



TAMPEREEN TEKNILLINEN YLIOPISTO
TAMPERE UNIVERSITY OF TECHNOLOGY

ANNA HIIDENSALO
A FRAMEWORK FOR IMPROVING COST-EFFECTIVENESS OF
PRODUCT DESIGNS BY CROSS-FUNCTIONAL AND INTER-
ORGANIZATIONAL COLLABORATION

Master of Science Thesis

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ABSTRACT

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The critical role of procurement to keep a company's costs under control has been widely researched in the past few years. However, the empirical research considering the role of procurement in the product development process has received less interest from scholars. Using a design-to-cost (DTC) process is one option to improve the cost-effectiveness of the product development process. Literature concerning the use of the DTC process in the environment of tailored single product manufacturing is still rather uncommon. The objective of this thesis is to construct a DTC framework for the case company that manufactures production equipment and provides them to their customers through projects. Cross-functional and inter-organizational collaboration is considered as an essential part of the DTC process.

The thesis is a qualitative single case study using an abductive approach to the analysis of the results. The construction of the proposed DTC framework was started from the theoretical perspective. The factors that needed to be taken into account when constructing the DTC framework were observed based on a literature review. The proposed DTC framework was further developed through workshop studies and semi-structured interviews. The research focused mostly on the first phase of the DTC framework in order to increase manufacturing cost-effectiveness by cross-functional collaboration.

As a result, the thesis presents a new framework for tailored product development process utilizing cross-functional and inter-organizational collaboration to benefit from supplier capabilities and integrate customer requirements into the process. The role of the procurement function is critical when forming the cross-functional and inter-organizational collaboration. The DTC framework can lead to increased knowledge of the best practices that can be applied in the product development process. The increased knowledge creates a foundation for the different organizational functions to develop the understanding of cross-functional targets. The study shows how DTC can be developed from being a routine and mechanical process into a framework that can adapt to globalization and outsourcing, along with a focus on innovative inter-organizational collaboration.

TIIVISTELMÄ

TAMPEREEN TEKNILLINEN YLIOPISTO

Tuotantotalouden koulutusohjelma

HIIDENSALO, ANNA: Viitekehys tuotesuunnitelmien kustannustehokkuuden parantamiseksi toimintojen ja organisaatioiden välisen yhteistyön avulla

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Hankinnan kriittistä roolia yrityksen kustannusten kontrolloimisessa on tutkittu laajalti viime vuosina. Kuitenkin empiirinen tutkimus koskien hankinnan roolia tuotekehityksessä on vielä melko tuntematonta aluetta. Design-to-cost (DTC) on yksi mahdollinen tapa kehittää tuotekehitysprosessin taloudellista kannattavuutta. Ennen kaikkea kirjallisuus, joka käsittelee DTC-prosessia räätälöidyn tuotteen valmistuksessa yrityksen toimintojen ja organisaatioiden välisen yhteistyön avulla on vielä melko harvinaista. Työn tavoite on muodostaa DTC-viitekehys case-yritykselle tuotannollisessa projektiliiketoiminnassa. Yrityksen toimintojen ja organisaatioiden välinen yhteistyö on myös huomioitu DTC-prosessissa.

Diplomityö on laadullinen yksittäinen tapaustutkimus, jossa hyödynnettiin abduktiivista tutkimusotetta. Viitekehityksen rakentaminen aloitettiin teoreettisesta näkökulmasta. Kirjallisuustutkimuksen pohjalta tunnistettiin tekijät, mitkä tuli huomioida DTC-viitekehystä muodostettaessa. Kirjallisuustutkimuksen perusteella ehdotettua DTC-viitekehystä täydennettiin työpajoilla ja puolistrukturoiduilla haastatteluilla. Tutkimus keskittyi pääosin DTC-viitekehityksen ensimmäiseen vaiheeseen tuotteiden valmistettavuuden kustannustehokkuuden parantamiseksi yrityksen toimintojen välisen yhteistyön avulla.

Diplomityön tuloksena syntyi uusi viitekehys räätälöityjen tuotteiden uudelleensuunnitteluprosessiin, johon kuuluvat organisaatioiden välinen yhteistyö, sekä toimittajien kyvykkyyksien hyödyntämiseksi ja asiakkaiden vaatimusten tunnistamiseksi. Hankintatoiminnon rooli on merkittävä kun muodostetaan yrityksen toimintojen ja organisaatioiden välistä yhteistyötä. DTC-viitekehys voi tarjota lisää tietoa erilaisista vaihtoehtoisista ratkaisuista, jotka ovat sovellettavissa tuotteen uudelleensuunnitteluprosessiin. Lisääntynyt tieto tarjoaa yrityksen eri toiminnoille perustan toimintojen välisten tavoitteiden paremmalle ymmärtämiselle ja kehittämiseksi. Tutkimus osoittaa kuinka DTC voi kehittyä rutiininomaisesta ja mekaanisesta prosessista viitekehyyksi, joka mukautuu globalisaatioon ja ulkoistukseen tavoitteena organisaatioiden välinen innovatiivinen yhteistyö.

PREFACE

The journey to get to this point of my studies has been long and a very colorful one. I am grateful for this opportunity, the end of my studies with the topic that I found very interesting and captivating. I would not be here, writing the last page of my thesis without several people who really deserve special thanks for their support.

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Tampere, 26 February 2016

Anna Hiidensalo

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1. INTRODUCTION

1.1 Background and motivation

The contemporary business environment creates a multitude of challenges for manufacturing companies, for instance globalization, outsourcing and increased customer expectations. The importance of the procurement function increases continuously because the trend is towards innovative and capable suppliers. (Schoenherr et al. 2012) The role of procurement within companies has changed significantly over the past 25 years, from simply buying goods and services to the execution of an integrated set of management functions. Procurement has its own role in every aspect of management, from category management to managing supplier relationships, contracts, payments, and strategy. (Butter & Linse 2008) According to Schoenherr et al. (2012) the procurement function carries the principal responsibility for interaction with the upstream supply chain, and is therefore crucial for sustaining and efficient operations. Dubois & Wynstra (2005) add that procurement function is an interface between the internal and external parties of the company.

The procurement of products and services generally covers a significant part of a company's costs, which means that the company's cost-effectiveness and competitiveness mainly consist of resources acquired outside (Iloranta & Pajunen-Muhonen 2015). The procurement has a critical role in keeping the costs under control, but its role is growing in supporting innovativeness and in the creation of new types of values (Heikkilä et al. 2013). The interest in procurement involvement in product development can be a result of two main factors: firstly, the increasing consciousness of the procurement function's potential impact on the company's strategic position, and secondly, the emerging importance of innovation and product development in constructing competitive advantage (Wynstra et al. 1999).

Wynstra et al. (2003) present that it is valuable to look at the goals of the purchasing function for better understanding on the logic of this integration between procurement and product development. According to Axelsson & Hakansson (1984) the procurement has three different roles: rationalization, structure and development. The rationalization role of procurement focuses on improving the company's competitiveness by minimizing the prices of inputs, the total cost of production, etc. The structure role of procurement concerns the company's ways to operate in a supplier network. The development role of procurement focuses on technological development, with the purpose of contributing to the development of the suppliers and the supplier network.

The successful integration of procurement and product development processes has to be based on these different roles. (Wynstra et al. 2003)

The globalization forces companies to produce low-cost and high-quality products in order to maintain their competitiveness at the highest level. It is much more effective to reduce the cost of a product at the design stage than at the manufacturing stage. Furthermore, if the product manufacturing costs can be calculated during the early stage, design can be modified to achieve proper performance and reasonable costs at this stage. (Shehab & Abdalla 2001) According to Wei & Egbelu (2000) the more reliable the cost estimating process is, the more likely the right decision considering the product design will be made. Several studies have proved that cost break down and ranking to core elements can create success for corporates (Abdalla & Knight 1994; Wei & Egbelu 2000; Shehab & Abdalla 2001; Rehman & Guenov 1998; Eversheim et al. 1998;). For instance, Rehman & Guenov (1998) revealed a method for modelling costs through the design phase of the product's life-cycle, from abstract to detailed design. Shehab & Abdalla (2009) present a rule-based and an object-oriented system for product cost modelling and design for automation at an early design stage. For the method by Rehman & Guenov (1998) and Shehab & Abdalla (2009) the term design-to-cost (DTC) can be used. The DTC is a concrete way to diminish manufacturing costs through product design.

Several researches have used DTC in different forms and in variable environments through their studies. Abdalla & Knight (1994) defined an expert system for the concurrent product and process design for mechanical parts. Their research enables designers to ensure that the product will be manufactured with the existing manufacturing facility at high quality and the lowest cost. Wei & Egbelu (2000) share the idea of a framework to estimate the lowest product manufacturing cost from the AND/OR tree representation of an alternative process. In conclusion, researchers have used DTC in quite divergent environments. Despite the understood importance of (DTC) at the early stage in product development, barely any research has managed to explain how to use DTC for a single product process. There is a shortage of research how to exploit the DTC process in the tailored product development.

Procurement involvement in the product development process has received increased attention in research at least for the last 15 years. The research by Williams and Smith (1990) involved procurement in product development. The role of procurement was found to be significant in the new product development, specifically in the early phase (Dowlatshahi 1992; Burt & Soukup 1985). The study by Wynstra et al. (1999) and Wynstra et al. (2000) found a coherent framework of procurement involvement in product development. Narasimhana & Dasb (2001) found that increased investments in procurement integration with manufacturing were observed to lead to higher performance returns. According to Johnson et al. (2002) industry context plays a significant role when forming the cross-functional procurement teams. Their results

indicate that the cross-functional procurement teams are more extensively used by the companies that manufacture discrete goods. The collaboration between procurement and the other functions in the new product development has received attention (Schiele 2010; Dowlatshahi 1992; Burt & Soukup 1985), but the cross-functional collaboration outlined to the product development in the tailored product business is mainly an unexplored area. Furthermore, there is a shortage of structural research on the relevant collaboration form with the functions of procurement, product development and production in the redesign process. In addition, there is a need for empirical research in a tailored single product oriented environment. The tailored single product manufacturing needs a more active role from the procurement function.

Manufacturing companies increasingly focus on their core competencies to meet the challenges, and at the same time, there is an increasing trend towards outsourcing (Schoenherr et al. 2012). Companies no more longer rely only on the manufacturing capabilities of their suppliers, they also recognize that suppliers have become a critical source of process and product innovation (Azadegan & Dooley 2010). Gottfredson et al. (2005) present that buying companies purchase not only products from suppliers, but also capabilities that can lead to competitive advantage. A review of Paulraj et al. (2006) found that companies can achieve a better supply integration with the nascent stage of strategic procurement. Wynstra et al. (2001) studied the supplier involvement early and intensively in product development. They found that companies still experience substantial difficulties in managing this involvement.

According to Lawson et al. (2009) inter-organizational collaboration with suppliers is positively associated with the informal mechanism as social events or communication guidelines instead of formal mechanism as matrix reporting structures. Johnson & Leenders (2006) present that teams can involve suppliers, customers or members of the organization in the context of the new product development. Furthermore, there is a dearth of research from the perspective of the inter-organizational and cross-functional collaboration considering the DTC process. Lawson et al. (2009) recommend that future studies take a multiple-source data collection approach to adequately address the issue of inter-organizational collaboration. Based on the Lawson et al. (2009) recommendation, this thesis use the customer, the suppliers and the case company as the source of data collection approaching the inter-organizational issue.

1.2 Research context and the case company

This thesis is a part of the Smart Procurement Program of Finnish Funding Agency for Innovation. The research program aims at accelerating the introduction of innovations through procurement excellence and the development of markets (Tekes 2015). To be precise, this thesis is also a part of the ProcuValue (Value creating procurement) research project. The project includes a qualitative multiple case study containing

surveys, interviews and case specific action research. There are four case companies in the project; Valmet, Posti, Tieto and Metsä Group. The ProcuValue project aims at promoting long-term and collaborative procurement which is seen to be significant from the viewpoint of purchasers and that of suppliers.

One of the main influencers of the thesis is the case company Valmet. The research problem is defined by Valmet. Valmet is a global Finnish industrial company, which has its head office in Finland and its shares are listed on the Nasdaq Helsinki. The company is organized for four business lines (Pulp and Energy, Paper, Services and Automation) and in five geographical areas (North America, South America, EMEA, Asia Pacific and China). In this thesis, the focus is restricted on two business lines: Pulp and Energy and Paper. The Pulp and Energy business line delivers solutions and technologies for pulp and energy production as well as to biomass conversion. The paper business line provides complete tissue, board and paper production lines and machine rebuilds. Valmet has 12,000 employees globally and its net sales in 2014 were approximately EUR 2.5 billion. (Valmet 2016b)

The procurement of Valmet addresses global operations and an extensive supply chain. The total spend in direct purchases is between EUR 1-2 billion annually, which is purchased from thousands of suppliers in over 50 countries. Furthermore, over half of the Valmet purchases come from Finland and Sweden, measured in the supplier spend. (Valmet 2016a) Valmet has merged and it has done acquisitions in the course of years. The company has over 200 years of industrial history. As a result, the product range of Valmet has changed over the years. Due to its history, Valmet strives to harmonize its variable working methods among different business lines. One of the company's strategic focus areas is to improve cost-effectiveness in the product redesign process which is highlighted in this thesis.

1.3 Research questions and study outline

This thesis focuses on creating a DTC framework that aims at improving cost-effectiveness and the cross-functional network at Valmet. The company has launched a cost savings project to procurement. One of the main methods to reach the cost savings target is to increase DTC practices in the business lines. The focus of product development in the DTC target identification is to give attention to the products' redesign instead of developing new products.

The aim of the research is to define a DTC framework for product development in manufacturing project business. Therefore, the following three research questions can be defined to guide this study:

What phases constitute the design-to-cost (DTC) framework and how do different actors relate to the DTC framework?

What practices can be used in improving collaboration between procurement and other key actors including internal functions, suppliers and customers?

How to identify potential initiatives for product development efforts?

This thesis will strive to answer these questions by combining theoretical information and adopting it to the demanding and specific factual connection of Valmet. The objectives of this study can be determined on the basis of these research questions. The first objective comes from a theoretical aspect and the other one is from the perspective of Valmet. The theoretical aim is to increase understanding about the cost-effectiveness of product development through inter-organizational and cross-functional collaboration. From the perspective of Valmet, the objective is to offer a framework for identification prospective DTC targets through procurement function, Valmet's other internal functions and inter-organizational collaboration.

The process of formulating the cost-effectiveness of the DTC model includes several aspects that need to be taken into account. The aim is to look for the right things which have significant impact on the total cost instead of minimizing the cost of small details. The developed model has to be comprehensible enough in order to be utilized in two totally different business lines. The framework should be tested and authenticated with the employees of Valmet to ensure its suitability. The opinion of company's different internal functions, especially procurement, product development and production views needs to be forged into the model.

1.4 Research philosophy and process approach

The literature review is presented first and it defines the theoretical framework of the thesis. The study is implemented as a qualitative case study research due the intertwined nature of the different research methods in the research process. The empirical part of the thesis consists of semi-structured interviews and workshops. The analysis of interviews acts as a basis for workshops. The idea of the workshops is to clarify and give more information about the collaboration between a customer, Valmet and suppliers. The methodology choices of this thesis are described in Figure 1. Figure 1 illustrates "research onion" which consists of research philosophy, research approach, research strategy and research choices as suggested by Saunders et al. (2009, p.108).

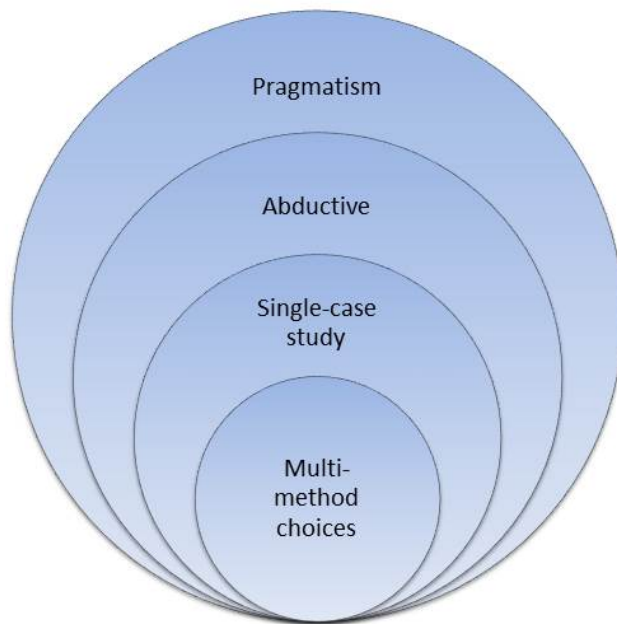


Figure 1. *The methodology choices of the thesis (adopted from Saunders et al. 2009, p.108)*

The research philosophy is an all-encompassing term, which relates to the development of knowledge and the nature of that knowledge (Saunders et al. 2009, p. 107). There are three main aspects in the research philosophy: ontology, epistemology, and axiology. Ontology concerns the view how the way world operates and the commitment of special views. Epistemology concerns what constitutes the acceptable knowledge. Axiology concerns the role of values in studies. (Saunders et al. 2009, pp. 109-119)

Saunders et al. (2009) present that management research can be comprised on the basis of four research philosophies; positivism, realism, interpretivism and pragmatism. They add that these four options differ from each other what comes to ontology, epistemology and axiology. This thesis is based on a *pragmatism* research philosophy. According to Saunders et al. (2009), the meaning and the observable phenomena can obtain acceptable knowledge dependent on the research question in pragmatism philosophy. They add that the focus is on practically applied research and for the help in interpreting the data, pragmatism integrates different perspectives. The thesis has a strong connection to the single case and it also inflects to the research problem. That indicates the influence of pragmatism research philosophy. This thesis has interconnections also with other research philosophies; as a matter of fact, it would not be appropriate to totally exclude the viewpoints of realism and interpretivism from the thesis. The thesis has different kinds of data from workshops and interviews. Furthermore, the thesis aims at practically connecting the information through the DTC framework, which links it to pragmatist research philosophy.

According to Saunders et al. (2009) the two main research approaches to the analysis of the empirical data are induction and deduction. With induction approach data are collected and a theory developed consequently of the data analysis. With deduction approach a theory is developed and a research strategy designed to test the theory. (Saunders et al. 2009) Dubois & Gadde (2002) widen the view of research approaches by presenting an abductive approach which is a mixture of deductive and inductive approaches. They describe that when the researcher goes from one type of research activity to another and between empirical observations and theory, it broadens the researcher's understanding of both the theory and empirical knowledge. The method where theoretical frameworks confront the empirical observations as the case study proceeds has been termed *systematic combining*. (Dubois & Gadde 2002) In this thesis, abductive systematic combining is exploited as a research approach. The thesis connects a presented theoretical framework to empirical study findings and develops the framework as the case study progresses.

The systematic combining is based more on the improvement of the existing theories than on inventing new ones. The systematic combining forms "*fruitful cross-fertilization where new combinations are developed through a mixture of established theoretical models and new concepts derived from the confrontation with reality*". (Dubois & Gadde 2002) The applied systematic combining in this study is closer to an inductive approach than a deductive approach. The DTC framework has continuous interaction between theory and empirical results, but the empirical part is stressed more heavily.

According to Dubois & Gadde (2002) the case studies provide unique techniques to develop theory utilizing an in-depth insight of empirical phenomena and their context. The research strategy of the thesis is a single-case study, because the thesis acquires knowledge concerning DTC in the environment of tailored product manufacturing. Halinen & Törnroos (2005) present that a single-case study is often the only option when the holistic description is wanted and the objective is in the contemporary business environment.

According to Saunders et al. (2009), in the choice of the research method, the researcher should first decide whether to use either a mono method or multiple methods. A mono method is a single data collection technique and analysis procedure. Multiple methods include more than one data collection technique and analysis procedure. Multiple methods have two options: multi-method and mixed-methods. This thesis focused on multi-method research. Hence, mixed-methods are not discussed further. A multi-method refers to combinations where more than one data collection is used with the associated data technique. A multi-method has two options depending on whether the data are quantitative or qualitative. (Saunders et al. 2009) Figure 2 illustrates the research choices of the thesis.

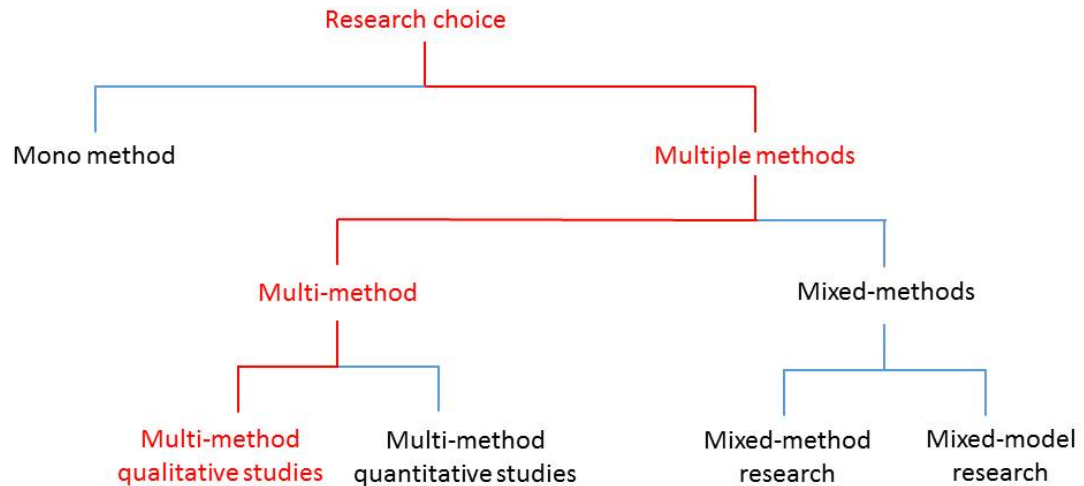


Figure 2. *The research choices of the thesis (adopted from Saunders et al. 2009, p.152)*

This thesis applies the multi-method qualitative studies as Figure 2 illustrates. A multi-method qualitative study refers to collecting qualitative data, for example, diary accounts and in-depth interviews and using qualitative procedures (Saunders et al. 2009). The data collection techniques utilized in this thesis are semi-structured interviews and workshops. According to Voss et al. (2002) the validity can be further increased through multiple ways of data collection. The collected qualitative data from interviewees will be categorized with the spreadsheet software program (Excel). Finally, the qualitative results from interview and workshop studies will be integrated into the DTC framework.

