or-buy and supply chain configuration related decisions (denotated as SC-STRA2). The strategic decisions are followed by a set of tactical level decisions. They are also grouped into two categories. The first category involves supplier related decisions such as identification of supplier requirements and capabilities (denotated as SC-TACT1). The second category involves logistics related decisions, including inventory levels, order quantities, and packaging (denotated as ST-TACT2). The identified supply chain related decisions considered in product development projects are shown in Table 1. These decisions are discussed during project meetings and the functions showed in the table are assigned based on who initiated the decision during the project meeting.

Table 1 Supply chain related decisions considered in product development projects

Decision	Category	Function
What are the target market needs?	SC-STRA1	Sourcing, Inbound supply
What does the company need to do for sustaining the current market position?	SC-STRA1	Sourcing, Inbound supply
What are the required capabilities to extend market share?	SC-STRA1	Sourcing, Inbound supply
How much resources does each supply chain function need are needed in terms of man/hour and budget?	SC-STRA1	Inbound supply, Supply-Product management
What are the priorities for the different products such as cost or time-to-market?	SC-STRA1	Sourcing
How strong is the buying power in the target markets?	SC-STRA1	Sourcing
How will the products be positioned?	SC-STRA1	Supply-Product management
What are the lead-time targets in order to bring the product in the target markets?	SC-STRA1	Sourcing
What are the expected timing for product phase in and phase out?	SC-STRA1	Sourcing
How is the component production going to be handled? (Make-or-buy)	SC-STRA2	Sourcing
If it is a make-decision, where should the production take place?	SC-STRA2	Sourcing
Where should the subassembly be done?	SC-STRA2	Sourcing
Which supply chain will be used?	SC-STRA2	Sourcing, Supply-Product management
What does the postponement strategy encompass?	SC-STRA2	Inbound supply
How can accurate supply chain strategy estimation be done for the future?	SC-STRA2	Supply-Product management
How should product and supply chain allocation be made?	SC-STRA2	Supply-Product management
How to do the product and market allocations? (Dimensioning)	SC-STRA2	Outbound supply
Where is the supplier base chosen?	SC-TACT1	Sourcing
What are the special requirements of sourcing and supply for supplier selection?	SC-TACT1	Sourcing, Inbound supply, Purchasing
What requirements does supply have regarding lead-time, terms of payment and delivery?	SC-TACT1	Sourcing
What are the required supplier capabilities in the early stages of product development projects?	SC-TACT1	Supply-Product management
Will the existing suppliers be able to meet new product's requirements?	SC-TACT1	Sourcing
How should be the supplier's lead-time targets aligned with the company's lead-time targets to keep up with the time-to-market objective?	SC-TACT1	Inbound supply
How many suppliers will be needed from the suppliers' list?	SC-TACT1	Sourcing
How will design changes affect the relationships with the suppliers?	SC-TACT1	Purchasing, Demand planning
Which supply organization will be responsible for the certain products?	SC-TACT1	Supply-Product management
What are the optimum buffer stock levels for a particular product in different stages of supply chain?	SC-TACT2	Inbound supply
How and where should the production be consolidated during phase in and out?	SC-TACT2	Outbound supply, Sourcing
How should minimum order quantities be changed during phase out?	SC-TACT2	Sourcing
What is the potential cost of improper product phase out for the inbound and outbound supply chain functions?	SC-TACT2	Outbound supply,
What are the packaging requirements that ease transportation and material handling?	SC-TACT2	Outbound supply
What are the packaging requirements that suppliers should meet?	SC-TACT2	Inbound supply

The decisions presented above have the ability to effect particular product development decisions, especially the ones about product architecture, product launch, phase in of the new products, and phase out of the declining products. Thus, it can be argued that the identification and understanding of conflicting objectives and motivating factors behind these decisions may provide support for the inclusion of supply chain related decisions in product development projects.

RQ2. Which product development related decisions considered in product development projects have an impact on supply chain performance?
The identified decisions in this category are related to the characteristics of the products and stakeholders, namely functionality, modularization, relations between stakeholders, and division of responsibilities among different stakeholders. The identified decisions are divided into two categories. The first category involves strategic decisions that focus on product architecture, functionality, and product launch (denotated as PD-STRA). The second category involved tactical decisions with the focus on other product development-related issues such as the new product introductions in the internal logistics systems, product instructions and design changes (denotated as PD-TACT). The identified product development related decisions in product development that have an impact on supply chain performance is shown in Table 2.