1.5 The key terms of the thesis

1.5.1 Procurement

Procurement, as a term, is often associated with other terms like sourcing, purchasing and buying. Furthermore, these terms are often used as synonyms for each other. (Van Weele 2010) Similarly Lendeers et al. (2006, p. 4) also present that terms like purchasing, material, materials management, procurement, sourcing, supply chain management, logistics and supply management are used nearly interchangeably. They argue that no agreement exists on the definition of each of these terms, and managers in private and public institutions may have substantially different titles but identical responsibilities.

For clarifying these terms and their interdependence, Figure 3 presents the procurement process model by Van Weele, which is widely utilized among experts in the field. The picture shows that these terms are closely correspondents to each other. Porter (1998, p. 41) uses the term “procurement” rather than “purchasing” because the usual implication

of purchasing is too narrow among managers: *”The dispersion of the procurement function often obscures the magnitude of total purchases and means that many purchases receive little scrutiny.”*

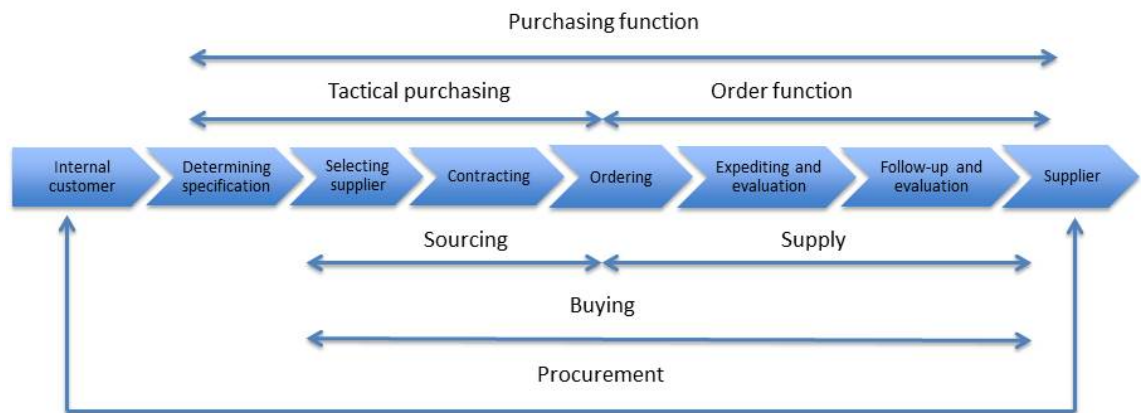


Figure 3. Procurement and some related concepts (adopted from Van Weele 2010)

Procurement refers to the function of purchasing inputs used in the company’s value chain. Purchase inputs include supplies, raw materials, and other consumable items as well as assets such as machinery, laboratory equipment, office equipment, and buildings. Purchased inputs are frequently associated with primary activities although purchased inputs are present in every value activity containing support activities. (Porter 1988) Procurement comprises the purchasing function, stores, traffic and transportation, incoming inspection, and quality control and assurance. Procurement allows firms to make supplier selection decisions on the basis of the total cost of ownership (TCO), instead of the price. Procurement is utilized when relating to buying based upon the total cost of ownership in a project environment. (Van Weele 2010)

The case company’s definition of procurement is: *“Procurement refers to all activities for the management of the supplier interface, being the highest level responsibility. Procurement deals with short, medium and long term issues of supplier management. It covers all supplier management activities, starting with sourcing and extending to include the purchasing transaction.”* Valmet uses the term procurement with quite an extensive meaning. However, Valmet’s definition of procurement is in line with Van Weele’s definition, yet it is broad and, at the same time, flexible. Hence, in this thesis, the term procurement is used according to Van Weele’s definition.

1.5.2 Design-to-cost

For the purpose of this study, it is necessary to clarify the concept of DTC. Michaels & Wood (1989) defined DTC as an acquisition management technique to achieve cost targets that meet the defined cost parameters. They insert that DTC can be described as a step by step process model which is intentional and iterative. Dean (1990) defined

DTC as a cost controlling method by establishing cost goals at specific levels of a work breakdown. After that he demands the project to do trade which will confirm that the product will meet those cost goals.

Gille & Kolkmeier (1990) share the idea of cost goals and describe DTC as a management technique for controlling cost by “designing to specific goals”. Two components of design to cost are: design the unit production cost and design to operate and support the cost. According to Williamson (1994), DTC was formally organized in 1985 under producibility of systems by Texas Instruments (Department of Defense). Texas Instruments define DTC as follows: “*An acquisition management technique to achieve defense system designs that meet stated cost requirements. The cost is addressed on a continuing basis as part of a system's development and production process. The technique embodies the early establishment of realistic but rigorous cost targets and a determined effort to achieve them.*” (MIL-STD-337 1989) Williamson (1994) successfully inserts that the definition comprises four concepts that are essential to the success of DTC. The concepts are:

1. DTC is a continual process
2. DTC demands the early establishment of realistic targets
3. DTC is a technique of management
4. DTC is a part of production and development process

These four concepts logically express all the others foregoing definitions of DTC. Hence, in this thesis, the original DTC definition of Texas Instruments will be applied.

1.5.3 Product development

At this point it is necessary to define product development to avoid confusion later on, because the case company commonly uses the term redesign in the context of this thesis. Desa et al. (1987) define redesign as “*the process of modifying or changing an existing design with the objective of improving one or more of its aspects.*” In their proportion, Krishnan & Ulrich (2001) define the term product development “*as the transformation of a market opportunity and a set of assumptions about product technology into a product available for sale.*” Eppinger et al. (1994) add that the product development mostly entails the redesign of the existing items instead of designing completely new items.

The term product development is the more widely used term in the academic field. Furthermore, the term product development in this thesis is used to describe the product development process in general, including the term redesign. The term product development in this thesis does not include the new product development.

1.5.4 Cost-effectiveness

The terms effectiveness and efficiency are frequently confused with each other. To avoid confusion later on, it is significant to define the meaning of cost-effectiveness in this thesis. According to Tangen & Stefan (2005), effectiveness is linked to the influence of the outputs of the productivity ratio and the creation of value for the customer. They add that the effectiveness is “*the ability to reach a desired objective*” or “*the degree to which desired results are achieved*”.

In this thesis, the term cost-effectiveness does not refer to trying to diminish the product cost. The focus is on understanding how to make tailored product manufacturing more cost-effectiveness. The cost-effectiveness is reached by improved and increased cross-functional collaboration inside Valmet and through inter-organizational collaboration.

1.5.5 Cross-functional collaboration

The cross-functional collaboration is a commonly used term in this thesis and it is one of the main factors behind the DTC process. Foerstl et al. (2013) defined the cross-functional integration as follows: the interaction and collaboration of the procurement and supply management function with other functions, such as production and manufacturing, product development and marketing.

For the purpose of this thesis, the cross-functional collaboration can be defined as follows: *the interaction and collaboration of the procurement function with other functions of Valmet*. The cross-functional collaboration is also a valuable way to diminish silo effect inside Valmet.

2. LITERATURE ON THE FACILITATING ROLE OF PROCUREMENT IN PRODUCT DEVELOPMENT

2.1 Organizing the procurement

2.1.1 The functional level of organizing procurement

The procurement function of the company is a conciliator between the external supplier and the internal customer. In several companies, the procurement function is still merely executing orders instead of actively trying to influence company demands. (Koppelman 1998, p. 4) The structure and location of procurement are highly dependent on situational factors and business characteristics (Van Weele 2010, p. 279).

Cavinato (1991) classified seven different procurement organization models: centralized procurement, decentralized procurement, a centralized coordinator, area planner concepts, supply manager concepts, commodity teams and logistics pipeline approach. Arnold (1999) simplified the definition of procurement organization models by specifying three general global sourcing models referring to different degrees of centralization. The first one is the central purchasing model which is useful for organizations with a high degree of centralization and with generally low international sourcing activities. The second is the coordination model which refers to the idea of cooperation among business units. The third is the outsourcing model which aims at enabling purchasing functions to source globally and maintain their autonomous and decentralized business units. (Arnold 1999)

Johnson & Leenders (2001) redefine the organization types of procurement by concluding the definitions of several authors (Trautmann et al. 2009b; Lendeers et al. 2006; Faes et al. 2000). Johnson & Leenders (2001) present three major procurement organization types: centralized, decentralized and hybrid structures. The previous definitions are clear but quite broad. Van Weele (2010) specifies the functional level of organizational structure by differentiating between of multi-unit and a single-unit company. For the purpose of this thesis, it is justifiable to concentrate on the organizational structure of multi-unit companies, because the case company is a global multi-unit company. Van Weele (2010) expounds that it should be decided on to what extent the procurement function is decentralized in a multi-unit environment. He successfully defines four different structures of procurement in multi-unit companies: decentralized, centralized, hybrid and cross-functional sourcing teams. This thesis focuses on decentralized, centralized and hybrid organizing forms of procurement and

their different team structures. The next paragraphs present detailed descriptions of these different forms of procurement function.

McCue & Pitzer (2000) present a completely centralized purchasing system. The model contains all the essentials procurement decisions and the responsibility of ensuring the integrity of the procurement process vested by the procurement agency. In the centralized procurement, coordination and communication stream from top to down and the centralization enhances internal and control program consistency. Furthermore, the responsibility for the actions of the individuals within the company is set by regulation and law. (McCue & Pitzer 2000)

Parikh & Joshi (2005) describe centralization of the organizational structure by the degree of hierarchy of authority. They also argue that when the level of centralization decreased, the employees gained more control and decision-making power over their small purchases. According to Lendeers et al. (2006 p. 36), centralization does not refer to where the procurement and supply staff are located geographically, because centralization indicates where spending decisions are made. Consequently, they argue that the amount of spend managed or controlled by corporate supply, is reflecting the degree of centralization. Corey (1978) found out that centralization is not right for every company. Van Weele (2010) presents that centralized purchasing structure also has a drawback: the management of the business unit has only restricted responsibility for the decisions on purchasing.

The decentralized organizational model consists of procurement being placed at field sites and these locations reporting directly to the general manager (Cavinato 1991). According to Johnson et al. (2006), decentralization provides control and autonomy for business units over key functional activities. Joyce (2006) describes that decentralized purchasing has the advantage of being more able to respond to “local” needs and it can offer a quicker response than centralized purchasing. On the other hand, decentralization is a risk in global sourcing. Arnold (1999) identified that one weakness of decentralization might be too small business units of procurement departments to purchase globally and in an efficient way. However, the centralization-decentralization issue is of key importance for the procurement structure in large corporates (Lendeers et al. 2006).

Many firms adapt to trade off corporate synergy in order to give their business units greater independence, from the 1980s till the early 1990s. Consequently, entrepreneurship at the business unit level was fostered, while, at the same time, corporate staff departments were slashed. (Rozemeijer et al. 2003) Joyce (2006) states that some corporates manage to take advantage of both decentralization and centralization by permitting individual units to handle certain items while centralizing other purchased items.

After all, one of the biggest issues for corporates in globally competitive markets is to conform their organizational structures and governance in growing complex organizations. By aiming at expanding global sourcing benefits, corporates are turning to hybrid purchasing organizations at the functional level of purchasing. (Trautmann et al. 2009a) Lendeers et al. (2006) also believe that in a hybrid organizational structure business units are partially decentralized and the supply function is partially centralized at the head office. Dubois & Wynstra (2005) define that the hybrid structure should allow selective opportunities to capture the benefits of both decentralization and centralization while ideally moderating the disadvantages.

Johnson & Leenders (2006) examined the high level change in the procurement organizations of large North American corporates by using the data from the large US and Canada procurement organizations in 1987, 1995 and 2003. They compared the procurement organizational changes between centralization, decentralization and hybrid (in different forms) structures. In 2003, they used a five-point scale: decentralized, decentralized-hybrid, hybrid, centralized-hybrid and centralized. The 1987 and 1995 surveys were conducted by a three-point scale; decentralized, centralized and hybrid. Consequently, in this thesis, in order to improve the comparable and relevance of the data, Figure 4 presents all the three years with the same three-point scale. Note that in 2003, hybrid organizational function includes decentralized-hybrid, hybrid and centralized-hybrid structure.

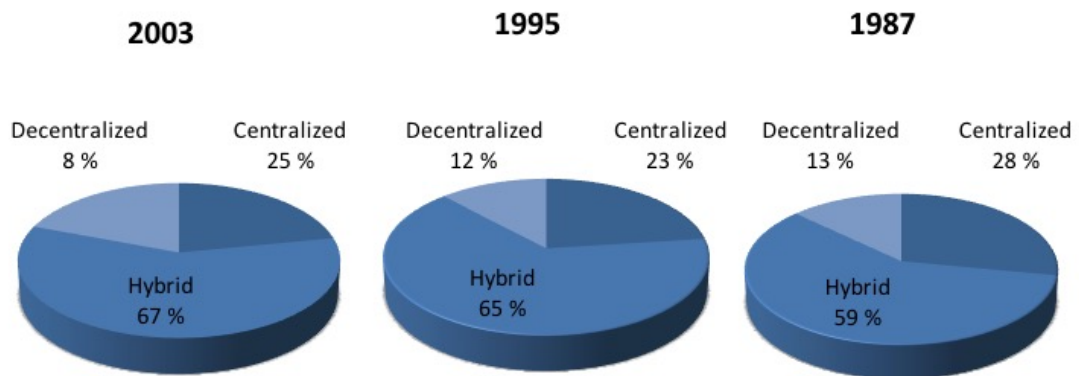


Figure 4. Procurement organizational structure in 2003, 1995 and 1987 (Adapted from Johnson & Leenders 2006; Johnson et al. 2006)

Figure 4 show that the decentralized structure has lost some of its importance during the examined years. The hybrid mode with 67% seemed to be the most popular in 2003, the centralization with 25% and decentralization with 8% seem to be quite far from hybrid organization function. Lendeers et al. (2006 p. 39) present that a change in overall corporate organizational structure is the reason for procurement organizational change. If the hybrid procurement structure has multiple benefits, it could be asked why the companies did not use it more. Lendeers et al. (2006) state that, in their research, none of the chief procurement officers' (CPO) had a free choice to select the procurement

organizational structure that was the most appropriate for the circumstances. The procurement organizational structure was forced to be similar to the overall corporate structure (Lendeers et al. 2006).

Rozemeijer et al. (2003) suggest that company procurement initiatives should be congruent with the level of maturity of the procurement function and the overall level of corporate coherence. Before continuing with the subject, procurement maturity and corporate coherence need definitions as terms. Van Weele (2010) defines corporate coherence as the extent to which the different parts of the corporation are managed and operate as one entity. Procurement maturity defined by Rozemeijer et al. (2003) reflects the level of professionalism in procurement at the business unit level. It is valuable to consider corporate coherence for the purpose of this thesis to diminish the organizational silo effect in Valmet.

Rozemeijer et al. (2003) implement five organizational model design rules, using the procurement maturity and corporate coherence, creating corporate advantage through procurement. In this model, corporates will use a more advanced and different approach to manage corporate procurement synergy when procurement function is highly mature, in comparison to a situation where procurement function is concerned with the problem of low procurement maturity. (Rozemeijer et al. 2003). The model presents a good overview of different organizational structures of procurement in variable situations. See Figure 5.

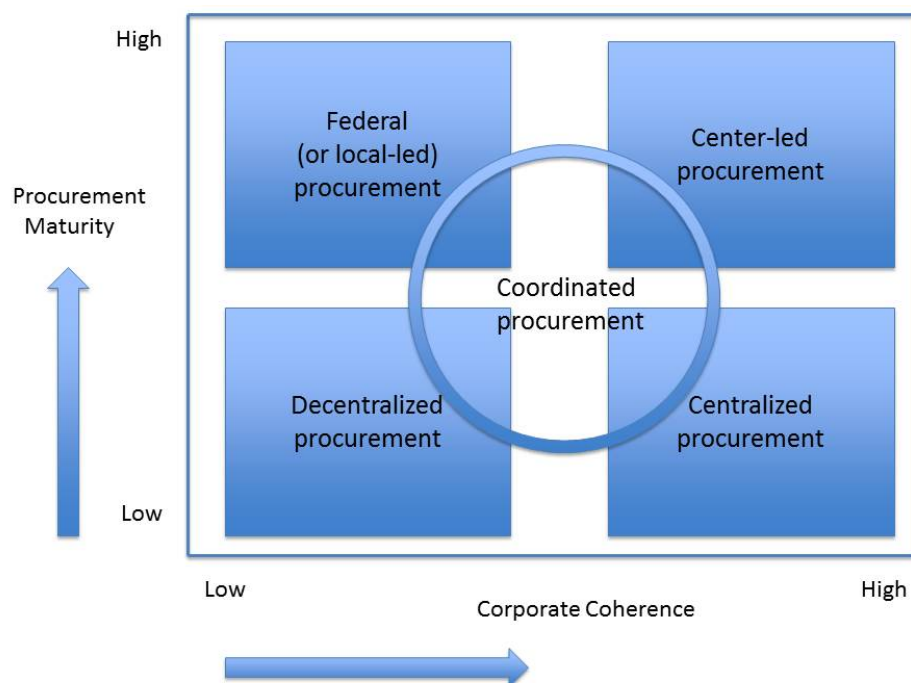


Figure 5. Procurement approaches (adopted from Rozemeijer et al. 2003)

In a situation where both the parameters; procurement maturity and corporate coherence, are low, decentralized procurement is the most probable option. In this situation, a little homogeneity in specifications across business units is expected. In the case where both procurement maturity and corporate coherence are high, center-led procurement structure is the most likely to be found. In this structure, co-ordination activities with the active support of the business units are conducted by cross-functional teams. If both constructs are medium, a hybrid structure with both voluntary procurement coordination activities and centralized procurement has good chances to succeed. The centralized procurement model is represented in organizations where corporate coherence is high and procurement at the operating corporate level is hardly developed. In a case where small corporate procurement staff support a number of autonomous decentralized procurement units in their voluntary efforts to conduct potential synergies, federal (local-led) procurement is to be chosen. (Rozemeijer et al. 2003; Van Weele 2010)

Corey (1978) presents several other situational factors affecting the choice of techniques to manage procurement. He summarized four relevant factors that drive companies to constitute stronger procurement functions:

1. Assure the long-term availability of needed resources and procurement shortages
2. Respond effectively to a changing business environment
3. The searching for improved performance of profit through the reduced costs of procurement
4. Need for increased professional development in procurement and for a more efficient use of rare talent in its multiply functions.

More than twenty years later Johnson & Leenders (2001) identified in their research quite like Corey (1978) that the environment and strategy influence the organization structure of procurement. They also describe that a conventional driver for company procurement organizational change is the attempt to improve its cost structure. As a result, the organization of the procurement function must be consistent with the company's structure and strategy. (Johnson & Leenders 2001)

Cavinato (1991) presents that the issue of decentralization, centralization, and to whom procurement reports is less important today than it was in the past. However, he says that the most relevant to the dynamics of the firm is that the rest of the company has equal goals to the procurement ones. The company is integrated with corporate-wide decision making process and it makes and evaluates its decisions according to the total cost and value (Trautmann et al. 2009a; Cavinato 1991). Trautmann et al. (2009a) also add that one of the key challenges is distinguished between categories to remain under the authority of each purchasing location in order to maximize procurement synergies and those to be integrated across the sites.

2.1.2 Procurement synergies with different business units

According to Rozemeijer (2000), the procurement challenge is to generate consciousness on how to structure and effectively manage procurement synergies between business units. When the field and significance of procurement increases, corporates increasingly recognize the necessity of co-ordination of their overall procurement efforts. Procurement synergies can give important benefits and even be in a vital role in some the corporate strategy of companies. (Rozemeijer 2000;Englyst et al. 2008). Rozemeijer, Smart & Dudas (2007) too, suggest that global coordination of procurement activities among business units is a logical step when exploiting the procurement synergies.

However, Englyst et al. (2008) remark that the leveraging synergies of global procurement are not straightforward tasks and comprise more than only centralizing the procurement function. Rozemeijer et al. (2003) suggest that for realizing purchasing synergy across business units, the interaction among four main stakeholders within the corporate is crucial. These four stakeholders are the CEO or top management, chief purchasing officer, business unit managers, and the business unit purchasing managers. To sustainably manage the purchasing synergy, they all have their specific roles and responsibilities. To facilitate this interaction, companies may use formal organizational mechanism, informal networking mechanism, advanced management and control systems and advanced company wide purchasing information and communication systems. (Rozemeijer et al. 2003)

Rozemeijer et al. (2003) present that the higher the competitive pressures to reduce costs, the more measures are taken to constitute stronger corporate purchasing functions. Corey (1978) was one of the first researches who found out that there is a relation between the corporate purchasing strategy and the business context. In the study by Smart & Dudas (2007), a problem concerning procurement synergy is presented in a situation where a large number of suppliers provide similar or duplicate commodities to different business units. According to them, in that situation product descriptions had the lack of harmonization and more significantly, the absence of a model or method for recognizing opportunities for synergy. After this consideration, decentralized purchasing decisions could be seen as negative concerning the benefits of synergy. Englyst et al. (2008) present that the corporate need to maintain an integrated procurement function that helps the leverage synergies and emphasizes the value of distributed interest while assigning each business unit the necessary consistency to adapt their particular environments.

In a study by Trent & Monczka (1998) as well, the number of procurement teams organized by the final product or other hybrid structures continued to increase. According to them, this shift towards the end-item and other hybrid structures is reflected in the growing need of procurement to become more integrated with other

functions of the organization. Johnson & Leenders (2006) defined that teams are a common approach to focus resources and the skills of multiple stakeholders on a specific task or objective, such as improved quality and lower cost. Trent (2004) argues that teams are important elements of current organizational structure. Johnson et al. (2002) highlight in their survey that the company's manufacturing of discrete goods used more extensively internal teams and councils than firms in the service sector.

2.1.3 The cross-functional teams

Van Weele (2010, p. 287) defines cross-functional commodity teams as teams consisting of professionals in product development, marketing, production, research and development, finance and distribution, together with procurement professionals. Koufteros et al. (2005) adapt Van Weele's definition of cross-functional teams by adding that the team members are the carefully selected array of specialists who make process, manufacturing and product decisions and share information, together and simultaneously. Gelderman and Van Weele (2005) present that cross-functional team participation should foster awareness, improved communication and integration of the procurement function with other functional groups in the corporate. In order to achieve better integration of cross-organizational teams, Paulraj et al. (2006) suggest that procurement function needs to proceed to the highest strategic level. In a study by Koufteros et al. (2005), cross-functional teams provide a mechanism for capturing learning, an opportunity to reduce equivocality, and a path to constituents to express affairs.

Trent (1998) remarks that teams are the convenient response when the companies encounter complex business decision requiring efforts of more than one individual. He also suggests that the competitive position of an organization is directly affected by the outcome of the assignment because important assignments can justify resources demanded to support teams while motivating team members. Instances of logical procurement team tasks include supplier development projects, source selection and evaluation for strategic items, commodity strategy development, and joint quality improvement initiatives and cost reduction with suppliers (Trent 1998).

Although teams can yield multiple benefits to the corporate, according to Trent (2004) teams have some disadvantages. For example, teams can waste energy and time of their members, and execute lower rather than higher performance norms. Trent & Monczka (1998) also add that the greatest challenge that cross-functional procurement teams can confront is to get non-procurement members and functions to support the team tasks. Because of procurement teams, assignments are usually part-time and members work reporting on a matrix structure (Trent & Monczka 1998). Englyst et al. (2008) define that it is significant to consider motivation at both theoretical and practical level. They remark that the difficulty is to align the goals for team members within the commodity

teams with other goals, including a team member's own career aspirations. The result is that they are motivated to participate in the procurement activities.

2.2 The role of the procurement function in the product development

Companies are nowadays forced to develop products in a shorter time with higher quality than formerly because of the pressure from the markets. The role of procurement in product development has received increased awareness during the past years (Lakemond et al. 2001). One reason for this increased attention is that the procurement function can contribute to the company's strategic position (Dowlatshahi 1992; Humphreys et al. 2000). According to Birou & Fawcett (1994) another reason for this increased awareness is that product development has a growing focus to survive in a competitive environment. Koufteros et al. (2005) remark that the complexity of the business environment adds equivocality. They present that constituents find it difficult to cope with ambiguity despite the availability of information.

Lakemond et al. (2001) state that product development processes are often carried out by project teams. The technical success is linked with effective communication over product development (Koufteros et al. 2005; Hartley et al. 1997). Olson et al. (1995) remark that product development projects need the participation of many functional specialists. According to Trent (2004), teams are a significant element of current organizational design. Each segment; for instance, emphasize product development teams that include supply and procurement representatives. Collocation of procurement personnel will become a significant part of the organizational design structure. (Trent 2004)

Koufteros et al. (2005) define that corporates may refine their product development processes to increase integration and knowledge sharing because of the surge of environment uncertainty and equivocality. In a study by Olson et al. (1995), the highest degree of horizontal coordination in the corporate is provided by teams. Lakemond et al. (2001) successfully add that project development teams do not have to be dedicated teams, because engineers tend to be involved in more than one project team when product development resources are limited.

Schiele (2010) describes that the professionals of procurement should be included in development processes and new product development teams when the intention of the company is to incorporate supplier innovations into the company while, at the same time, confirming the commercial viability. Procurement can be involved in product development projects in different ways. Birou & Fawcett (1994) identified five facilitating roles of procurement in the product development process; building more durable buyer-supplier relationships, facilitating better and more consistent

communication, cataloguing supplier's technical and design expertise, contribute to early supplier involvement and developing environment that makes suppliers invest in product development capabilities. Lakemond et al. (2001) argue that purchasers can be integrated into the project development projects full-time or part-time when purchasers may be involved in other development projects or may perform operational procurement activities. They remark that when additional coordination activities are needed, a purchaser takes a coordination role with a project team, and may be supported by other purchasers in the procurement structure. However, in this thesis, the way of Lakemond et al. (2001) to involve procurement in the product development process is adopted. Lakemond et al. (2001) present six possible configurations to involve purchasers in product development processes. See Figure 6.

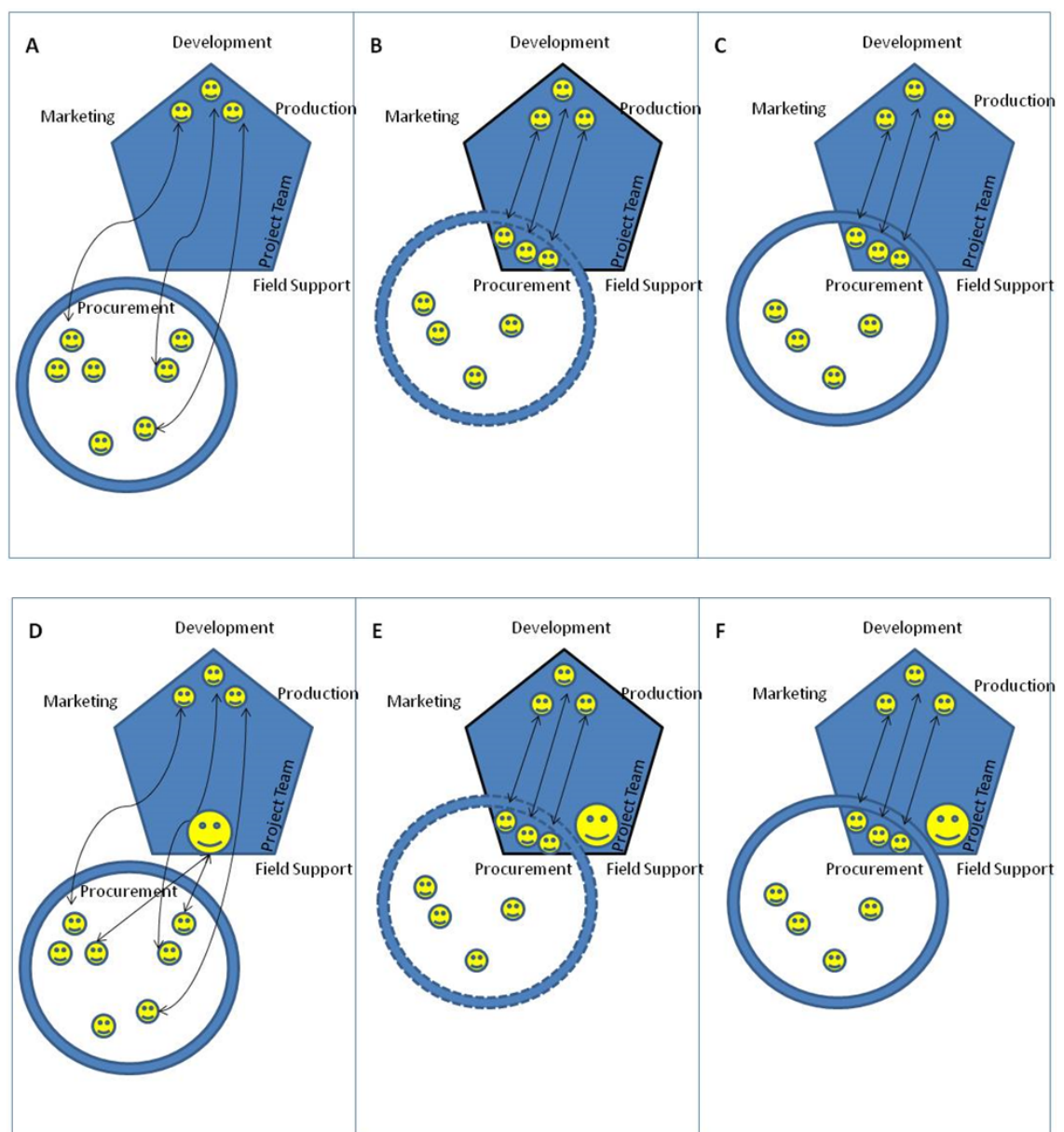


Figure 6. Configurations of procurement involvement in product development projects (adopted from Lakemond et al. 2001)

These six possible configurations are:

- A. Procurement specialists are contacted externally to the project team on an ad hoc basis by engineers.
- B. Procurement specialists are integrated on a part-time basis into the project team and work closely with an engineer concerning specific materials/parts/technologies.
- C. Procurement specialists are integrated on a full-time basis into the project team and work closely with engineers concerning specific materials/parts/technologies.
- D. A procurement coordinator is added to the members of the project team and takes care of coordinating purchasers external to the project team.
- E. A procurement coordinator is added to the members of the project team in combination with part-time integrated procurement specialists.
- F. A procurement coordinator is added to the members of the project team in combination with part-time integrated procurement specialists.

Alternatives A, B and C offer opportunities for the more in-depth and dedicated project involvement of procurement specialists. Increasing purchaser involvement is expected by ascending the degrees of project innovation. When the project has a high level complexity or a long duration, it is expected to drive the need for procurement specialists. However, alternatives D, E and F approve higher degrees of coordination. After all, it could be said that some configurations of procurement are more suitable for certain projects than others. (Lakemond et al. 2001) Trent & Monczka (1998) are in the same steps with Lakemond et al. (2001) and they present that some organizations have developed a commodity and product focus on their procurement department. These six possible configurations to involve purchasers in product development processes are a practicable way to understand the role of procurement in the product development. However, this Figure 6 will be used in the thesis semi-structured interviews later on.

Weak communication can affect many problems among functional teams during the technology development process. Hartley et al. (1997) present that weak communication among functional teams can lead to product-related technical problems along with project-related technical problems, for instance missed due dates. In the best scenarios, Trent (2004) successfully presents that product development teams can rely on the procurement to identify suppliers with production needs or early design involvement, question specifications, monitor supply trends and markets, and help production to achieve its target cost. Olson et al. (1995) agree with Trent (2004), and add that each specialist must believe that the members of other functional departments do their jobs effectively so the team can reach its collective aim. In the study by Lakemond et al. (2001) it was found that it is a benefit to recruit purchasers with R&D background. They also add that skills and the competencies of the purchasers appeared to facilitate procurement involvement in product development.

Lakemond et al. (2001) remark it is significant to note that procurement function does not have to coordinate all the contacts with suppliers. Other internal departments, such as manufacturing and R&D, may have substantial knowledge about supplier markets and they can have an important role in coordinating the involved suppliers. Above all, procurement department never commits suppliers solely; it is an integrated task and carried out by several business functions, in alternative constellations. (Lakemond et al. 2001)

Carr & Smeltzer (2000) realize in their study considering different skills that between procurement skills and corporate's performance the most important category of skills is technical skills. They also remark that procurement professionals are expected to be able to communicate intelligently technical ideas when they are related to technical activities. When it comes to the role of procurement in product development it can be said that technical skills are quite important to purchasers who work in product development teams. Lakemond et al. (2001) have also noticed the same as Carr & Smeltzer (2000), whereupon they remark that advanced skills and competencies of purchasers may facilitate the procurement involvement in product development.

However, it is always important to observe both the counterparts, the whole entirety in commitment. Wynstra et al. (2000) present, that it does not matter how proactive or technically skilled the purchasers are if, in the product development projects, their counterparts, (development engineers), do not perceive purchasers being capable of adding value to the project. In these circumstances, the involvement of the purchaser will not be efficient. Dowlatshahi (1992) remarks that the essential and the most important prerequisite between procurement and product development is the elimination of walls. However, he inserts that the effective dialogue between procurement and product design can only occur when the walls and barriers – the whether real or imaginary- are removed.

2.3 Suppliers' involvement in product development

It is valuable to consider mechanisms which facilitate the creation of new innovations by and with suppliers. Azadegan & Dooley (2010) present that supplier innovativeness has positive impacts on the manufacturer's quality, cost, delivery, product development and flexibility performance. They remark that it is beneficial to the two partners to have opposite learning styles when the outsourcing involves low levels of design responsibility. Alternatively, if the outsourcing is design-intensive, it is beneficial to have a supplier with an explorative learning style. (Azadegan & Dooley 2010) An illustrative example of an outsourced design-intensive option is product modularity.

Mackenzie & DeCusatis (2013) appointed that companies producing modular products are increasingly outsourcing selected components to achieve both enhanced innovation benefits and reduced costs. Lau (2011) remarks that as product components or modules

are outsourced to suppliers, supplier involvement becomes more significant to specify and create modular products. Song & Di Benedetto (2008) add that when a highly innovative product is developed, the manufacturer seeks information from suppliers in order to shorten product development time and to reduce the costly design changes. A study by Squire et al. (2009) compressed the result of Song & Di Benedetto by indicating that the supplier's flexibility, responsiveness and modularity directly affect company responsiveness. Sanchez & Mahoney (1996) defined modularity: "A special form of design which intentionally creates a high degree of independence or loose coupling between components design by standardizing component interface specifications." To understand the value of supplier innovativeness, it is useful to look at supplier commitment.

The involvement of the supplier promotes the development and sharing of technological expertise, network effectiveness and better resource utilization (Birou & Fawcett 1994). Wynstra et al. (2001) defined conditions for successful supplier involvement. According to them, there are three issues that the manufacturer seems to be facing in achieving efficient and effective supplier involvement. These three issues are: 1) Identifying specific processes and emission that need to be carried out, to support at the integration of product development and procurement 2) Forming an organization that embraces the execution of such tasks 3) Employees which have the right commercial, social and technical skills. (Wynstra et al. 2001) However, it is also valuable to look at different ways to manage supplier collaboration at different stages in the development process.

In a study by Lakemond et al. (2006) there are three general types of supplier coordination typology. The first is an integrated way of working where information is changed on a continual basis. The second is an ad hoc approach; the supplier is contacted when a problem occurs. The third is based on a more independent role of supplier. The three types of coordination are presented in more detail below. See Figure 7.

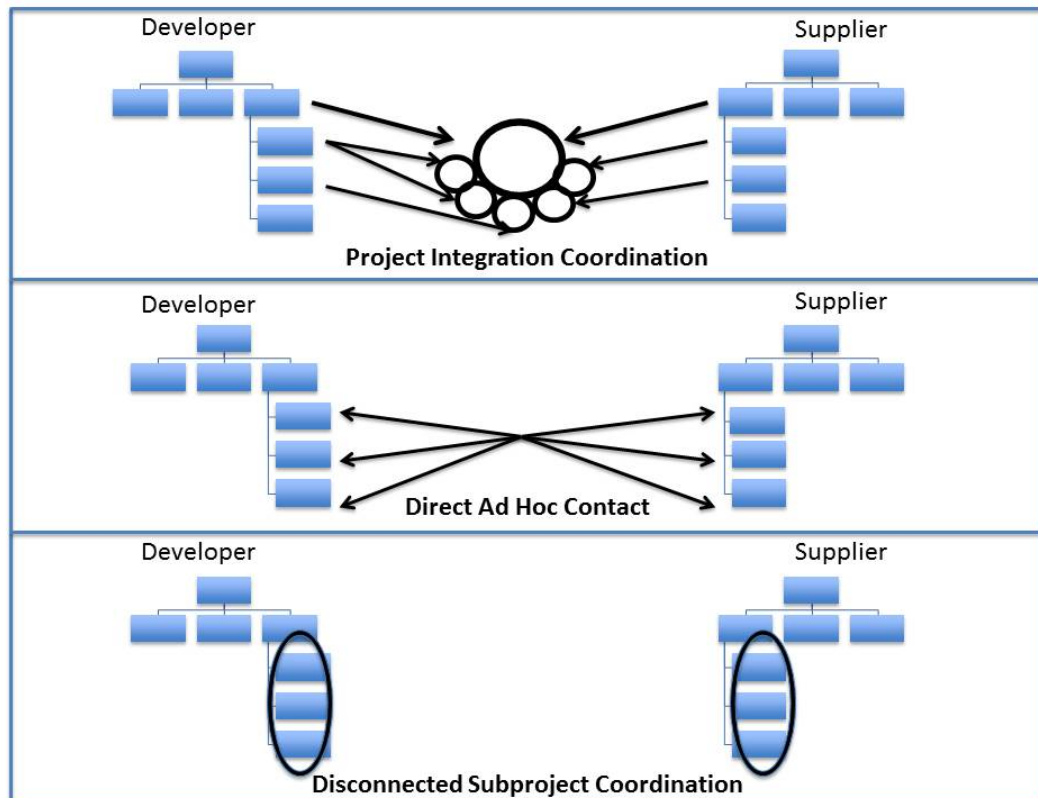


Figure 7. Approaches to involve suppliers to product development projects (adopted from Lakemond et al. 2006)

The first coordination type, project integration coordination, indicates an interactive way of working with a supplier. The supplier becomes part of the product development team and executes its tasks in close collaboration with the development firm. As an opposite of the project integration coordination, the second coordination type refers to incidental contacts. The direct ad hoc coordination implies a situation where a purchaser from the developer company directly contacts his or her counterpart in the supplier organization. The third coordination type, disconnected subproject coordination refers to a circumstance where a supplier designs a task that is executed relatively independent of the developer company. (Lakemond et al. 2006) Furthermore, it is necessary to understand that even if a company has the right suppliers or correct involvement type, it is not a pledge of the success of product development. This Figure 7 will be used in the thesis semi-structured interviews later on.

According to Tsai et al. (2012), firms that encourage supplier collaboration as an end in itself but disregard adequate technological capacity and promotion capacity, or neglect changes in technological environments may not achieve their intended objectives in product development. However, it is valuable to notice that supplier collaboration is not always a benefit. Tsai et al. (2012) identified that supplier collaboration is not so effective when technological knowledge changes very quickly.

Furthermore, it has been argued that it is difficult to execute the apparently positive outcomes of supplier involvement in product development (Wynstra et al. 2001; Wagner & Hoegl 2006). Wynstra et al. (2001) present that problems in managing suppliers to product development may be attributed to the relation between a manufacturer and a supplier, the manufacturer itself and the supplier. Croom (2001) identified a number of critical causal factors in managing supplier involvement. According to Croom, for example, the supplier might not be acquainted with the peculiarities of the developer company's operation processes and the particular technical requirements.

Aminoff et al. (2015) identified how companies could promote or have an access to supplier innovations or identifying innovative suppliers. They present three sub-themes which address stimulating suppliers to innovate. The first is the creation of a new innovation which promotes the suppliers' creation of new innovations. Rowley et al. (2000) indicate that an inherent relationship with a customer motivates the supplier to use its own knowledge to develop innovations that meet the buyer company's needs. On the other hand, the supplier may perceive a risk that the buying company will use supplier information to vertically backward and contend with the supplier (Noordhoff et al. 2011). The second sub-theme is sharing innovations, which refers to how suppliers could share their innovations with the buyer companies.

Ellis et al. (2012) identified that the preferred customer status is positively associated with the willingness of suppliers to share new technology with the buyer company. They also demonstrate to procurement managers the importance of reinforcing their company's image as the best buying company for suppliers. Schiele (2012) adds that all suppliers are not willing to cooperate with the buying companies, which is why it becomes important to achieve the preferred status with the key suppliers. He argued that companies which are unsuccessful in becoming preferred buyers of leading suppliers may find it difficult to advance technology leadership. Furthermore, Wagner & Bode (2014) investigate which conditions the suppliers are willing to provide for the buying companies with innovative ideas. Their study results highlight that suppliers are more likely to share process innovation and are less hesitant to share product innovation with customers when the relationship-specific investments go along with long-term and strong buyer-supplier collaboration.

The third sub-theme is pulling innovations, which concentrates on pulling innovations from suppliers. Song & Di Benedetto (2008) present supplier involvement to radical innovation performance, which is an illustrative example of pulling innovations from suppliers. They identified that the supplier's high level of specific investments encourages the latter to risk losing most of the investments or to stay involved in the relationship. Mackenzie & DeCusatis (2013) express that companies which outsource multi-technology components face the challenge of how to sustain innovation over direct control in the long run. They highlighted actions that outsourcing companies can

use to develop closer relationships with component suppliers: a multi-year contract, the exchange of intellectual property, ensuring information flow, and technological roadmaps as a means of developing a shared view of the future. Similarly as supplier capability is an important part of the efficient product development process, customer requirements are that as well. The customer needs are one of the main parts of successful product development process. Therefore, the next Chapter presents the anticipation to the customer needs.

2.4 The anticipation to the customer needs

Gummesson (2002) expresses that, today, the concept of quality interprets the customer perceived quality especially, meaning that it focuses on the customer satisfaction and is marketing-oriented. The appreciation of the customer is the starting point of profitable business. According to Ravald & Grönroos (1996), a satisfied customer is supposed to stay loyal to the company for a long time and to buy more than other customers. Companies can no longer integrate their processes and resources only internally. They have to integrate internal processes and resources with their key customers, ending up to a co-creation view of value (Zhang & Chen 2008).

The importance of collaborating with customers in the development of innovative products has been identified many years ago. However, collaboration with customers has become a major component of many organizations' development efforts. (Greer & Lei 2012) The role of the customers is changing and companies see customers more and more as a source of knowledge. According to Lichtenthaler (2008), companies learn from their customers and new technologies push towards open forms of innovation and cooperation with customers. For companies, it is valuable to get the customers to participate in product development.

Lagrosen (2005) presents a framework for customer involvement at the different levels of the relationship. According to Ford et al. (1998), the level of closeness with the customer can be separated at the three different levels of relationships: transactional, facilitative and integrative. The transactional relationship involves no integration between the customer and the supplier. The facilitative relationship includes the customer's wishes to acquire undifferentiated products at the lowest cost but both the parties are anxious to invest in activity links. The integrative relationship involves the customer's expectations of the benefits due to lower costs on one hand and increasing business opportunities on the other. These different Ford et al. (1998) levels of relationships are exploited in the framework of Lagrosen (2005). The framework could give some instructions to product development at different levels of the relationship and the suitable methods. The methods for customer participation are presented in Table 1.