Table 2 Product development decisions that have an impact on supply chain performance

Decision	**Category**	**Function**
What type of product architecture and platform will be used to optimize design to cost objective?	PD-STRA	PD Project management, Inbound supply
What are the required functionalities that the target markets ask for?	PD-STRA	PD Project management, Mechanical design
What will the extent of product modularization be?	PD-STRA	PD Project management, Mechanical design
How many different parts will be included in a certain product?	PD-STRA	PD Project management, Mechanical design
What time will the final products be launched?	PD-STRA	PD Project management, outbound supply
When should the new products be introduced to the internal system?	PD-TACT	PD Project management, Mechanical design, Inbound supply.
How should external and internal stakeholders be involved to establish long-lasting collaboration?	PD-TACT	PD Project management,
When should the design changes be frozen?	PD-TACT	PD Project management, Purchasing, Planning
Which organization will be responsible to send instructions of the product introduction?	PD-TACT	Supply-Product management
What are the possible impacts of the design changes on the relationships with internal and external stakeholders?	PD-TACT	PD Project management, Planning
Where do product instructions come from?	PD-TACT	Supply-Product management

The respondents from product development functions stressed the benefits of their instant feedback about supplier performance and prototype quality to the supply chain functions. Later sourcing and supply functions can use these feedback to re-evaluate supplier selection and evaluation processes with regard to: (1) Whether current supplier base will be able to meet the future requirements of the company, (2) where to choose supplier base from, (3) how to develop suppliers further to meet company's requirements, and (4) what the quality assurance criteria are for the suppliers and how to execute supplier screening process.

RQ3. Which supply chain related decisions are missing in product development projects?
The respondents from the supply chain functions were asked about whether they believe that any supply chain related decisions are missing in product development projects, that the product development functions should be aware of. The identified decisions are tactical level decisions (denotated as M-TACT). They focus on the information logistics, alterations in the market, and the facility related issues. One of the respondents especially stressed the importance of how to tunnel the particular information from sourcing to the project teams to be involved more in the innovation process. The identified missing supply chain related decisions are shown in Table 3.

Table 3 Missing supply chain related decisions in product development projects

Decision	Category	Function
Which products should be bundled together or sold alone?	M-TACT	Outbound supply
When should the software installation be done to make site installation easier for outbound supply teams?	M-TACT	Outbound supply
What are the particular design, component and technological changes that designers should be aware of?	M-TACT	Sourcing
How will the information regarding product-production plant assignment be communicated within the project team?	M-TACT	Sourcing

An interesting fact is that some of these missing decisions are more like product development related decisions. However, they were highlighted by supply chain functions. Even tough product development functions stressed that their feedback to the supply chain functions are very critical and valuable during supplier selection and evaluation, it can also be argued that, by identifying these decisions, the supply chain functions show that their feedback also becomes crucial for improving the product development process.

Discussion

The findings of the study indicate that the supply chain functions have considerable awareness in terms of involving their decisions during product development project. In comparison, product development functions feel less pressure about how product development decisions will impact the performance of different supply chain functions. On the strategic level, obligation (or the pressure) of including supply chain decisions in product development reveal itself more significantly as many critical decisions that affect the majority of supply chain cost should be made during the early stages of the product development projects (Appelqvist et al., 2004; Khan et al., 2012). Most of the strategic level decisions are shared between supply chain and product development functions, namely product development functions should be aware of the fact that considering the decisions related to market conditions, lead time and cost priorities, make-or-buy, product architecture will be the concern of supply chain functions as well. With regard to the tactical level decisions, they are not shared as extensive as strategic decisions are shared among two functions, however various supply chain decisions have been identified, which case company considers during the product development projects and fewer decisions have been identified which are thought to be influential on supply chain performance.