Table 1. Customer involvement in product development at different levels of relationship (adopted from Lagrosen 2005)

Level of relationship	Longitudinal customer involvement	Lateral customer involvement	Suitable methods
Transactional	Only in the early phases	Design for the customer	Observations, focus group interviews, surveys
Facilitative	In the early phases, in the testing phase and occasionally in the other phases	Design with the customer	Delphi methods, QFD, prototype testing, team customer visits
Integrative	In all phases	Design by the customer	Integrated product development teams including representatives of both the supplier and the customer

Lagrosen (2005) divides the methods of customer participation by the level of relationship. The customer involvement can exist at three different levels. Kaulio (1998) proposes that customer involvement to product development is based on two dimensions: the longitudinal dimension and the lateral dimension. The longitudinal dimension includes the points of interaction between the design process and the customer. The lateral dimension explains how deeply customers are engaged in the design process. The categories of lateral dimension can be separated in the following way:

- “Design for” signifies an approach where products are designed on behalf of the customers.
- “Design with”, where in addition to the above customers can react to different proposed design solutions.
- “Design by” denotes an approach where customers are actively involved and participate in the product design.

Enkel et al. (2005) remark that inherent risks of customer integrations should not be neglected. They list that the possible risks may cause the company’s loss of know-how to the customer, the company being limited only on the incremental innovations and the company’s dependence on customers. Risks always exist in customer integrations, but Lagrosen (2005) implies that for the seller companies, a high level of interaction is certainly worthwhile in most relations in the business to business environment.

However, it is valuable to understand suitable methods for customer involvement in different situations. Large companies mainly use formal tools for customer involvement. At the first design stage, suitable methods are observations, surveys and

focus groups. (Lagrosen 2005) At the second stage, design with the customer, the aim is to maintain a formal dialogue with customers, for example beta and prototype testing. At the third design stage, customers are actively included in the process of selecting and developing different solutions, for example through a small group exercise. (Kaulio 1998)

In a study by Lagrosen (2005), the product development process is more systematic in larger companies where it consists of specific stages. His findings indicate the value of cross-functional teams. The ideal case is that the customers should be involved in the teams. Ramani & Kumar (2008) express that good customer relationship management between industrial customers and manufacturing companies encourages customers to provide important suggestions for improving the products.

In conclusion, a company will succeed well if it integrates customers and suppliers in order to optimize the total performance of all the members in the supply chain. (Tsai 2009; Zhao et al. 2011) In a study by Lau (2011), the supplier and customer involvement are highly integrated. He adds that when a company develops supplier involvement, it authenticates a good foundation for customer participation and vice versa.

2.5 Proposed framework for the analysis of empirical results

Several scholars have identified that 70%-80% of the product costs are already caused during the product design process (Weustink et al. 2000; Dowlatshahi 1992; Abdalla & Knight 1994). As a consequence, Weustink et al. (2000) remark that most of the opportunities for the cost decrease have passed after the design process has been completed. They continue by saying that, during the design process, it is important to have knowledge about the cost impacts of decisions. The manufactured product cost is typically caused by four main stages: design, manufacturing, procurement (materials) and administration (sales). However, 70% of the production cost of a product is formed during the design stage. Meanwhile, it can be recognized that the design stage itself caused only 6% of the total development costs. (Shehab & Abdalla 2001; Abdalla & Knight 1994) See Figure 8.

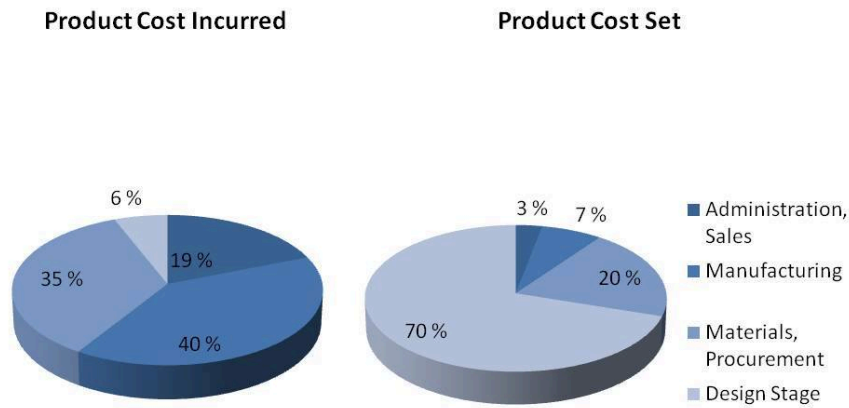


Figure 8. Product costs in different phases (adopted from Shehab & Abdalla 2001)

The cost targets are set in the early phase of product definition. Therefore, reasonable cost estimations are critical for defining DTC goals. Cost estimation is associated with the assertion of the costs related to the series of activities before they have actually been finished. Cost estimating approaches can essentially be classified as intuitive methods, generative cost estimating models, parametric techniques and variant based models. Many cost estimating methods, at the design stages, are based on knowledge bases, operations, features, similarity laws, material and physical relationships. (Shehab & Abdalla 2001)

Rehman & Guenov (1998) describe a method for modelling costs through the design phase of the product's life-cycle, from abstract to detailed design. Their research of design assessment has a benefit to encourage designers to design to cost and decreasing the amount of design rework. Eversheim et al. (1998) developed generic methodology to combine cost modeling and quality function deployment in order to estimate the potential trade-off between costs and performance for competing product alternatives at the early stage of the production system design process. Their cost model evaluates the system design instead of a single component design.

It can be noticed that there is a shortage of research considering the existing literature on how to improve cost-effectiveness in the tailored product development process with the help of cross-functional teams. As a matter of fact, after the literature research it can be said that there is no framework exactly fitting the purpose of this thesis since the existing literature on DTC has been oriented towards mass production contexts. However, the proposed framework for combining procurement and product development will be formalized on the basis of various kinds of models including views on cost estimating, product development and cross-functional teams.

A few cost estimating models have established their position in the field of product development research. One example is a target costing process resembling the idea of DTC. According to Ellram (2000), target costing is a *“process whereby an organization*

develops specific goals, or targets, for its costs to produce a good or service. The target costs are based upon desired profit margin and projected selling price for the good or service, and reasonable estimates of what the item or service should cost.” The target costing is more pricing oriented than the DTC process.

The target costing process includes earlier supplier involvement and concurrent engineering. The focus is on creating a product that is both desirable and affordable for the customer and profitable for the producing company. (Ibusuki & Kaminski 2007; Ellram 2006; Helms et al. 2006) Ellram (2000) presents a well-defined target costing process model. She also adds that target costing is an integral process in the larger process of product development and it can be used in developing new products or improving existing products. Figure 9 demonstrates the target costing process model in a study by Ellram (2000).



Figure 9. *The target costing process (adopted from Ellram 2006; Ellram 2000)*

The target costing process model includes 6 stages. The first step identifies a need in the marketplace and identifies the product that will fulfill that need. In step two, the highest selling price for the customer is established. The third step determines the allowable target cost. In step four, product costs are broken down hierarchically. After the costs are assigned at high level, they are then broken down by an individual component, material or service level. Step five is the most time-consuming and resource-intensive step of the target costing process. Step six indicates when the company has achieved the target costs and step six involves continuous improvements efforts. (Ellram 2000)

In this thesis, the design of a DTC framework closely followed the guidelines laid down by Ellram (2000) in her target costing process. In addition, the framework will be

formed and supplemented with divergent models which are based on product development, cross-functional teams and decision-making process. The content of each phase is described in more detail in the following paragraphs. The first phase of the framework will be *preparation phase*, which includes the identification of the target and it is on line with the target costing model of Ellram. Identifying product characteristics in the first step is preferred among the target costing models (Filomena et al. 2009; Ellram 2006) and also in the decision-making models (Humphreys et al. 2002; McIvor et al. 1997).

Effectively implemented, target costing requires active teamwork and support from each member of the company (Zengin & Ada 2010; Castellano & Young 2003). Ax et al. (2008) add that teams have various methods and tools available in order to achieve their objectives. The frequently used tools and methods, according to Cavalieri et al. (2004), include functional analysis, value engineering, design for manufacture and assembly, quality function deployment, and functional analysis. Platts et al. (2002) successfully present a decision making model, where the first phase also includes selection and briefing of the project team. McIvor et al. (1997) argue that the cross-functional team has to focus their attention on the customer needs and the competitive advantage. They define that the core activity of the corporate is to successfully serve the needs of the potential customers in each market. The activity is observed by the customers as increasing value and consequently being a major determinant of competitive advantage (McIvor et al. 1997). Ellram (2000) also recognizes the importance of customer needs but customer needs are not mentioned in the target costing model phases. In conclusion, the first phase in this thesis also includes selection of the cross-functional team and analysis of the customer needs.

Steps two and three in the target costing process of Ellram diverge too far from the purpose of this thesis since these steps are absorbed in the cost accounting. Therefore, steps two and three will be passed. Weustink et al. (2000) argue that if a product structure is available, it is clearly advantageous to relate the cost information of a product to the same structure. A product can be represented by utilizing the elements and relationships between those elements. Ibusuki & Kaminski (2007) combine product development and cost management in their model. They successfully present an analytic stage, where the following steps are accomplished:

1. Identify and define functions of the product, in correspondence with the functional analysis, which uses active verbs and measurable substantives.
2. Classify functions as main or secondary.
3. Construct the functional structure of the product.
4. Estimate the cost of functions.

Weustink et al. (2000) define a framework for effective cost estimation and cost control in product design in more detail. It is only useful to allocate costs to physical product

elements. Because of function integration, modularization and standardization, it is almost impossible to allocate manufacturing costs to non-geometrical elements. Their framework is based on the four cost driving product characteristics (material, geometry, process and product planning). It is a systematic method, applied during the design process to control the costs. (Weustink et al. 2000) This framework is presented in Figure 10.

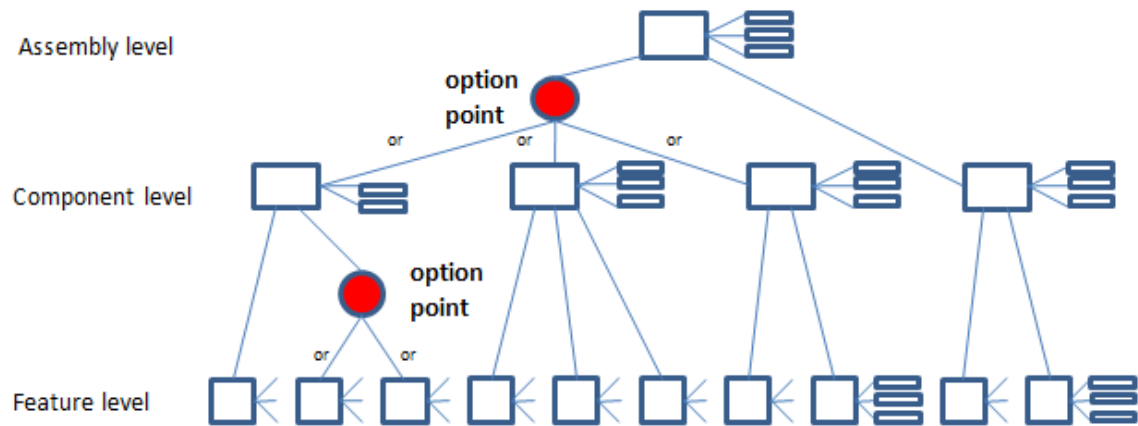


Figure 10. Option points with the aim of choosing between design alternatives (adopted from Weustink et al. 2000)

The high value of the cost attribute processes at the feature level can be caused by the material of the component and the geometry of the feature. The costs of the different design alternatives can be compared easily. The conclusions about producing in-house or buying standard, semi-standard or semi-manufactured products can be made by using the values of cost attributes. (Weustink et al. 2000) Filomena et al. (2009) add that when the product is an original design, the only way to break down the target cost is to use the experience of the company's team, and that experience gives the internal and external lack of information to the corporate. A framework of Weustink et al. includes steps four and five from Ellram's model. Phase two is *design-to-cost activity*, which includes different steps of Ibusuki & Kaminski's model and Weustink's model dealing with cost breakdown to the detailed level of the component.

Ellram (2000) presents that when a corporate has achieved the target cost, the next logical step contains: product rollout, target cost monitoring, and continuous improvements. In this thesis, the product rollout and cost control are included in phase three. The phase three is *implementation and evaluation*. Park & Simpson (2005) defined a production cost estimation framework, where the last step of the framework estimates the production costs by connecting them together in a structured way. They also analyzed the activities developed in the production system to find any resources to be shared, selected, reduced or eliminated. The manufacturing input can be seen as an

important part of the DTC process. Therefore, phase three includes the manufacturing input to the DTC process as well.

The result of this literature review can be formulated into a DTC framework. The framework consists of three phases as Figure 11 shows. The first step is the preparation phase where the right DTC target is identified, customer needs are analyzed and the correct people are selected for the cross-functional team. Phase two is the specification of the DTC object, with a view to formulate cost break down to the detailed level of components and to compile all the necessary changes. The last phase is implementation and evaluation. This phase includes the cost control of the DTC object. Manufacturing gives its input on how to find resources to be shared, eliminated and selected in the future, for example what could be done better and why.

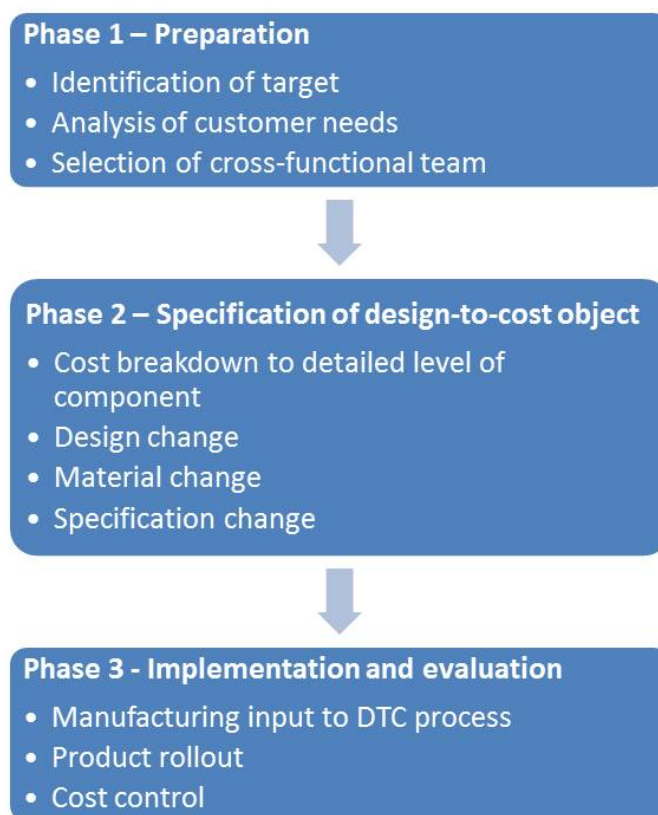


Figure 11. A generic DTC framework based on literature review

This proposed generic DTC framework takes into account the internal affairs of the company. However, it would be good to observe the role of procurement, and the potential added value of suppliers and customers in the DTC process more closely. The literature review did not provide clear solutions to these open questions. The empirical part of this thesis strives to answer these open questions and gives a detailed description of the role of procurement in product development.

3. LINKING INTERVIEW STUDY RESULTS TO THE DESIGN-TO-COST FRAMEWORK

3.1 Data collection and analysis methods

The empirical part of this research consists of two main phases. The first phase is based on qualitative interviews. The second phase is constructed by workshop studies, which are presented more precisely in Chapter 4.1. The interviews of this study are semi-structured interviews. According to Saunders et al. (2009, p. 324), a semi-structured interview provides an opportunity for interviewees to lead the discussion into areas that the researcher had not previously considered but which are important to understand. They also present that the interviews give each interviewee an opportunity to think about issues they may not have thought about before.

The interviewees represented Valmet's four different functions: procurement, research & development, production and engineering. The interview questions were allocated beforehand taking into account what function an interviewee represented. As a consequence of the interviewees' different backgrounds, the semi-structured interviews were based on three divergent questionnaires: procurement, product development and production. The product development questionnaire was applied for both engineering and research & development functions. Engineering and R&D functions represent almost the same viewpoint to the DTC process and that is the reason why these two were connected together. The themes include background information about the interviewee, the role of procurement in product development, supplier relationship management, the DTC, and production topics. Figure 12 illustrates the segments of the interview structure and the literature sources for the different themes.

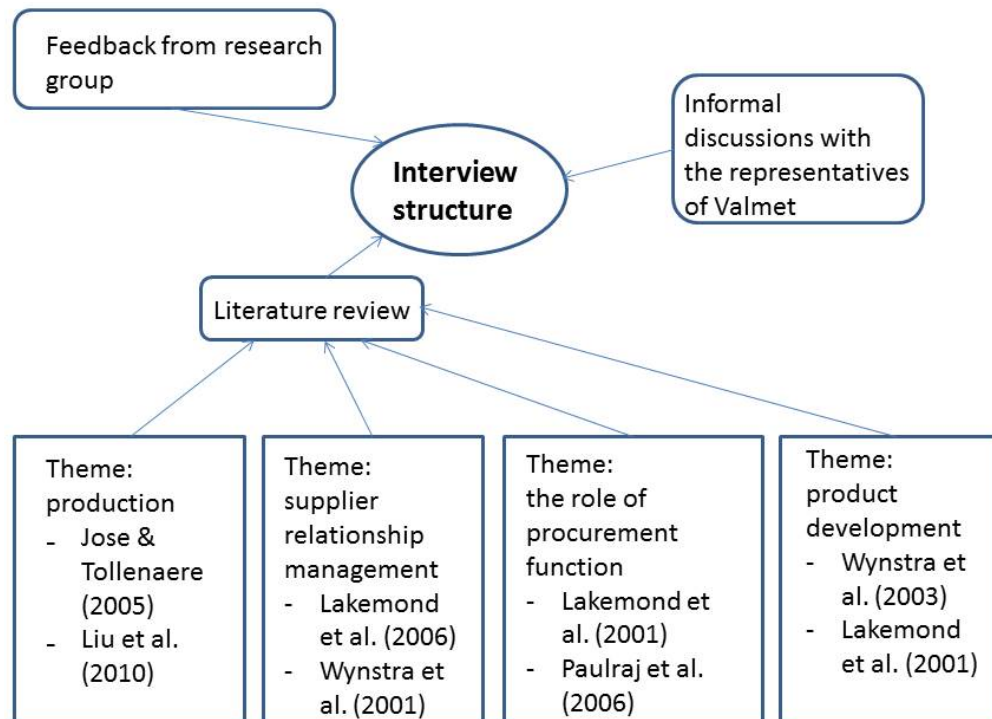


Figure 12. *The segments of the interview structure*

The interview questions were drawn up to suit the interviewees and the questions reflected the researcher's insights gained from the previous informal conversations with the case company representatives and from the literature review. The interview questionnaire was mainly based on the literature review. The interview themes and questions were partly the same and partly different for the interviewees from the different functions. Figures 6 and 7 were presented for the interviewees from procurement and product development functions. Figure 6 illustrated the procurement role in the product development process and Figure 7 illustrated how to involve suppliers to the product development process. The interview questionnaires are presented in Appendix 1, Appendix 2 and Appendix 3.

The respondents were chosen by their knowledge of the interview themes and by their experience in using or developing the DTC. The representatives of Valmet guided in identifying the most suitable interviewees. In total, there were 14 interviewees. The interviewees represented Paper and Pulp & Energy business lines and the interviewees were category managers, senior managers or directors. Table 2 presents background information of the interviewees.

Table 2. Background information about the interviewees

		Number of interviews in business line	
		Paper	Pulp & Energy
Organizational functions	Procurement	3	3
	Product development	3	3
	Production	1	1

12 interviews were conducted face-to-face in Valmet's offices. The remaining two interviewees were working abroad and these interviews were conducted via Lync. In these Lync interviews two figures were not shown because the risk of misunderstanding without visual contact was remarkable. The Lync interviews were conducted in English and the rest of the interviews in Finnish. The interviews were conducted in May and June 2015. The duration of the interviews was from 40 to 90 minutes. The interviews were audio-recorded and transcribed to on electrical document. Self-memos were written during the interviews and they were stored as electrical documents.

The analysis of the data was conducted in several parts. The data were categorized in the spreadsheet software program (Excel). The comments from the interview study were translated from Finnish into English, which may have induced some nuances. According to Saunders et al. (2009, p. 492), categorizing data involves developing categories and attaching these categories to meaningful chunks of data. The analysis of the interview data started inductively but the next steps were conducted deductively. The categories of the data analysis were derived from the generic DTC framework based on the literature review.

3.2 The inspection of interaction between procurement, product development and production functions

This chapter inspects the present condition of cross-functional interaction and the challenges of the functions in the contemporary business environment. Above all, the understanding of the status interaction between different functions lays a foundation for understanding the requirements of a DTC framework. There is always something that could be done better between functions and according to the interview of the procurement director, more attention should be paid on the collaboration between all functions. In particular, more attention should be paid to the interface of company

functions and to the flow of information between these functions. The procurement director said:

“We have a possibility to improve cooperation through all functions, from selling to product development, engineering and manufacturing.”

“How could we conduct this whole process effectively? We are now moving from one function to another, from engineering to procurement, from procurement to manufacture, etc. We have plenty of information gaps. The solution is to re-write the whole process again. What is the correct form to give the information onwards and what are the right tools for this? Now we have plenty of divergent methods of working.”

On the basis of the interview study, it can be said that it is significant to look at the coherency of employees’ understanding to give the information onward in congruent form. If the employees do not comprehend each other, the interaction between functions may be insufficient and there is a risk of misunderstanding the information.

From the view of the most employees of procurement, the early involvement of procurement and suppliers to the product development projects is valuable. This is true especially when the focus of the development project is something else than the development of the company’s own technology and there is a need for an extrinsic resource. Furthermore, some of the interviewees representing procurement wished that product development and procurement could be more associated with each other.

One notable subject concerning the interaction is that different functions see the target for development of the DTC from divergent aspects. According to the procurement category manager, engineers are tightly booked for customer projects and they do not have enough time for DTC projects. Resources of the employees are one of the challenges. The procurement category manager describes the situation:

“Sometimes we may not have enough resources to take on all design-to-cost projects because engineering has to bear a heavy load in the beginning, especially in the phase where we are looking into different potential initiatives. They are quite often heavily booked in our customer projects. We need more engineering resources. That is one essential target that we have to reach.”

Like the above-mentioned procurement category manager, the interviewees of product development deemed that the present personnel of procurement do not have enough time to participate in DTC projects since they are so intensively tied into to customer projects. The product development director said:

“The challenge is that procurement does not have enough time. They are all the time involved in buying, hence it is challenging to get them connected with these product development projects.”

The product development director adds:

“Do the employees of procurement have enough time to procure? In some cases, they do not have. – In our own project, the focus should always be on the fact that the procurement gets sufficient input data in time. Hence there would be enough time for professional procurement. Clearly, this concerns both engineering and procurement functions.”

Based on these citations, a dissent between procurement and product development interviewees can be seen. Both parties remark the lack of personnel resources. One solution to diminish dissenting opinions is to add communication and transparency between these functions. After all, it is significant that the functions notice by themselves where there might be shortcomings and how they could be corrected. The product development director said:

“We are slightly siloing people that we do not converse enough about these subjects. We must look at the mirror and sometimes invite representative of procurement to a department meeting and tell them about these things.”

However, it is significant to notice that, from all the functions of the interviewees, there is one common acquisition; the aim of the collective positioning of the common target for all functions. The functions wanted the common target to be transparent and that the target is constructed with a common process. When the targets are positioned together, it is easier to execute goals and the situation is clear for all sides.

According to a procurement director:

“Positioning the goal to the procurement and the other functions it is essential that the target is transparent and a shared process, for instance shared DTC targets. On the basis of shared targets, it is easier to commence collaboration.”

According to a product development director:

“We have now had slightly separate targets, but when we have shared targets, we follow them together and support each other to reach the targets.”

According to a production director:

“We should have the shared development aspirations and rationale for these wishes throughout the organization, in spite of the function. -- . We must be able

to describe our subject to the other functions, because we do not all see the same things and we do not have similar ideas.”

All these three functions emphasize the same thing: the functions must have shared targets. The shared targets diminish the segregation of functions. It is valuable that the management has set the shared horizontal goal to the functions and that it is measurable in a sensible way. If the targets of the functions are not compiled in a horizontal view, there is a risk that the functions are part-optimized to fulfill their own targets. This may lead to harmful results concerning the interest of the whole company. In conclusion, based on the quotations from different functions in this Chapter, it can be said that the cross-functional teams are one solution to increase information flows between different functions and also to diminish the silo effect between different functions.

3.3 The phase one of the design-to-cost framework- Preparation

3.3.1 Initiative for the design-to-cost process

In identifying the right DTC target, it is significant to recognize the potential cost management objects and to reduce costs in product development. The starting point for identifying the DTC process is to have initiative for the whole redesign process. Before identifying the DTC target, it is essential to consider where the initiatives for the possible DTC process come from. The employees of Valmet are one crucial source for the DTC initiatives. When considering the company itself, a procurement category manager presents the next three options for the sources of initiatives:

“1. Product-specific team, because they are in the last aware of their product and they have detailed information. 2. The top management gives a signal to improve price competitiveness. 3. The same research team which has been familiarized with the new manufacturing method, and the material. It is now time to consider whether it could be benchmarked in a project.”

When looking at the sources of initiatives outside Valmet, according to the interviewees, one of the main initiators is the customers. Moreover, according to several interviewees, customers are the most significant impulse to start a DTC project. According to a product development director, customers create a cost pressure to begin redesign projects.

“Customers indicate that we are too high-priced in that area, and we get a good conception of what area we have challenges in compared to the product cost of a competitor. It starts from the customers, in other words cost pressures are the practical initiative.”

The third source for an initiative in DTC processes are the suppliers. The suppliers can give their ideas on how the product could be manufactured better or if they have recognized that there is something unnecessary in the product. The purposeless demands have been arisen in feedback meetings with the suppliers for example. A procurement director describes the situation:

“We are in close collaboration with a supplier to develop a cost competitive solution for our needs and their capabilities.--. We have regular meetings with the supplier twice a year. We have both contributed to the new initiatives over the years.”

In conclusion, based on the interviews, there are three main sources of initiative to start the DTC process:

1. The employees of Valmet
2. Suppliers
3. Customers.

3.3.2 Identifying the possible design-to-cost target

Several important aspects about identifying possible DTC objects were found during the interviews. One of them is to choose a product which has great sales volume or a possibility to achieve cost savings. A product development director describes the situation:

“What is the estimation of the product’s sales price and sales volume? It is certainly formed in the product development project. There has to be comprehension of the costs of the product.”

According to the interviewees, the markets have changed and the pressure for cost-effectiveness is extremely high. Recently, there have been projects where product definitions have been simplified and the material has been changed in order to reduce the costs. The objective has been simply the price competitiveness. According to a product development director:

“We converse with the business unit on how to advance product definition of products which have complex and high-priced structure --.”

When a product has a complicated structure, it is reasonable to analyze if there is something unnecessary in the demand of the product. According to the interviewees of production, it is cost effective to remove or change unnecessary limits of product parts. A production director describes the situation:

“Why is there this kind of product quality requirement or structure? It costs this much, why. The original reason for these requirements has to be found, where it came from 15 years ago.”

Another production director adds:

“Some circumstances exist where no one can explain why, in some situations, there are extremely tight manufacturing tolerances. Product development cannot explain it. It is not necessary for this company. Someone has designed it a long time ago, it is updated, and the same tolerance is still there.”

Furthermore, customer needs can create a need to identify the possible DTC target. The requirements of a product should be based on customer needs. According to a product development director, the target must be in customer needs.

“We have to aim at customer’s needs so that there is nothing extra in the product. After that we can develop a new way to operate.”

However, the DTC target should also be in the company’s own products because then cost objects can be affected. In the procurement of commercial products, traditional category management can be used. A procurement director explains the situation:

“Commercial products have been bought at a market price; we cannot influence this very much. The company’s own products have engineering and cross-functional focus and it is possible to exploit the DTC process.”

In conclusion, the possible DTC target can be identified from several important aspects. The aspect can be the product which has a great sales volume or a possibility to achieve cost savings. The complicated product structure is also one reason to start the DTC process if there might be something unnecessary in the demands of the product structure. Furthermore, customer requirements are one of the main reasons to commence the DTC process. Customer requirements can indicate the unnecessary demands of the product structure.

3.3.3 The role of procurement and the selection of a cross-functional team

Because Valmet has over 12,000 employees globally, it is extremely significant that the cross-functional teams of different functions work effectively and fluently. Valmet has an endeavor that product development projects are cross-functional and the composition of the team varies depending on the situation. A procurement director describes:

“We have a template ready to help us remember who could be asked to be part of the team and who could be involved in the project. Then we together agree on what kind of team it is and give it targets, thereafter it is ready to start work.”

The role of procurement in product development projects has increased in the recent years. Earlier it could be seen that the role of procurement in product development teams was not so meaningful, if there even was a role of procurement at all. An active appearance is demanded from the procurement when product development exploits suppliers or their innovations. Therefore it is significant to look at the attendance of procurement in product development project teams and how they have advanced.

A product development director:

“I think that the big potential would be to have procurement involved in the product development. When we develop new things so that we can use DTC and do not have to re-design afterwards. That is the key fact.”

A procurement category manager:

“If the project needs external resources, for example special knowledge of manufacturing, procurement should be included in the project team in the early phase of the process.--. If the project is so extensive that there is a demand for special knowledge of a supplier or subcontractor there is a reason for the procurement being part of the project team.”

According to all the interviewees from procurement, production and product development functions, the role of procurement varies according to where the product is manufactured, whether it is made by the purchaser company itself or by a supplier, and where the impulse for the development project comes from. The role of procurement in product development teams is more essential when the product is manufactured by the subcontractor.

The configuration of procurement involvement in the product development projects was tested among the interviewees through a picture. Figure 6, which was described in Chapter 2.2, was presented to the interviewees. There were six different options in Figure 6. The interviewee chose an option which was the way how procurement was involved in the product development projects at the moment. Table 3 presents the answers of the employees. The answers described the current situation in Valmet. A letter X means that interviewee is sure of this answer and letter O means that the interviewee is not sure what option or options are in use.

Table 3. Configuration of procurement involvement in the product development projects

	A. Purchaser involvement on an ad hoc basis	B. Purchaser involvement on a part-time basis	C. Purchaser involvement on a dedicated basis	D. Procurement coordinator	E. Part-time integrated purchaser involvement in combination with procurement coordinator	F. Dedicated integrated purchaser involvement in combination with procurement coordinator
Interviewee 1 from the procurement				X		
Interviewee 2 from the procurement					O	O
Interviewee 3 from the procurement		O	O			
Interviewee 4 from the procurement	X				X	
Interviewee 5 from the procurement	X	X		X		
Interviewee 6 from the product development	X	O		X		
Interviewee 7 from the product development					X	
Interviewee 8 from the product development				X		
Interviewee 9 from the product development		X				
Interviewee 10 from the product development		O	O		O	

Table 1 demonstrates that option B *Purchaser involvement on a part time basis* has two Xs and three Os, based on the number of letters, it is the top-rated option for the interviewees. Nevertheless, if only certain answers are considered option D *Procurement coordinator* is the most desired, because it has four Xs. It is valuable to notice that the opinions of both functions are well in line with each other. Option D, for

example, has four Xs, two from procurement and two from product development. Option E has two Xs and two Os, one O and one X from both functions.

It seems, however, that at the moment procurement people are more or less on a part-time basis in the project, like in the option B. Nevertheless, the prospective scheme of things seems to be that one person participates in the project and coordinates the information for the other person of procurement, like option D.

Since the role of procurement in the product development projects was discussed in the interviews, it is also valuable to study the stage when the procurement function will be integrated in the product development projects. This subject caused dissenting opinions even among the representatives of the same function. According to a procurement director, a procurement function is typically integrated to the product development process when a new project is almost finished and designed technically, and the next stage is the implementation phase. After that, is time to think where the components will be purchased from and what brands the components are. Then procurement will be integrated into the product development project. With that, designings and suppliers are widely decided on and procurement does not have much liberty.

A procurement category manager describes the situation:

“When we [Valmet] are developing new projects and so on engineering may have a bigger role especially at the beginning of a project. Still, after a while, procurement perhaps gets a more important role and takes on the coordinating role more or less. Especially when we have development projects between Valmet and a supplier.”

According to a product development senior manager, it is the project contents which define when procurement will be integrated to be part of the team. He describes:

“We have projects where procurement is not integrated into the team and then again, we have a project where procurement is in the leading role and everything revolves around the purchase chain.”

Quite a common opinion among the interviewees is that the procurement function should be integrated earlier into product development projects. A product development director has valuable opinions of when and how procurement should be integrated into the development team:

“My wish is that they should be involved from day one. They should not only be there to get information. They should also participate in the development. Normally, they might be involved in a project but they do not contribute too much in the beginning. When we have engineers ready and drawings ready, then we

start to get comments. Typically, that is quite late and there is too little time and too much costs involved to start all over again.”

He describes what the possible mindsets in both aspects are:

“From the engineering point of view, I think we do not divide them [procurement] in a good way. From their [procurement] perspective, I think that they have a kind of mindset that they do not have anything to contribute in these early phases. --. If engineering makes a drawing and specifications, they can then start asking for prices. That is typically too late. We also increase the understanding and competence of procurement people so that they think that they can contribute as well.”

And finally he presents a solution to this problem:

“From the engineering point of view, it is really important that we invite them in a good way. That we really try to work together with them. Not start running off doing designs that are not confirmed and discussed with the procurement as well.”

It is a significant notice that procurement may not contribute so much in the early phase of the project, because employees of procurement may have a mindset that they do not have anything to give in the early phase of the project. A good solution is to increase the understanding and the competence of procurement people and, above all, work together in the team. A product development director describes the situation from his point of view:

“The close involvement of procurement and production people already in these early phases, is not considered until we have the drawings ready. Then look at how we can make it cheaper. --. For instance, if we are looking at the different--solutions for a machine. The comparison and selection of components must be done very early [from finishing stage] already when developing it. Not try to do it afterwards, because then it is often too late. Then you have already spent a great number of hours and nobody has time to do it all over again.”

In conclusion, the role of procurement varies according to where the product is manufactured, whether it is made by Valmet or by a supplier, and where the impulse for the development project comes from. The role of procurement in product development teams is more essential when the product is manufactured by the subcontractor.

3.3.4 The analysis of customer needs

The analysis of customer needs was found to be an important part of the DTC process. Valmet has a term “fit for purpose”, which means that production and product

requirements have to be scaled by customer needs. For example, Valmet personnel can incorrectly think that it is reasonable that the product life-cycle is for example 50 years although a customer aims at a 12-year life cycle.

It is crucial to recognize the customer needs and after all, to understand whether the product of the company responds to these customer demands. According to a product development senior manager:

“There is an aspiration to construct a project in such a way that the customer is always involved in it so that we know what to develop.”

It has to be known in detail which characteristics of the product are those that the customers appreciate, the life span or the usability of the product, for example. According to a procurement director, customer preferences can be culture-bound. In certain parts of the world, customers do not respect usability. If the company competes in these kinds of markets with the high usability of product which has a long maintenance interval reflected on the product price, the product is wrong for the needs of the customer. When the customer does not appreciate the characteristics of their products, the company is in markets with incorrect products. According to a procurement category manager, everything extra “nice to have but I do not need it” is useless. He describes the situation:

“Everything starts off from the customer’s needs. What the customer experiences value producing in delivery? We should avoid everything that does not really increase the value of the product.”

Valmet has developed a customer configurator for the different parts of a certain product. This configurator produces the description of a customer solution. According to a product development director:

“Customer solution consists of various modules, which have certain volume per year or per machine.”

The interviewees were asked how they see product characteristics versus costs in their business environment and what options are potential alternatives in DTC efforts. In the interviews four options were presented. The interviewees had an opportunity to mention as many options as they wanted. The idea was to find out if there are possibly some parts that the customer does not appreciate. Table 4 demonstrates the answers of the interviewees from the different functions.

Table 4. *Product characteristics versus costs*

	Number of interviewees from procurement	Number of interviewees from product development	Number of interviewees from production	Total
A. The cost will decrease and the facility of product will decline in some part	5/6	4/6	1/2	10/14
B. The cost will decrease and the facility of product will stay steady	6/6	6/6	2/2	14/14
C. The cost will decrease and the facility of product will get some improvements	6/6	2/6	2/2	10/14
D. The cost will be the same or increase and the facility of product will be better	2/6	0/6	0/2	2/14

Option B, *The cost will decrease and the facility of the product will stay steady*, is found to be the most top-rated option among the interviewees. Furthermore, option B was favored by every interviewee. The interviewees exemplified their points with concrete examples. A common opinion was that Valmet should check its design criteria. A procurement director describes the situation like this:

“What are our own safety factors --? Anyway the product has to meet the customer and law requirements. Exclude some surface finishing, for example, because it has only visual importance.”

Valmet has all the time been developing its paper machines quicker, more powerful and wider in size. Nevertheless, the general line now is to go back to smaller and narrower machines which are adjusted to the contemporary production environment. It means that when machines are designed to be smaller, it should also be remembered to check the old criteria. The criteria of the product should be related to the reformed products. A product development director describes the situation:

“When we drop down the criteria, the costs will be reduced, but the product will still fulfill its targets concerning the requirements of the end machine.”

According to a production director:

“We have to eliminate unnecessary requirements and useless details from manufacturing. This should not, in any way, affect the properties of the product. At the moment, we have option B, but the target is option C.”

Option C is seen as a DTC alternative. The costs will decrease and the facility of the product will get some improvements. This is the most desired option but, at the same, time the most difficult one to implement. According to a procurement category manager:

“If we talk about systems where the number of parts reduces, the possibility to make a mistake decreases, at the same time. Accordingly, the properties of the entirety will become better. --. The customer gets the same added value and maybe more, and, after all, costs will diminish.”

An illustrative example of this kind of a situation is a case where the weight of the product was lightened. The features of the product did not change even though the product was the lighter. For the customer this change was useful, because the product was easier to install and overhaul. The ease of serviceability is significant for a customer. The procurement category manager illustrates the situation:

“This is related to the DTC process. --. How to define improvement, from your own viewpoint or from the customer? What is the additional value that the customer seeks? That is what we should produce to the customer, and not our own feeling of how efficient and powerful a machine we made.”

Option A is found to be fulfilled by deliveries to low cost level countries. According to a procurement category manager:

“We have to consider where we could use this. A low-priced option cannot be used for a customer who appreciates high usability or low maintenance interval solution.”

A product development senior manager describes the situation in certain areas:

”-- we have the industrial sector and usually good products, but twice more too expensive. What we need, what could be omitted, and finally make that kind of a product.”

Some customers are only interested in what the payment period and the price of the machine are. Then the only option is meet the demands of the markets. This means that the life span of the product will be made shorter and the product will be cheaper to produce. The procurement director describes the situation like this:

“The answer is a fit-for-purpose solution. Where a customer may want resolution with shorter life cycle.”

Option D was the least popular option among the interviewees. Only two people from procurement regarded option D as a possible alternative. According to a product development director:

“This is not a valid option anymore these days.”

A procurement category manager describes the situation where he thinks option D could be possible:

“A project which has the high guarantees of usability, may have over 99 per cent in a power plant. All key solutions which maintain usability must be dependable. Then there is this situation that facilities improve but, at the same time, costs will also increase”

Furthermore, a product development director has an illustrative viewpoint which condenses the main idea behind the DTC process.

“Our target is to excise purposeless, omit everything that no one wants to pay for and leave the part which customers are interested in paying for.”

In conclusion, according to the all interviewees one of the main focus in the product development process is to analyze customer needs. The properties of the product should meet the customer requirements and it is necessary to remove everything that does not increase the value of the product for the customer.

3.4 The phase two of the design-to-cost framework- Specification of the design-to-cost object

3.4.1 Modularization and standardization

Modularization and standardization are closely related to phase two. On the basis of the interviews, modularization and standardization have a significant impact on reduced design hours and the control of the material costs. Modularization is a quickly growing method and used in Valmet. Modules have divergent variants and the combination of these variants enables different customer solutions. The product will be configured on the basis of the customer wishes. According to a product development director:

“Modularization is extremely significant for efficient procurement and its development. It standardizes certain articles that will be purchased.”

For these standard modules, it is possible to construct a production system which means Valmet’s own assembly, manufacturing and procurement. Valmet drives forward modularization and the target is to get a configure-to-order operation mode. The whole operational process must support modular solutions. Modularization is exploited by large and small plants alike. Large plants are case projects where customization is used based on customer wishes.

Modularization can significantly reduce product costs as well as manufacturing design costs. When a part of a product is always similar, it is more cost-effective to execute procurement and manufacturing. According to a procurement director, there is not yet factual data to support modularization, because Valmet is a beginner with modular solutions. He describes the benefits of modularization:

“Simplification of the projects, shorter lead-time, more reliable quality, but in the end the most substantial benefit may be the total cost of the project.”

According to a product development director:

“Our quality costs are clearly better in hand if we use ready considered solutions.”

However, it is significant to see modularization in a functional mode also. Modularization is a valuable way to collaborate with customers. According to a product development director, modularization can produce two fundamental customer values:

“If the first customer value is that the customer gets a machine with a Valmet-brand at a reasonable price, accordingly, the second customer value is that the start with the machine is rapid [modular structure is quicker to assemble] in order to make money quickly. When we do it the modular way, it helps both.”

A common viewpoint of the interviewees is that with modularization it is possible to reach benefits in almost every function of Valmet, such as procurement, product development and production. When the modularization is exploited, it is necessary to recognize the factors that have impact on modular decisions.

3.4.2 Factors impacting on modular decisions

As described earlier, the recognition of customer needs is a critical phase. It is extremely significant to do far-reaching careful reasoning about customer needs also when considering modularization. According to a procurement director:

“New markets requiring new products are the pushing force towards modularization.”

According to a product development director:

“This kind of industry [what we are doing now in Valmet] may not have been modularized so far”

Modularization has also challenges. It is a big challenge how to update the modular solution in the future, what the extent of the update is and how to maintain it. Furthermore, what are the financial consequences of the update? In old solutions, it is

more difficult to exploit modularization because there are already existing technical definitions. According to a product development director:

“We have lots of products and some of these products are very seldom sold, sometimes not even one product per annum. For those machines and products, there is less benefit of having them modularized.”

According to a procurement category manager:

“We are in the project oriented business, where our products are quite often specially made. Every project is unique. That is the biggest challenge that we have.”

The interviewees see the challenges in a slightly different way. A product development director expresses his opinion:

“The biggest challenge is our way of operating, that we get the culture to this company.--. On the other hand, it is also a possibility.”

Modular solutions are good especially when customers want simple and reliable products. At the moment, the biggest factors impacting on the modular decisions are competitiveness and cost-effectiveness. A product development director describes the situation:

“All products can be modularized in one way or another. The only thing you need to think of is to do it in a smart way. Let us say a product which is very seldom sold, you have less benefit. Nevertheless, as soon as you start having a couple of them every year at least, you start getting the benefit.”

In conclusion, everything commences from the fact that the modular decision must have business benefits. When the benefits of modularization have been recognized, it must be considered to what level the modular solution is used. Then the need of the customer has to be known extremely well so that the required numbers of the variants can be made. According to procurement director, it is not necessary that the variants satisfy 100 per cent of the customer needs, it may then be too complicated and expensive to build. The variants of the product have settled for the certain level and the rest is customized.