Findings of this study can be discussed from multiple perspectives. This will deepen the discussion in terms of evaluating the roots of how companies take actions to include critical supply chain decisions in the entire product development process. First, it is important to understand what are the facts that underlie the motivation of including supply chain decisions, reconsidering product development processes as an influential factor for supply chain performance and understanding the companies' dynamics (i.e. organizational structure) and priorities while considering the extent of including supply chain decisions. The company does have management teams, which make strategic level decisions and transfer them to the other functions and project teams. Fawcett et al. (2012) stated that the company establishes such upper level teams in order to facilitate efficient collaboration and continuous communication. Furthermore, they establish bridge functions that are involved in management teams and in the other projects teams. These bridge functions act like a coordination mechanisms between product development and supply chain functions and based on their job descriptions, they communicate the requirements and demands from different supply chain functions (i.e. supply, sourcing) and from product development functions (i.e. design and development).

There are two reasons for such settlement. First of all, companies need to enhance the coordination capabilities in order to balance organizational diversity and complexity (Narasimhan and Kim, 2002) and the bridge functions helps the teams to alleviate the complexity and diversity originating from different motivations and conflicting objectives. Second, bridge functions enable frequent communication inside the teams and among the teams (Fawcett et al., 2012) so the supply chain and the product development functions can discuss about their conflicting objectives and reach an agreement as well as discuss the factors that

motives the different functions to agree on the decisions. According to Wong et al. (2011) the companies that emphasize concurrent product and production development (a.k.a. concurrent engineering) will achieve higher percentages in terms of performance metrics such as delivery, cost, quality and flexibility. Based on the interviews done in two different locations, it can be argued that the company emphasizes the concurrent engineering philosophy and they work concurrently by involving product development, supply and sourcing together to achieve "design for manufacturing" and "design to cost" goals of the company.

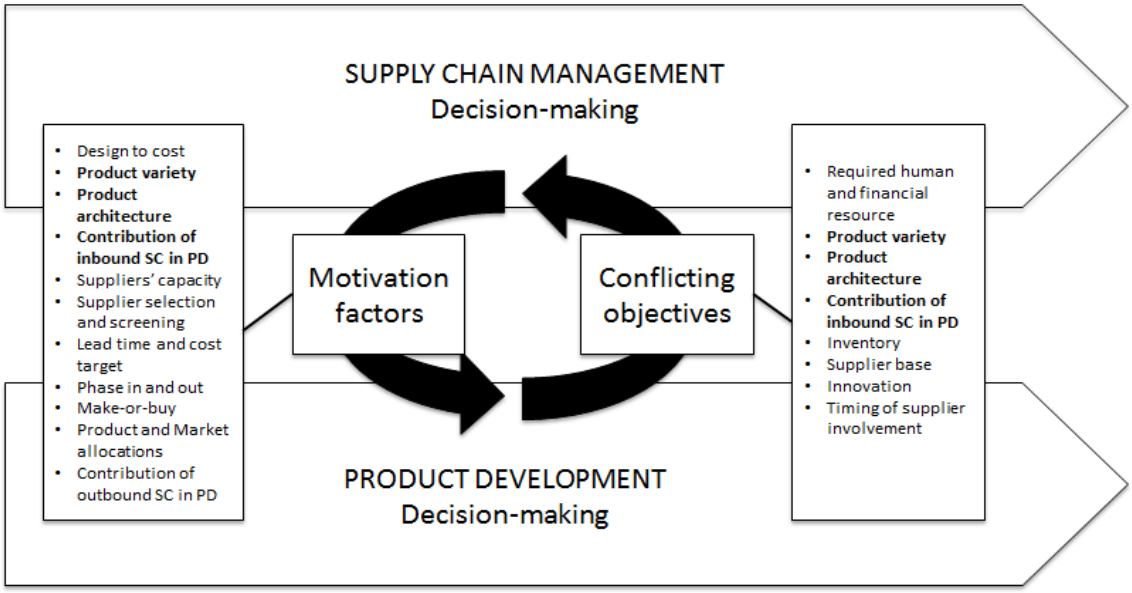

Figure 1 Dynamics of decision-making

The collaboration and the integration bring people from supply chain and product development functions to work together and form project teams. However, it is not as easy as it sounds. Such collaboration and/or integration are built upon a certain number of motivation factors and conflicting objectives. Recognition of including critical supply chain decisions in different stages of product development projects or realizing the impact of particular product development decisions on other supply chain decisions are originated from these motivation factors and conflicts. Figure 1 shows the constituents of the act of decision-making in the context of this study. One of the eye-catching details of the figure is that some aspects such as "product variety", "product architecture" and "contributions of inbound supply chain in product development" are tagged as both motivation factors and conflicting objectives. Product variety appeared as a confliction between product development and supply functions, because while R&D wants more functionality, this means more parts to be supply and more suppliers to negotiate, select and control. Therefore, supply and sourcing functions demand a product portfolio that enables these functions to have less complicated material flow and accurate forecast numbers. Outbound supply chain function also mentioned that less variance in the product portfolio would make life cycle monitoring and buffer stock calculation easier.