3.5 The phase three of the design-to-cost framework- Implementation and evaluation

The third phase of the DTC framework consisted of implementation and evaluation. On the basis of all the interviews, a feedback appointment is used in large projects. The co-operation meeting can be the type of formative, for example consider why these

solutions did not work and what to do in the future. According to a product development director:

”It is extremely important that we get the feedback from projects and then we drive forward this feedback to standardized solutions. Particularly, we collect this feedback from the project, how we managed to produce, how we managed to install, how the implementation went. Then the required changes are carried out to the standardized solutions.”

According to production personnel, they consider together with designing, procurement and manufacturing how the redesign of products affects the costs. A production director describes the situation:

“In the significant changes we summon the team to estimate if this change is possible and what it costs.”

It is significant to observe the forthcoming changes in products and production. Feedback conversations with suppliers have highlighted what kind of demands Valmet has and above all, if these demands are necessary. According to a production director, feedback conversations with suppliers are valuable and it is possible to discover unnecessary demands.

“We have discovered many points, where we have noticed that those are not necessary demands any longer. The structure of product could be different.”

These unnecessary demands on some products are a result of tacit knowledge which has been forgotten. A production director explains:

“It is a risk that no one comprehends, what the reasons for the demands are [in product specifications] because they are not written down.”

When changes are made to the older products, it is extremely significant that all cause and effect connections in product specifications are found out. Similarly, it is important to canvass where there might be unnecessary specification demands, because through purposeless demands it is possible to achieve cost savings. One way to find out these purposeless demands is to collaborate with suppliers in product development.

3.6 Suppliers as a part of design-to-cost process

Interacting with the suppliers is a significant part of the company’s quotidian life. According to all the interviews, the suppliers must be trustworthy and have a solid financial standing, otherwise there is a risk of late delivery. The selection of the supplier is a considerable task for the company because on one hand there is a possibility to have durable and innovative supplier relationships, but on the other hand there lies a financial

risk if the buyer company makes the wrong selection. A production director explained how Valmet has successful conversations with suppliers but there are things still to be improved. Suppliers are followed up and they know it. The production director describes the situation:

“We always follow the principle ‘lessons learned’. When the subcontractor has achieved a certain point in the project, we go through [with supplier] where we think Valmet succeeded and where there still is something to be developed. What are our opinions of the successes and failures of the subcontractor, and the other way round.”

According to the production director, the company’s own needs have to be known first, for example what kind of manufacturing or product knowledge is needed. Thereafter, it is time to estimate the processes of a supplier more accurately in this Chapter.

3.6.1 Subjects that motivate suppliers and Valmet to common targets

One of the motivating methods for both buyer and supplier companies is naturally the success in business. Achievement of overall cost savings was quite a common answer among the interviewees. An illustrative example of cost savings was a tight cooperation agreement, where the aim has been in the streamlining and developing of the delivery process. It is significant that benefits can be divided between the parties.

The subject that motivates to collaboration with a buyer company varies depending on the supplier. In a simple product manufacturing business the motivating subject is production volume. The contrast is a supplier who wants to innovate and the technology of the products is highly appreciated. A procurement director describes the situation where the supplier appreciates high technology:

“We [Valmet] are quite keen in development, and by that we are quite an interesting customer to our suppliers.--. Especially, when they [suppliers] want to test new products, they want to test them with us because we have quite a highly demanding process.”

However, one respected subject among the suppliers is ensuring continuity of collaboration. According to a procurement director:

“Suppliers appreciate if there is a business that they might be involved in for a longer time.”

A common development project is a guarantee of continuity for both sides. In conclusion, the high technology solutions support a long lasting supplier relationship

and efficient communication. Some of Valmet's products are extremely specific, tailored products, which sustain the long lasting supplier relationship

3.6.2 Product development projects with suppliers

The company's own manufacturing is not always necessarily the most efficient way of producing products. According to a product development director, it should be considered precisely what is worth making by the company itself and what the initial reason to do so is. It has been observed that the focus of the product is much clearer when Valmet works together with a supplier. Valmet has various examples of well-executed development projects with suppliers. The supplier may have competence in some particular fields. According to a procurement category manager, a supplier with a good idea can radically accelerate project accomplishment. He describes:

"We have had design to cost workshops together with this supplier and we have been able to reduce the cost --. So we are working quite closely together on the procurement side, on the engineering side and together with the suppliers."

When product development projects are executed, with the aim of cost savings, the company has to be extremely careful that the development is not falling down to sub-optimizing. The expected savings in one place of the product can cause the same amount of costs somewhere else. A procurement category manager described an executed development project where a supplier was a part of it. He describes the situation:

"The outcome was not quite what we searched for. The settled targets were not realized. Proposed amendments [from supplier] were too big. The proportions are on hold until the restrictive factors [from the structure of the product] are off."

The project was not a success. Valmet has encouraged suppliers to bring out divergent development ideas. Suppliers are invited to be a part of product development projects. This is the case especially when the share of Valmet's own manufacturing diminishes and the same input is searched for from the subcontractor field. A procurement director explains:

"The challenge is that Valmet has not managed to establish a reliable enough [its own] feedback process. The process where a development idea is delivered through our organization the way it will certainly be paid attention to and we can give the feedback to the supplier what their idea was like."

However, in order that this kind of process could work it needs active collaboration through cross-functional teams and between Valmet and the suppliers. According to all the interviewees, Valmet must have an interaction process in how to encourage

suppliers to give and innovate ideas. The supplier's idea must be processed and given reasonable feedback. All ideas are not feasible.

An impulse to initiate product development projects with suppliers may come inside Valmet, for example if they recognize a need for external competence. Alternatively, the supplier may be the active part. Previous experience, confidence and the supplier's capability to develop products are highly valued properties of the supplier. On occasion, when the company's own resources are not available or the organization simply does not have resources with required competence, subcontractors are a valid option. A product development director describes how they develop solutions together with a supplier:

“Now we are in close co-operation with a supplier to develop a cost-competitive solution for our needs and their capabilities.”

Furthermore, it can be contemplated how the supplier's product could be more suitable for the requirements of Valmet, what should be changed. It is significant that designs of Valmet respond to the manufacturing and the capabilities of suppliers.

3.6.3 Communication relationships with suppliers

The products of Valmet are extremely technical, which demand openness. One proposal for improvements was that there should be more dialogue between suppliers and the organizational functions of Valmet. There is a need for more inter-organizational collaboration with suppliers. A procurement director describes the benefits of inter-organizational collaboration:

“The supplier and procurement will directly get the viewpoint from the product owner, who is the closest to the business and comprehends better the business needs.--. Product development could bring new aspects to which direction it [the requirements of product] should be developed. Respectively, procurement or the supplier could communicate about new possibilities to the product development.”

Now when a supplier and a buyer meet, the conversation may be restricted to the conventional topics like load situation and price level. Valmet aims at regular supplier meetings where information about the market situation, the success of deliveries and the forthcoming development projects is exchanged. A procurement category manager clarifies the situation:

“We have a couple of those suppliers [suppliers with whom Valmet has regular meetings]. They have unique products for Valmet. Those, of course, we want to have a long term relationship with. They are the suppliers that we work quite closely with in developing new technological solutions.”

According to the interviews, it would be good if Valmet had an online platform in conjunction with the suppliers. Valmet could share the technological information of products with suppliers. The place where it could be possible to undergo material changes with a foreign supplier, for example.

Approaches to involving a supplier to product development projects were tested among the interviewees with Figure 7, which is described in Chapter 2.3. The interviewees chose an option which they thought was the most suitable to involve the supplier in product development. There were three different options in the picture. The first option, project integration coordination, means that the supplier becomes a part of the product development project and is in close cooperation with the developing corporate. The second option, direct ad hoc contact, is valid for example when a purchaser from the customer corporate directly contacts his or her counterpart in the supplier organization. The third option, disconnected sub-project coordination, takes place when a supplier is formally assigned a task that is accomplished relatively independently in the customer corporate. Table 5 presents the answers of the interviewees representing procurement and product development.

Table 5. *Supplier involvement in product development*

	Interviewee from procurement	Interviewee from product development
Project integration coordination	2	2
Direct ad hoc contact	1	2
Disconnected sub-project coordination	1	0

The total number of answers to this question was eight. Two interviewees did not select an option: one did not have experience, the other could not name a single answer. All the options were resonated among the interviewees. According to the interviewees, all the options can be found in the cooperation forms of Valmet and suppliers. The cooperation form depends on what the development project is like. Furthermore, the first option, where a supplier becomes a part of the product development project and is in close cooperation with the developing corporate was the most mentioned. It was chosen by two interviewees from both functions. The first option was seen as the most effective alternative to integrate the supplier with a customer corporate. A product development director described:

“In the long run ‘Supplier is a part of product development project’ is good. It demands that strategic nexus of the supplier is found good and efficient. The start

with the supplier takes place with the third option, the supplier has a modified assignment, where the supplier is alone mainly responsible for development project.”

However, sometimes there may be problems to commit suppliers to product development projects. According to a procurement director, it has to be clear how the benefit is apportioned between suppliers and Valmet when the product development project is executed in collaboration. Suppliers may have suspicions of how loyal the customer company is. Therefore, it is significant to have common perception among the supplier and the buyer company. Companionship and ideology must also develop inside the buyer and the supplier.

The supplier has to know what the benefits are if they commence the developing project with the buyer company. When the costs are concerned, the control of subcontractors becomes significant. An interviewee from production contemplated how much should be invested in the product development of the suppliers and how significant its role is. According to a procurement category manager:

“If the supplier’s position is strong the cooperation must develop -- with active presence. This is the way risks are minimized and we know all the time what the supplier is doing”

According to the interviews, when the company’s own manufacturing has decreased, the role of suppliers has become increasingly important. However, if the position of the supplier is strong, the buyer company has to pay attention to being active in collaboration with the supplier.

3.7 Key suggestions for implementing design-to-cost in the case company

Chapter 2.5 presented the generic DTC framework which was based on the literature review. In Figure 13 the key results of the interview study are utilized to complement the framework in order to highlight the requirements of Valmet. For the sake of clarity, complemented and new items are illustrated with the red color.

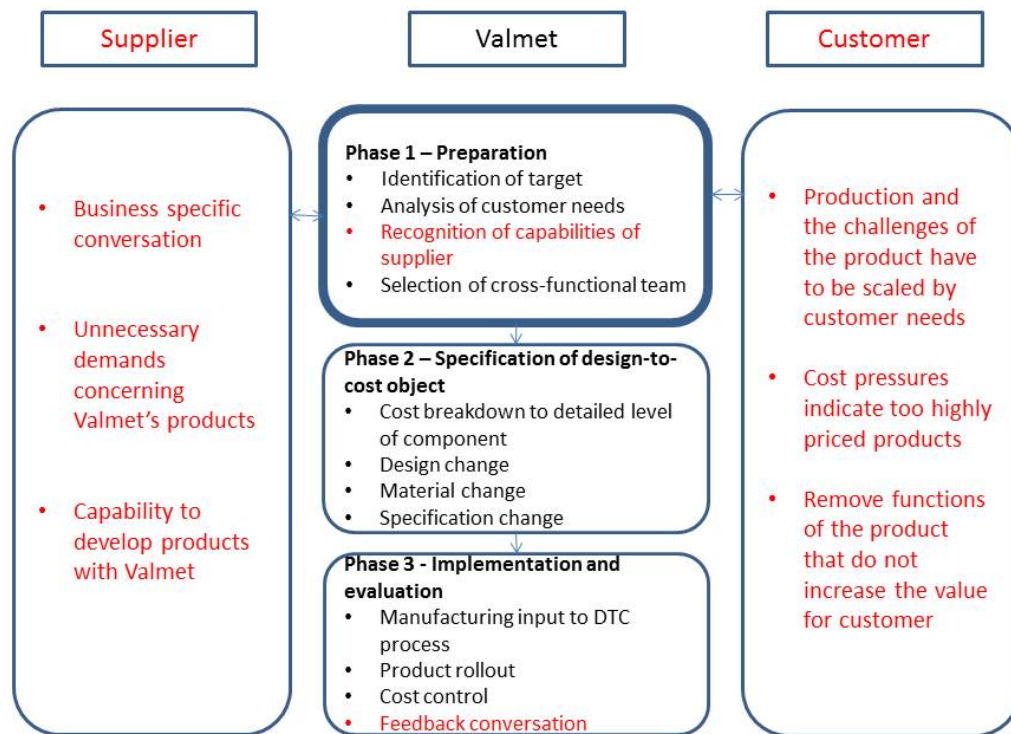


Figure 13. The enhanced DTC framework on the basis of the interview study

The enhanced DTC framework includes the main points of the interviews. The most significant observation based on the interviews is the role of customers and suppliers in Valmet's product development process. These viewpoints were currently mentioned by the interviewees and they were not clearly visible in the previous studies on DTC and related areas. The enhanced DTC framework now constitutes three factors: the supplier, Valmet and the customer. It is crucial to understand that the effectiveness of the DTC process is dependent on all of these three actors and their collaboration.

The customer indicates the needs of products and Valmet's role is to manufacture the product with the correct characteristics. Above all, the DTC process is useless if the customer needs are neglected there. The product development must adjust to the requirements of the customer. The third party of the DTC process is the supplier, which may have the necessary resources for identifying the sources for the cost-effectiveness of the product development process. It is valuable and extremely significant to recognize the capabilities of the supplier for the product development process. From the horizontal aspect, the DTC framework is formed by suppliers, Valmet and a customer. At the same time, from the vertical aspect, the DTC framework constitutes three DTC phases. However, together these aspects formed the enhanced DTC framework.

The next part of this study consists of workshops aiming at finding out more precisely how to enhance the effectiveness of collaboration between the supplier, Valmet and the customer. The aim is also to clarify Valmet's possibilities to promote innovations by suppliers and customers, and with suppliers and customers.

4. WORKSHOP STUDIES ON THE PREPARATION PHASE FOR DESIGN-TO-COST

4.1 Data collection and analysis methods

The second phase of the empirical part of this thesis is constructed by two workshop studies. The first phase of the DTC framework through the fluency of collaboration between customers, Valmet and suppliers was chosen to be the focus area on the basis of the interview study results. The inter-organizational collaboration was seen as an interesting and beneficial theme to be absorbed in. The DTC process was in early stages in Valmet and the first phase of the DTC framework was seen to be valuable for Valmet's purpose to reach multiple initiatives for the DTC process.

The workshops with complementing personnel roles and organizational parties were seen as a valuable way to acquire deeper information about the collaboration between customers, Valmet and suppliers. According to Ven & Delbecq (1986), group discussions are increasingly involved when creative solutions are needed for complex problems. They add that interacting groups perform better than their best member alone. Interactive group technique involves an unstructured group discussion for generating information and pooling judgements among representatives (Van & Delbecq 1974). This thesis utilized the interactive group technique with the exception that group discussions were semi-structured workshops.

Kim & Ahn (1999) present that increasing complexity of the contemporary environments makes it less possible for a single decision maker to consider all aspects of the problem. Therefore, they imply that many organizations exploit discussion groups in decision making. In the workshop studies of this thesis, the conversation themes were discussed from different perspectives and the ideas which were undevelopable were recognized immediately by the participants.

The first workshop was mainly based on the results of the interview study. The first workshop included two themes: the motivating factors for product development among the suppliers and the customer and the comprehension of the demands between the organizational parties. The second workshop was mainly composed of the results of workshop one and the literature review about suppliers and customers. In that workshop, Valmet's internal issues were studied.

Workshop two focused on the possibility of using the discussive activities tested in workshop one as a tool in the first phase of the DTC framework. Another focus area

was the factors that stimulated customers and suppliers to the product development process. Figure 14 illustrates the forming process of the workshop studies.

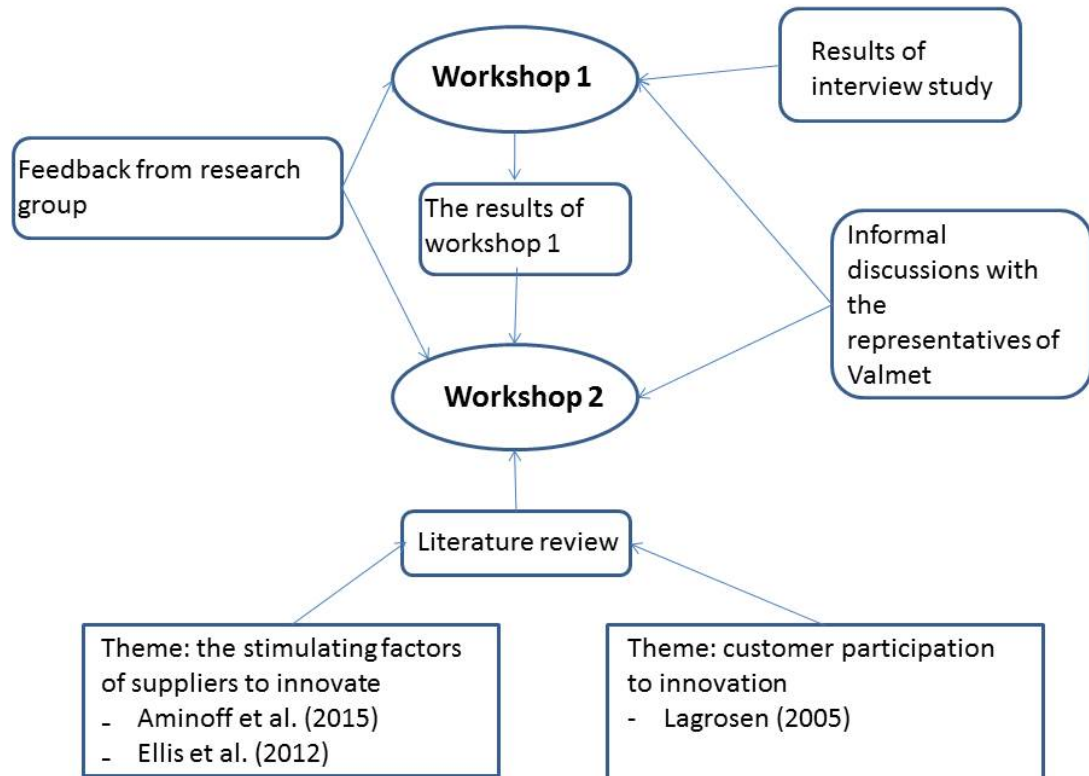


Figure 14. *Forming process of workshop studies*

After the analysis of the interview study findings, two informal meetings were organized with two representatives of Valmet. The representatives of Valmet were a director and a program manager. These informal meetings had an impact on to the content of both workshops. The first workshop was organized in October 2015 and it lasted three hours. The participants of the first workshop represented the end customer perspective, two supplier companies and Valmet. In the first workshop there were six representatives from Valmet, two representatives from end customer and one representative from each of the supplier companies. All the representatives were category managers, senior managers, account managers, senior product managers, program managers and directors. There were also four representatives from the research group, who observed the discussions and facilitated the event.

In order to retain the anonymity of companies, no detailed information is presented and the companies are called Customer A, Supplier A and Supplier B later in the thesis. Customer A is a Finnish forest industry company that operates in international markets. The offerings mainly consist of tailored wood trade services as well as forest and nature management services. Supplier A is a global technology company. The offerings consist of products and technologies related to rotating equipment. Supplier B is a global company in the engineering industry. It provides tailored power industry-specific solutions.

The first workshop consisted of group conversations where the participants were divided into three smaller groups. The first small group composed of two representatives from Customer A and Valmet. The second small group consisted of one representative from Supplier A and two representatives from Valmet. The third small group included one representative from Supplier B and two representatives from Valmet. Additionally, one research group member participated in each small group documenting the notes. At the end of each theme, all the participants discussed the perceptions and different solutions together. The representatives of Customer A, Supplier A and Supplier B had knowledge about Product A. In order to retain the anonymity of that certain product it is called with the name of Product A. Three employees of Valmet were heavily involved in the relationships with the suppliers and the customer. The other representatives of Valmet were using or developing the DTC process and some of them were also related with Product A.

The second workshop utilized the first workshop as a tool in the first phase of the DTC framework. The target was also to have deeper comprehension about the stimulating factors among the customers and suppliers. All the eight participants of the second workshop were from Valmet and they were category managers, senior managers, managers or directors. Some of the participants had been in the interviews and in the first workshop, but there was also one new representative. Additionally, there were three representatives from the research group documenting the notes. The second workshop was organized in December 2015 and it lasted three hours. Memos and ideas were written down to an electrical document. In this workshop, all the participants discussed together as one group.

The gathered data from workshop one were presented to Valmet, Customer A, Supplier A and Supplier B in a slide show in order to get feedback and to ensure the correctness of the data. The results of the workshops were analyzed through the DTC framework.

4.2 The first workshop- Increasing collaboration between the customer, Valmet and suppliers

This chapter inspects the collaboration between Valmet and Supplier A & B, and between Valmet and Customer A. Table 6 presents the factors that motivate Customer A, Supplier A and Supplier B to produce initiatives to the product redesign process. Furthermore, Table 6 shows the factors that Valmet can do to promote the collaboration with Customer A, Supplier A and Supplier B. The opinions of Suppliers A and B were close to each other and because of that the opinions of suppliers are presented in the same table.

Table 6. *The motivating factors in collaboration*

	Factors that motivate to generate new initiatives to product redesign	Factors that Valmet can do to promote collaboration
Customer A	<p>There is a problem in manufacturing and a solution is needed.</p> <p>Searching for cost savings.</p> <p>The features that the customer appreciates.</p>	<p>Employees with a better understanding about manufacturing.</p> <p>Finally, the beaten or lost case should always be analyzed.</p> <p>The ideas from customers should be served internally.</p>
Supplier A&B	<p>The supplier's own product development.</p> <p>Co-operating in product development when the supplier can bring out its competence.</p> <p>Assurance of continuity.</p> <p>Prospective potential of business.</p> <p>Global status of the customer.</p> <p>Cost potential lies in collaboration in the design.</p>	<p>To contact as soon as possible the product development process.</p> <p>The projects of collaboration, is the promise of business (need mutual confidence).</p> <p>Open conversation about costs.</p> <p>Significant to conserve confidence.</p>

From the viewpoint of Customer A, an aspiration to Valmet arises to consider customer needs and demands. Customer A presented that Valmet should have an active role in looking for the cost savings in the product development. The customer is mainly active when it has a problem with the product and a solution is needed. Customer A wanted a feedback system where it could give the feedback information to Valmet. Customer A also expected that Valmet would process the ideas that it gives to Valmet. According to Customer A, it is valuable to remember that formal methods (technical systems) and informal methods (common conversations) do not exclude each other, on the contrary, formal and informal methods promote one another.

Suppliers A and B present that one of the main motivating factors to produce initiatives to product development is to express their own competence to Valmet. Furthermore, when the motivating and promoting factors are defined, it is valuable to verify that these parties understand each other's requirements. Suppliers A and B presented that the significant cost potential lies in the collaborative product design. The supplier can suggest alternative material changes to the components for example. Valmet can promote its supplier collaboration by contacting the supplier as soon as possible in the

product development process and have an open conversation about the costs which are related to the product development process. The collaboration in product development is the promise of business for suppliers. Furthermore, the cost-effective product development process needs mutual confidence between the supplier and Valmet.

In semi-structured interviews the requirements of customers were recognized to be a crucial part of the product development process. However, the requirements of the customer were discussed in the first workshop. Table 7 presents, from the viewpoint of Customer A and from the perspective of Valmet, how Valmet understands the demands of Customer A.

Table 7. *The comprehension of each other's demands; Valmet and Customer A*

From the viewpoint of Customer A, how Valmet understands the needs of customer	From the viewpoint of Valmet, how Valmet understands the needs of Customer A
Customer A has a need for more specified technological knowledge in some particular areas.	The products are not considered from the viewpoint of one customer. Valmet considers the entirety.
The functional business of Valmet has focused on service to Finland.	Communication is easy and common product development history.
Changing the improvement idea to practice sometimes takes too long a time.	The Customer A has many kinds of demands (product and service).
Valmet understands divergent and versatile needs.	

Customer A expresses that it demands more technological knowledge from Valmet in some areas. According to Customer A's feedback to Valmet, the improvement idea for changes sometimes takes too long to realize in practice. From the viewpoint of Valmet, Customer A has many kinds of demands, including the requirements of products and the requirements of service. Both parties agreed that Valmet understands divergent and versatile needs, and the result that Valmet and Supplier A share the similar product development history. The inter-organizational communication is easy between Valmet and Supplier A and the collaboration is working.

The communication in the first workshop between Customer A, Valmet, Supplier A and Supplier B was interesting to observe, because the roles of the participants were so visible. The representatives of Supplier A, Supplier B and Valmet, for instance, made notes during the conversations and the representatives of Customer A did not make any notes. Customer A had the strongest position, because Valmet was the supplier to Customer A. In proportion, Valmet was the customer of Suppliers A and B.

The customer needs were also discussed between Valmet, Supplier A and Supplier B, because it is valuable to understand how Suppliers A and B recognize the needs of Valmet and the end customer. Table 8 presents the customer needs of Valmet from three different perspectives: those of Supplier A, Supplier B and Valmet.

Table 8. *The customer needs of Valmet from different perspectives.*

From the viewpoint of Supplier A, what are the customer needs of Valmet	From the viewpoint of Supplier B, what are the customer needs of Valmet	From the viewpoint of Valmet, do the suppliers understand the needs of Valmet
"Quality enough" for the end customer. Do not deliver over-quality, the quality must be high enough.	Valmet wants systematic estimation from savings.	There is a need for development, where the component would meet an end customer's requirement standards.
Supplier A has two brands: premium and lower. Because of the small volumes of Valmet for Supplier A, the tailored "quality enough" is not possible. There is a need for DTC-process.	Appointments, where to promote mutual understanding. The conversation subject can be something else than costs.	Valmet expects courage to the DTC-process from suppliers. The courage challenge why the product has these requirements.
Supplier A's understanding about the end customer of Valmet and its end customer field is weak.	The shared technology and education concerning it. Furthermore, more shared development projects.	Precisely selected people to coordinate sections in different functions, which promote collaboration.
Suppliers bring ideas for DTC-process through end customer segmentation.	Brainstorm together about product requirements, and go through every product demand separately.	In a balanced collaboration things are conversed more thoroughly.

Supplier A presented that the supplier could bring ideas to the DTC process concerning the end customer better if the supplier understands the field of the end customers better. Supplier A demonstrated that its components could better respond to the requirements of the end customer, because it is reasonable to deliver "quality enough" to the end customer and diminish the costs in the supply chain. Supplier A and Valmet emphasized the same demand: there is a need for the development process where Valmet's component responds to the end customer's product requirement standards. Customer A agreed with Supplier A on the idea of delivering "quality enough" to the end customer. The DTC process through inter-organizational collaboration was seen as a significant

way to diminish product cost and improve the cost-effectiveness of product development process, on the basis of this conversation about Valmet's component correspondence to the end customer's requirement standards.

Supplier B pointed out that Valmet wants systematic estimation about cost savings. Supplier B presented that collective brainstorming conversations can be one solution to figure out the possible cost savings of products. The meetings were to brainstorm together about the requirements of products and go through every product demand separately. Supplier B added that one significant aim is also to have meetings where to promote understanding about each other.

At the same time, Valmet presented that it expects suppliers to be a part of the DTC process. The courage of suppliers challenges Valmet's product requirements and materials. Valmet had a conversation with Suppliers A and B concerning the stable relationship between the supplier and the buyer company. The balanced relationship between the supplier and the buyer company was seen as the key factor for the effective collaboration by Valmet, Supplier A and Supplier B. If the buyer company has too dominant a role in the collaboration, it can, in the long run, run down the supplier economically. Correspondingly, if the supplier has too dominant a role in the collaboration, it may not have enthusiasm for collective product development projects. Valmet, and Suppliers A and B settled on the collective result; the relationship between the supplier and the buyer company is balanced when both counterparts benefit from the collaboration and neither counterpart feels exploited economically. Valmet, Supplier A and Supplier B together agreed on that the collaboration between Valmet and Suppliers A and B is in balance.

In conclusion, the first workshop indicates that one of the most significant challenges is to have more intense collaboration between both Valmet and Customer A and Valmet and Suppliers A and B. Customer A expressed that there is a need for this kind of workshop where their requirements become perceived. Customers have their demands and if they do not get the response to these demands, they will search for the answer from the competitors. Furthermore, customers are generally active only when they have problems. Suppliers A and B hoped more meetings to discuss product requirements and to promote understanding between Valmet and Suppliers A and B. From now on, to avoid misunderstandings in this thesis, the term *DTC workshop* is used to describe the workshop involving a customer, Valmet and a supplier.

When the requirements are identified between all counterparts, it is time to consider how these needs can be implemented. Furthermore, it can be recognized that Suppliers A and B as well as Customer A are anxious to be a part of the possible DTC process. The next phase identifies how to increase Valmet's understanding about better exploiting suppliers and particularly customers in the DTC process.

4.3 The second workshop- The design-to-cost workshop as a tool in the first phase of the design-to-cost process

The second workshop is constructed of two parts. The first section aims at figuring out and developing the DTC workshop in a potential commencement for the DTC process. The second section strives to figure out how to stimulate suppliers and customers to innovate product development in the future.

The DTC workshop is an example of a practical tool for improving the collaboration between the supplier, Valmet and the customer. On the basis of the conversations in workshop two, the initiative for the DTC workshop may come from the conversations between the customer and Valmet. When the possible DTC target has been found, the suppliers will be asked to join in the DTC workshop. One possible option is also that the supplier has an idea to the redesign process, but the supplier cannot implement it alone. It is extremely significant to recognize the characteristics of information flows when the DTC process begins to formulate. There is always a risk with the suppliers and the customer, because after all, these counterparts impel their own interests. Figure 15 presents what the desirable information model in the DTC workshop is from the viewpoint of Valmet with different information flows between the supplier, Valmet and the customer.

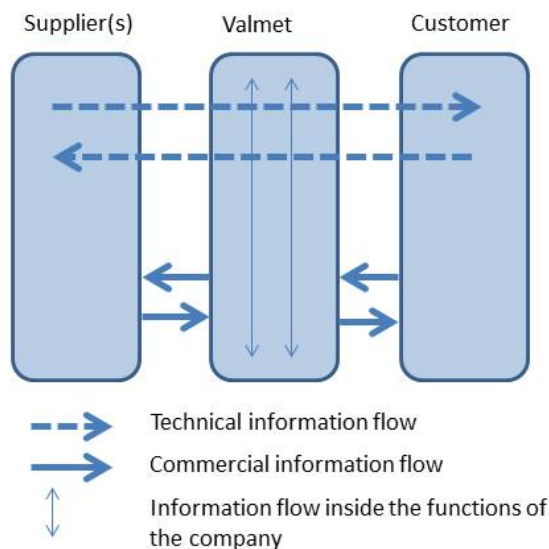


Figure 15. The information flow between supplier(s), Valmet and customer

The technical information can flow from the suppliers to the customer and the other way round. Respectively, from the viewpoint of Valmet, the commercial information has to go through Valmet to avoid commercial collaboration among suppliers and the customer. At the same time, the technical and commercial information flow goes inside the different functions of Valmet in order to avoid silos between business functions.

According to the discussion in workshop two, the participants of the DTC workshop should vary depending on the DTC target. A prospective target can be restricted by one product category. The target must be tightly focused: otherwise there is a risk that the conversation stays at too general level. When the innovation subject comes from the supplier, the possible DTC workshop should include one supplier only. This is because suppliers do not typically develop their inventions with other suppliers. Furthermore, when the DTC workshop is defined concerning the participants and the target, it is time to be absorbed in how to stimulate the suppliers and get the customer to participate in the DTC process.

The second part of workshop two concentrated on stimulating the innovations of the end customer and suppliers. Three possible stimulating methods the suppliers to innovate were presented. These methods (creating innovations, push-model and pull-model) were already explained in Chapter 2.3. The participants of the second workshop presented their opinions on creating innovations, push-model and pull-model. These views are demonstrated in Figure 15. In the second workshop, three possible models for customer participation were illustrated; the models “design for the customer”, “design with the customer” and “design by the customer”. These models are demonstrated and tabulated in Chapter 2.4. According to the participants of workshop two, “design with the customer” was chosen the most wanted model between Valmet and the customer. In that model, both the participants can contribute to the cost-effectiveness of the product. See Figure 16.

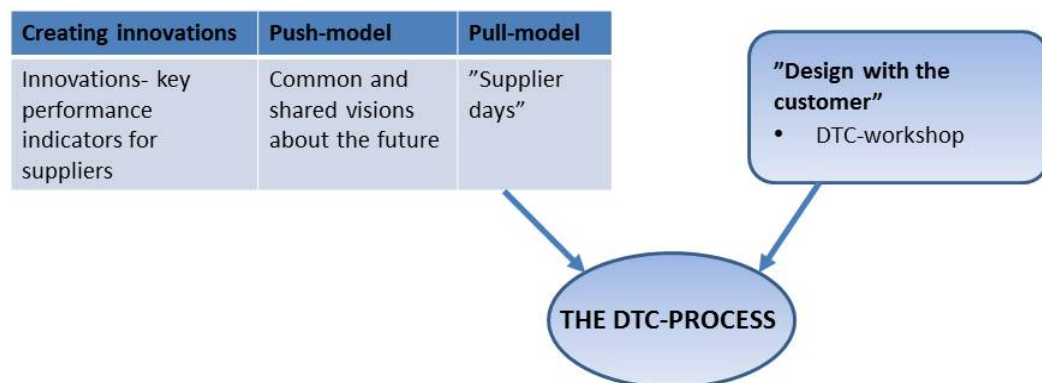


Figure 16. *The stimulating methods of suppliers to innovate and the participating model of the customer*

The possible tool for applying “design with the customer” model is the DTC workshop. There the participants can the most affect the end result of the product and the collaboration between the customer and Valmet is fluent. All the three stimulating methods of suppliers to innovate were chosen to be functional and these were used in Valmet. The push-model is effective in the product development process, because there the product requirements cannot be tightly restricted in advance. If the product

requirements are tightly defined, it is challenging for the supplier to innovate possible improvements to the product.

4.4 The final version of the design-to-cost framework

The first DTC framework based on the literature review was presented in Figure 11 (Chapter 2.5). In the next stage, the DTC framework was complemented with the interview study findings. The enhanced DTC framework was illustrated in Figure 13 (Chapter 3.7). In the last stage, workshop study results are complemented to the DTC framework. Figure 17 shows the final version of the DTC framework from the perspective of this thesis. The complemented items from the workshop study findings are presented with the red color. The complemented items which are presented with the red color are topics that caused the most conversation among the suppliers, Valmet and the customer. See Figure 17.

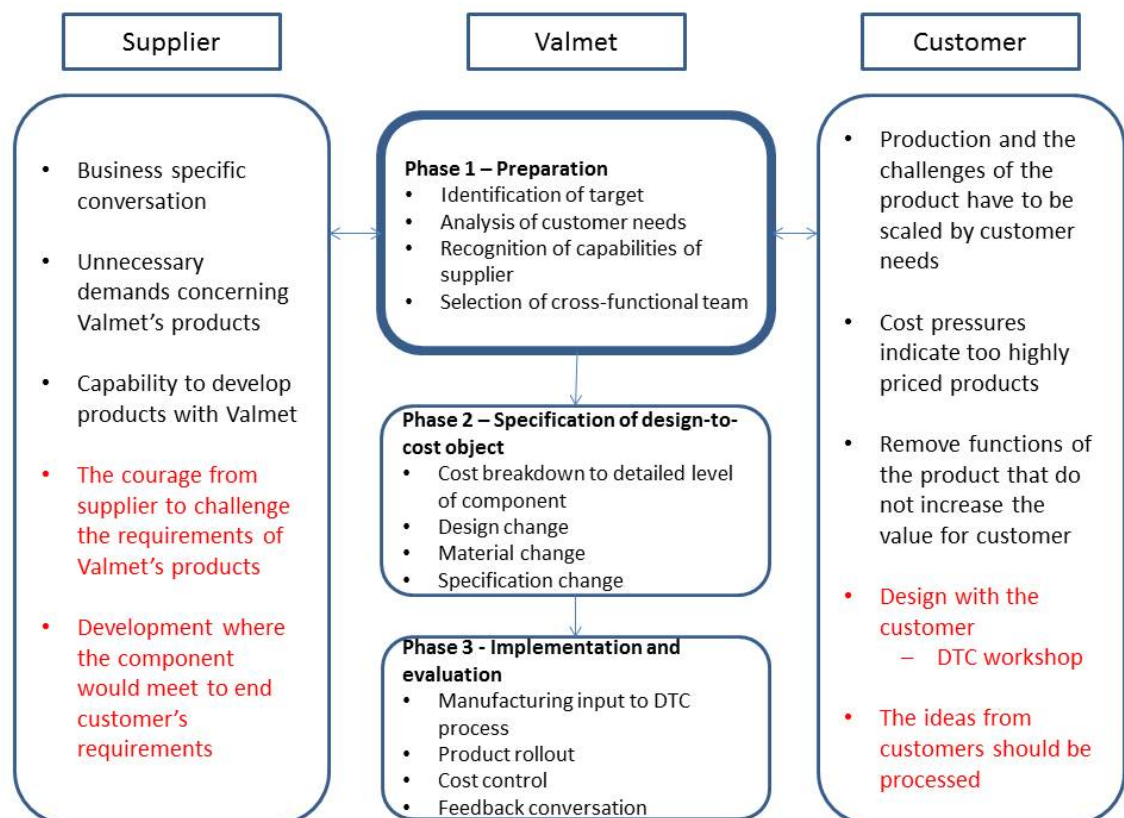


Figure 17. The final version of the design-to-cost framework

The information flow in the first phase of the DTC process between the supplier, Valmet and the customer is reviewed briefly. The technical information can go from the supplier to the customer and the other way round. The need of the customer is straightly communicated to the supplier and the supplier can improve its component to respond better to the requirements of the customer. Furthermore, this is one significant way to improve the cost-effectiveness of the product development process.

5. CONCLUSIONS

5.1 Summary of the research results

The thesis concentrated on defining a DTC framework for product development in a manufacturing project business. The thesis had two objectives as mentioned in the introduction. The theoretical aim of the thesis was to increase understanding about the cost-effectiveness of product development through inter-organizational and cross-functional collaboration. From the perspective of Valmet, the aim was to offer a framework for recognition of prospective DTC targets through procurement function, Valmet's other internal functions and inter-organizational collaboration.

Therefore, to reach the purposes of the thesis three research questions were compiled. The three research questions were formed in the following way:

What phases constitute the design-to-cost (DTC) framework and how do different actors relate to the DTC framework?

What practices can be used in improving collaboration between procurement and other key actors including internal functions, suppliers and customers?

How to identify potential initiatives for product development efforts?

For the first research question, the answer is presented in Chapter 4.4 where the final version of the DTC framework is described and illustrated in Figure 17. The DTC framework constitutes three phases. The first phase is *Preparation*. The preparation phase includes the identification of the DTC target, the analysis of the customer needs, the recognition of the capabilities of the supplier, and the selection of the cross-functional team. The second phase is *Specification of the design-to-cost object*. The specification of the DTC object phase includes the cost breakdown to a detailed level of the component, the design change of the object, the material change of the object, and the specification change of the object. The third phase is *Implementation and evaluation*. The implementation and evaluation phase includes manufacturing input to the DTC process, product rollout, cost control and a feedback conversation. The first phase of the DTC framework through the fluency of collaboration between customers, Valmet and suppliers was chosen to be the focus area, on the basis of the interview study results.

The most significant observation on the basis of the interviews was the role of customers and suppliers in Valmet's product development process. These viewpoints

were currently mentioned by the interviewees and they were not clearly visible in the previous studies on DTC and related areas. The DTC framework now constitutes three factors: the supplier, Valmet and the customer. The customer indicates the needs of products and Valmet's role is to manufacture the product with correct characteristics. The third part of the DTC process is the supplier, who may have necessary resources for identifying the sources for the cost-effectiveness of the product development process. It is crucial to understand that the effectiveness of the DTC process is dependent on all of these three actors and their collaboration.

To the second research question, the answer is cross-functional and inter-organizational collaboration. The cross-functional teams include procurement and other internal functions of Valmet. Chapter 3.3.3 presents how the cross-functional teams are formed in Valmet and when the time is right to integrate different functions into the cross-functional teams. The inter-organizational collaboration between Valmet, the suppliers and the customer are a crucial part of the DTC process. The practical tool to improve the inter-organizational collaboration is the DTC workshop, where all parties can present their improvement ideas concerning the product development. The DTC workshop methods are presented in Chapter 4.1 and Chapter 4.2 showing how the DTC workshop is formulated.

The answer to the third research question is presented in Chapter 3.3.1 where the interview study results indicate that the potential initiatives for the DTC process can come from customers, suppliers and the employees of Valmet. These interview study results broaden the range of possible sources of the DTC initiatives. Chapter 3.3.2 presents potential ways to identify the DTC targets. The possible DTC target can be a product which has a great sales volume or a possibility to achieve cost savings. The customer requirements are one of the main reasons to commence the DTC process. Customer requirements can indicate the unnecessary demands of the product structure.

5.2 Theoretical contribution

Several researchers have used DTC in different forms and in variable environments in their studies. Rehman & Guenov (1998) described a method for modelling costs through the design phase of a product's life-cycle, from abstract to detailed design. Eversheim et al. (1998) developed generic methodology to combine cost modeling and quality function deployment in order to estimate the potential trade-off between costs and performance. Abdalla & Knight (1994) defined an expert system for the concurrent product and process design for mechanical parts. Wei & Egbelu (2000) share the idea of a framework to estimate the lowest product manufacturing cost.

These DTC models evaluate system design instead of single component design. As noted in the literature review, there is a shortage of research how to exploit a DTC process in the tailored single product development. The existing literature on DTC has

been oriented towards mass production contexts (Abdalla & Knight 1994; Wei & Egbelu 2000). This thesis shows and introduces a framework which is composed of and supplemented with divergent research models based on target costing models (Filomena et al. 2009; Ellram 2006), cost estimation models in the product design (Ibusuki & Kaminski 2007; Weustink et al. 2000) and the decision-making models (Platts et al. 2002; Humphreys et al. 2002; McIvor et al. 1997).

As many previous studies present manufacturing companies recognize, the significance of the collaboration with suppliers in the product development process (Birou & Fawcett 1994; Wynstra et al. 2001; Dubois & Wynstra 2005; Song & Di Benedetto 2008), but most of the development methods do not pay any attention to the collaboration between the supplier, the purchasing company, and the end customer. The DTC framework links tailored single product development the cross-functional teams. Additionally, it improves the cost-effectiveness of the product development process by integrating supplier capabilities and customer requirements. Hence, the thesis presents an entirely new framework for the tailored product development process via inter-organizational collaboration through supplier capabilities and customer requirements.

In a study by Koufteros et al. (2005) cross-functional teams provide a mechanism for capturing learning, an opportunity to reduce equivocality, and a path to constituents to express affairs. Gelderman and Van Weele (2005) present that cross-functional team participation should foster awareness, improved communication and integration of the procurement function with other functional groups in the company. The results of the thesis are consistent with the views of Koufteros et al. (2005) and Gelderman & Van Weele (2005). The DTC framework includes the forming of a cross-functional and inter-organizational team. The results from the workshop and interview studies present that cross-functional teams enable the employees of Valmet to collaborate more effectively and share insights and ideas about the new ways of working together.

The professionals of procurement should be included in development processes and product development teams when the intention of the company is to incorporate supplier innovations into the company while, at the same time, confirming the commercial viability (Schiele 2010; Birou & Fawcett 1994; Lakemond et al. 2001). The technical success is linked with an effective communication over product development (Koufteros et al. 2005; Hartley et al. 1997). The engagement of procurement function to the product development teams was consistent with the results of this thesis. The interviewees from product development, production, and procurement agreed that procurement should be involved earlier in the product development teams. Nevertheless, as Lakemond et al. (2001) state and the interview study results presented, procurement function never commits supplier management solely; it is an integrated task and carried out by several business functions, in alternative constellations.