A similar story exists for the product architecture preferences. Inbound supply, sourcing and production want product development to consider production lead times while defining the product architecture and design a product that will make the company avoid the lead time bottlenecks and extra machining times. According to the respondents from inbound supply functions, inbound supply and production teams work together to simulate how the parts are assembled together and they can provide instant feedback to the design. The instant feedback loop can be a motivating factor for design function to hear voice of supply and production with regard to avoid late design changes and conscious choice of materials that will be used in the product. However, concerns about the costs can cause major delays in the entire system when they choose a component, which shows weak performance in prototype testing. Another aspect, which appears as a conflicting objective, is about inventory. The items that companies keep in

their warehouses increase their operational flexibility since they will be able to respond changes in the demand pattern immediately (Chopra and Meindl, 2012). On the other hand, keeping all these items will bring cost. At this point, respondents from sourcing mentioned about they are intend to make negotiations in larger quantities for getting the advantage of quantity discounts and as well as economies of scale. However, this situation put pressure on other departments like inbound supply who need to align inventory turnover and cost targets.

Thus, desire for the high product variety and making higher amount of sourcing will create conflicts between sourcing, product development and supply. Based on the findings, supplier related decisions hold a significant importance compared to the other decisions. For instance, all product development and supply chain functions are aware of the fact that the potential suppliers should be capable of fulfilling the company's requirements and keep up the pace. Therefore, this is a motivation factor for product development functions, supply and sourcing to understand and emphasize the importance of finding appropriate partners that the company can establish long-term relationship instead of the temporary relationship for the sake of lower prices. It leads the company to improve flexibility towards their suppliers, develop the suppliers and improve performance of the project. On the other hand, sourcing and R&D can have conflicts with regard to timing of involvement. While R&D requests to involve suppliers starting from the early design stages, sourcing may object to this decisions since they may not complete the supplier auditing process.

Conclusion

This study aimed to investigate which supply chain related decisions that are considered in product development projects, which product development related decisions considered in product development projects that have an impact on supply chain performance, and which supply chain related decisions that are missing in product development projects. The extent to which supply chain related decisions are considered in product development projects as well as the type of decisions considered is strongly dependent on which part of the supply chain the company focuses on more. Depending on where in the supply chain the company can add most value to the product and where in the supply chain the company is most cost sensitive, the supply chain focus and emphasis will differ. The case company mostly focus on the inbound supply and sourcing functions and less on other functions such as outbound distribution, purchasing, and planning. The contribution of this paper is twofold: First, the results of this study make a contribution to the existing knowledge by identifying critical supply chain related decision to consider in product development projects and product development related decision that have an impact on supply chain performance. In addition, the results provide evidence on organizational efforts that companies can undertake to include supply chain functions and their critical decisions in product development projects.

This study has identified motivational factors and conflicting objectives that lead different functions to recognize their constraints and requirements. Second, the results are evaluated from the lenses of internal collaboration, organizational complexity and diversity. This study comes with some limitations. To begin with, these results are based on a single company. In order to validate these findings, different companies can be chosen based on a product innovation scale. Same questions can be answered for from more innovative and technology sensitive products to the less complex and less technology sensitive products. As a suggestion for further research, new empirical studies can be designed in B2B companies as these companies get limited attention in the existing literature. This study focuses on the decisions that are already in use during current product development projects. For future studies, completely new development projects can be studied from the beginning in order to see what type of supply chain related decisions are considered. These studies also can be designed as longitudinal studies that will allow benchmarking retrospective projects and new projects regarding inclusion of supply chain decisions in product development.

Acknowledgements
We would like to thank all the respondents in the case company for their valuable inputs and for their time.

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