5.3 Managerial implications

The preparation phase of the DTC framework includes the DTC workshop, which is an efficient tool for identifying potential initiatives for product development projects. The interview study results emerged the number of possible initiators in the product development process because before the interviews were conducted, customers were not recognized as the initiator for the DTC process. Based on the DTC framework the potential innovative idea can come from suppliers, customers or inside the different functions of Valmet. At the same time, the DTC framework lists recommendations that should be observed concerning suppliers and customers in the preparation phase of the DTC process.

The highlighted issues are the information flow and collaboration between the suppliers, Valmet and the end customer. The DTC workshop is a concrete tool for improving the inter-organizational collaboration. The results provide support for Bstieler (2006), who presented that knowledge sharing in collaborative product development requires shared understanding and the development of trust built up through experience. Liker & Choi (2004) add that inter-organizational interaction increases the shared information through close working relationships and buyers understand better how their supplier works.

The DTC workshop is also a significant link between the requirements of the end customer and the capabilities of the suppliers. It is a unique opportunity to converse potential needs. Furthermore, when all parties are in the same room, it is possible to discuss what components or functions are insignificant in the terms of customer satisfaction. The required design changes can be made and the costs can be minimized. Above all, the DTC workshop increases the overall understanding about the product development process in Valmet. Another important issue is the collaboration inside Valmet. Through the use of the DTC workshop, Valmet is able to enhance the collaboration among the different business functions. The cross-functional teams that need to be constructed in the DTC process are an efficient way to diminish the organizational silo effect inside the company.

In addition, one aim of the thesis was to define the DTC concept for the purposes of Valmet. The DTC concept has mainly been used in the context of automated mass production. The context of this research, i.e. tailored single product manufacturing, is different in many respects from the earlier DTC application environments. The term DTC was formed during this whole thesis process when the DTC framework was constructed. For the purposes of Valmet, the term DTC does not merely mean a technique to achieve designs that meet the stated cost requirements. For Valmet the DTC process is constructed by four main factors: customer value, collaboration, capabilities and cost breakdown. See Figure 18.

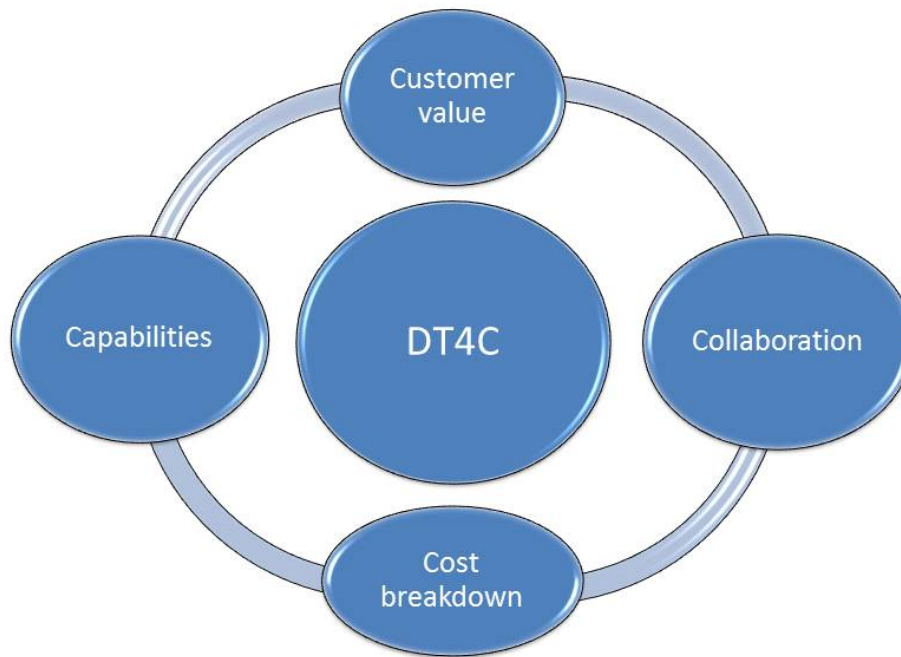


Figure 18. *Design-to-four-C*

Figure 18 illustrates the main factors of Valmet’s DTC process, and integrating these together forms *Design-to-four-C* (DT4C). By observing the customer’s requirements, insignificant components can be minimized and the customer’s demands fulfilled. Above all, the *Customer value* increases. The *Capabilities* consist of the capabilities of suppliers and the capabilities of Valmet. The DTC target defines what kind of capability is needed. The *Collaboration* includes the cross-functional teams formed by different functions of Valmet and the inter-organizational collaboration through suppliers and a customer. The *Cost breakdown* is a way to figure out the cost structure of the product and it is also a crucial part of the DTC process. The DTC has evolved from being a routine and mechanical tool to a framework that can adapt to the globalization and outsourcing, along with a focus on innovative inter-organizational collaboration.

5.4 Limitations and critical review

The limitations of the thesis relate to the validity and reliability of the proposed DTC framework. Gummesson (2000) presents that, in case study research, validity refers to “*continuous process that is integrated with theory and that requires the researcher to continuously assess his assumptions, revise his results, retest his theories and models and reappraise the given limitations that have been set for the study.*” According to Riege (2003), to establish the validity and reliability of qualitative data, it is important to determine the quality and stability of the data obtained. Ellram (1996) describes that the design of the case study research requires construct validity, internal validity, external validity and reliability. Riege (2003) is in the same line with Ellram (1996), but he argues that there is not a single coherent set of validity and reliability tests in the case

study research. The research methods of the thesis are established through construct validity, internal validity, external validity and reliability.

Construct validity is associated with the establishment of the proper operational measures for the concepts being studied (Ellram 1996). The theoretical prediction of this thesis is the constructed DTC framework for tailored product development through cross-functional collaboration. The thesis is considered as construct valid, since the predictions about the cost-effectiveness of the DTC framework through the cross-functional collaboration could be proven with empirical results. Riege (2003) implies that to increase construct validity in the case study research, multiple sources of evidence should be used in the data collection phase to prevent researcher bias. The thesis exploited semi-structured interviews and workshops in the data collection phase.

Internal validity in a case study research refers to considering alternative explanations, making proper inferences from the data and using convergent data. Internal validity is a concern in explanatory case studies, where it tries to demonstrate that the outcome was produced by an independent variable. (Ellram 1996) The DTC workshop exploits the direct data gathering sources. The requirements of the customers and the capabilities of the suppliers are collected directly from the customers and the suppliers. This increases the internal validity of the chosen method significantly.

External validity concerns the accuracy of the results in the studied phenomenon and the generalizability of the results. The lack of generalizability is the major criticism of case studies. (Ellram 1996) The external validity of the method is weakened by the use of single-case study. The validity of the method would have increased if the data had been collected through multiple cases. According to Lee & Baskerville (2003) "*A theory may never be scientifically generalized to a setting where it has not yet been empirically tested and confirmed*". Therefore, the results of the thesis are not universally representative and cannot be generalized to cover all different environments using DTC framework.

According to Gummesson (2000, p. 91), reliability refers to a situation where "*Two or more researchers studying the same phenomenon with similar purposes should reach approximately the same results*". As mentioned earlier, the research methods of the thesis consisted of semi-structured interviews and interacting groups. Regarding semi-structured interviews, Diefenbach (2009) argues that they have disadvantages. He presents that the selection of interviewees is not objective and systematic. Furthermore, the interview situation influences the interviewees and they may not be reliable sources of information because of unconscious bias. (Diefenbach 2009) The sample of the interviews in this study was quite small, only 14 representatives. The small sample size may diminish the reliability of the results and cause possible bias in the collected data. Nevertheless, Diefenbach (2009) argues that an increase of the number of interviews

conducted and interview data gathered might be more convincing and reassuring in everyday sense but it does not increase their validity in a methodological sense.

Riege (2003) states that, in a case study context, reliability can be increased by recording data mechanically and using a structured or semi-structured case study protocol. In this thesis, each of the semi-structured interviews was audio-recorded. No additional tests were conducted as to the DTC framework, which leads to a situation where the reliability of the framework cannot be ensured. The main result of this thesis is, however, the compiling of the DTC framework.

Green (1975) criticizes interacting groups, the other research method of the thesis. He presents that the nominal group is superior to the interacting groups a situation where group effectiveness is measured by both the quantity of unique ideas and perceived group satisfaction. Ven & Delbecq (1986) express that group pressure for the conformity and implied threats of sanctions from the more knowing members reduce the performance of interacting groups. Nevertheless, Rietzschel et al. (2006) expound that large numbers of ideas are never the ultimate aim of a group discussion. They suggest that high productivity in group discussions is not sufficient to lead to better solutions. Instead of trying to make groups more productive, it would be more profitable to make groups more efficient in all the stages of the innovative process. (Rietzschel et al. 2006) The workshop studies were conducted with the interactive group technique. The conversation themes were discussed in from different perspectives and the ideas which were undevelopable were recognized immediately through the different participants. Above all, the DTC workshop is a valuable tool for improving and innovating ideas among suppliers, customers and Valmet.

5.5 Future research

Future research is needed to validate and improve the functionality of the DTC framework created in this thesis. The scope of this thesis is mainly limited to the first phase of the presented DTC process. The in-depth part of the empirical study did not address phases two and three of the DTC process. Hence, further research is needed to test the phases two and three of the created DTC process in the environment of tailored single product manufacturing.

The created DTC framework is a partial representation of a more complex collaboration and product development process. The impact of supplier networks and the end customer on the adoption of the shared product development process in the tailored single product manufacturing came up during the thesis research. Further research is needed to clarify the relationships between the underlying attributes of the structuring choices of inter-organizational relationships and the capabilities between the buyer company, the end customer and the suppliers in the product development process.

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APPENDICES (3 PIECES)

APPENDIX 1: Questioning frame for procurement

1) Haastateltavan taustatiedot

- a) Mikä on toimenkuvasi ja keskeiset tehtäväsi?
- b) Mikä Valmetin tuoteryhmä/-kategoria on teitä lähimpänä?
- c) Kuinka pitkään ja missä tehtävissä olet työskennellyt Valmetilla tai sen edeltäjissä?

2) Hankinnan rooli yrityksessä

- a) Miten hankinta ja sen tavoitteet näkyvät koko Valmetin strategiassa?
 - a. Millä tavoin kustannusten säästötavoite näkyy hankintafunktion toiminnassa? Anna esimerkkejä.
- b) Minkälaisia kokemuksia teillä on hankinnan roolista yrityksenlaajuisissa kehittämisprojekteissa? (Esim. DTC)
- c) Kuinka hankinnan rooli vaihtelee eri tuotekehitysprojekteissa? Mikä vaihteluun vaikuttaa? Vaikuttaako projektin koko tai kompleksisuus?
- d) Kuvaile esimerkin avulla miten ja missä vaiheessa hankinta integroidaan tuotekehitykseen mukaan?
- e) Mikä seuraavista vaihtoehdoista kuvaa parhaiten hankinnan osallistumista tuotekehitykseen?
 - a) Hankinnan työntekijöihin otetaan erikseen yhteyttä tarpeen vaatiessa
 - b) Hankinta integroidaan osa-aikaisesti projektitiimiin
 - c) Hankinta on integroitu täysipäiväisesti projektitiimiin
 - d) Hankinnan koordinaattori on mukana projektitiimissä ja välittää tiedot muulle hankinnan henkilökunnalle
 - e) Hankinnan koordinaattori on mukana projektitiimissä ja lisäksi hankinnan spesifioituneet työntekijät ovat osa-aikaisesti mukana projektitiimissä
 - f) Hankinnan koordinaattori ja hankinnan spesifioituneet työntekijät ovat täysipäiväisesti mukana projektitiimissä (kuva 1)
- g) Onko hankinnan henkilökunta erikoistunut tiettyihin teknologioihin tai tuotteisiin samalla periaatteella kuin tuotekehitysinsinöörit?
 - a) Kuinka paljon tuotekehitysprojekteissa mukana olevilla hankinnan työntekijöillä on teknistä osaamista taustalla?
- h) Hyödynnetäänkö suunnittelemissanne tuotteissa modularisointia tai standardisointia?
 - a) Jos ei, miksi? Näetkö modularisoinnissa haasteita? Entä potentiaalisia hyötyjä modularisoinnissa tai standardisoinnissa yleisemmin?
 - b) Jos kyllä,
- i) Kuka tekee päätöksiä modularisointiin liittyen? Miten päätöksiä tehdään ja mitkä tekijät vaikuttavat päätöksiin?

- j) Minkälaisin kriteerein tulevia hankintoja arvotetaan, mietitäänkö käytännön hyötyjä? (potentiaalisen arvon arvioiminen)
 - a) Onko käytössä muitakin kuin rahallisia kriteerejä? Käytetäänkö intuitiota?

3) Toimittajat

- a) Onko yhteisiä kehityshankkeita toimittajien kanssa tai onko tällaisia suunnitteilla? Minkälaisia?
 - a) Kuka olisi mielestäsi sopivin P&E ja paperin yhteinen toimittaja projektin haastattelukohteeksi?
- b) Miten ja millä perusteella päätetään toimittajan kanssa tehtävästä yhteistyöstä tuotekehitysprojektissa?
 - a) Mietitäänkö yhteistyötä aina yksi projekti kerrallaan vai pidemmälle aikajänteelle?
- c) Millaisia yhteistyömuotoja teillä on toimittajan kanssa tuotekehitysprojektissa? Voitko kertoa esimerkin?
 1. Toimittaja osa tuotekehitysprojektia
 2. Toimittajalle on muotoiltu tehtävä, josta on pitkälti yksinään vastuussa. Toimittajan ja tuotekehitysprojektin välillä on vain pieni riippuvuus
 3. Vain tarveperusteisesti; toimittajalla ja asiakkaalla vakaa suhde. (kuva 2)
- d) Mitkä asiat motivoivat toimittajia ja teitä pyrkimään yhteisiin tavoitteisiin?
- e) Onko toimittajien sitouttamisessa tuotekehitykseen ollut ongelmia? Millaisia?
- f) Koetteko, että joidenkin toimittajien asema on vahva?
 - a) Mistä toimittajan vahva asema johtuu ja aiheuttaako se haasteita?
- g) Millaiset keskustelusuhteet ovat toimittajien kanssa?
- h) Kenen kanssa toimittajat ovat mielestäsi yleisimmin tekemisissä; hankinnan, tuotannon tai tuotekehityksen? Onko tilanne sinusta tällä hetkellä kunnossa, vai pitäisikö jotain parantaa?
- i) Miten viestitte avaintoimittajien kanssa?
- j) Tukevatko teknologiset ratkaisut pitkäkestoisten toimittajasuhteiden johtamista, millä tavoin?

4) Design-to-cost ajatteluun soveltuvien kohteiden tunnistaminen

- a) DTC ajattelussa pyritään säästämään tuotteen valmistuskustannuksissa
 - a) Minkä tai mitkä seuraavista vaihtoehdoista näkisit teidän tapauksessa mahdollisiksi (esimerkkejä):
 - a) Kustannukset pienenevät, ja tuotteen ominaisuuksia heikennetään joiltain osin, esim. lyhyempi elinkaari tietyille komponentille
 - b) Kustannukset laskevat ja tuotteen ominaisuudet pysyvät samoina
 - c) Kustannukset laskevat ja tuotteen ominaisuuksiin saadaan parannuksia
 - d) Kustannukset pysyvät samana tai jopa nousevat ja ominaisuudet paranevat

- b) Mistä löytyy mielestäsi selkein potentiaali kustannussäästöihin, mikäli hankintakustannuksia ei oteta huomioon?
 - a) Tuotteiden suunnittelusta
 - b) Tuotannon suunnittelusta
 - c) Valmistuksesta
 - d) Tietyistä kustannuseristä, esim. henkilöstö, logistiikka ja asennus.
- c) Tuleeko mieleesi esimerkkitapaus, jota voisi pohtia design-to-cost kohteena projektissamme?
- d) Miten mittaatte hankintojen kokonaiskustannuksia niiden elinkaarella? Liittykö haasteita tai kehityskohteita?

5) Muuta

- a) Tarkasteltaessa hankinnan yhteistyötä yrityksen muiden funktioiden kanssa, missä näet keskeisimmät kehityksen kohteet?
- b) Tuleeko mieleesi jotain muuta haastattelun aiheeseen liittyvää tai lisättävää?

APPENDIX 2: Questioning frame for product development

1) Haastateltavan taustatiedot

- b) Mikä on toimenkuvasi ja keskeiset tehtäväsi?
- c) Kuinka pitkään ja missä tehtävissä olet työskennellyt Valmetilla tai sen edeltäjissä?
- d) Millainen rooli hankinnalla on työssäsi?

2) Tuotteen uudelleensuunnittelu

- a) Mikä tuoteryhmä on teitä lähimpänä?
 - a) Missä siinä on merkittävin paikka vähentää kustannuksia uudelleensuunnittelun näkökulmasta?
- b) Kuvaile teidän tuotteen uudelleensuunnitteluprosessia
 - a) Mistä tai miten aloite uudelleensuunnitteluun syntyy?
 - b) Missä vaiheessa prosessia tuotteen kustannuksia mietitään? Miten kustannusajattelu otetaan mukaan? Mihin kustannuksiin kiinnitetään erityisesti huomiota?
- c) Miten ja missä vaiheessa hankinta integroidaan tuotekehitykseen mukaan?
- d) Vastaako jokin seuraavista vaihtoehdoista Valmetin hankinnan osallistumista tuotekehitykseen:
 - a) Hankinnan työntekijöihin otetaan erikseen yhteyttä tarpeen vaatiessa
 - b) Hankinta integroidaan osa-aikaisesti projektitiimiin
 - c) Hankinta on integroitu täysipäiväisesti projektitiimiin
 - d) Hankinnan koordinaattori on mukana projektitiimissä ja välittää tiedot muulle hankinnan henkilökunnalle
 - e) Hankinnan koordinaattori on mukana projektitiimissä ja lisäksi hankinnan spesifioituneet työntekijät ovat osa-aikaisesti mukana projektitiimissä
 - f) Hankinnan koordinaattori ja hankinnan spesifioituneet työntekijät ovat täysipäiväisesti mukana projektitiimissä (kuva 1)
- e) Onko hankinnan henkilökunta erikoistunut tiettyihin teknologioihin tai tuotteisiin samalla periaatteella kuin tuotekehitysinsinöörit?
 - a) Kuinka paljon tuotekehitysprojekteissa mukana olevilla hankinnan työntekijöillä on teknistä osaamista taustalla?

3) Tuotanto

- a) Hyödynnetäänkö suunnittelemissanne tuotteissa modularisointia tai standardisointia?
 - a) Jos ei, miksi? Näetkö modularisoinnissa haasteita? Entä potentiaalisia hyötyjä modularisoinnissa tai standarnoinnissa yleisemmin?
 - b) Jos kyllä,
 - (a) Kuka tekee päätöksiä modularisointiin liittyen? Miten päätöksiä tehdään ja mitkä tekijät vaikuttavat päätöksiin?

- b) Miten tuotteen modularisoinnin suunnittelu lähtee liikkeelle? Onko lähtökohtana yhteinen tuotealusta vai muokataanko olemassa olevia tuotteita standardisoimalla komponentteja?

4) Toimittajat

- a) Onko yhteisiä kehityshankkeita toimittajien kanssa tai onko tällaisia suunnitteilla? Minkälaisia?
- a. Kuka olisi mielestäsi sopivin P&E ja paperin yhteinen toimittaja projektin haastattelukohteeksi?
- b) Miten ja millä perusteella päätetään toimittajan kanssa tehtävästä yhteistyöstä tuotekehitysprojektissa?
- a. Mietitäänkö toimittajan kanssa tehtävää yhteistyötä projektikohtaisesti vai pidemmälle aikajänteelle?
 - b. Millaisia toimittajan yhteistyömuotoja teillä on tuotekehitysprojektissa?
 1. Toimittaja osa tuotekehitysprojektia
 2. Toimittajalle on muotoiltu tehtävä, josta on pitkälti yksinään vastuussa. Toimittajan ja tuotekehitysprojektin välillä on vain pieni riippuvuus
 3. Vain tarveperusteisesti, toimittajalla ja asiakkaalla vakaa suhde (kuva 2)
 - c. Vaihteleeke yhteistyömuoto toimittajan kanssa tuotekehitysprojektin aikana?
 - d. Onko toimittajien sitouttamisessa tuotekehitykseen ollut ongelmia? Millaisia?
- c) Millaiset keskustelusuhteet ovat toimittajien kanssa?
- a. Kenen kanssa toimittajat ovat mielestäsi yleisimmin tekemisissä; hankinnan, tuotannon tai tuotekehityksen? Onko tilanne sinusta tällä hetkellä kunnossa, vai pitäisikö jotain parantaa?
- d) Koetteko, että joidenkin toimittajien asema on vahva?
- a. Mistä toimittajan vahva asema johtuu ja aiheuttaako se jotain haasteita?

5) Design-to-cost ajatteluun soveltuvien kohteiden tunnistaminen

- a) DTC ajattelussa pyritään säästämään tuotteen valmistuskustannuksissa
- a) Minkä tai mitkä seuraavista vaihtoehdoista näkisit teidän tapauksessa mahdollisiksi (esimerkkejä):
 - a) Kustannukset pienenevät, ja tuotteen ominaisuuksia heikennetään joiltain osin. Esim. lyhyempi elinkaari tietylle komponentille
 - b) Kustannukset laskevat ja tuotteen ominaisuudet pysyvät samoina
 - c) Kustannukset laskevat ja tuotteen ominaisuuksiin saadaan parannuksia
 - d) Kustannukset pysyvät samana tai jopa nousevat ja ominaisuudet paranevat

- b) Mistä löytyy mielestäsi selkein potentiaali kustannussäästöihin, mikäli hankintakustannuksia ei oteta huomioon?
 - a) Tuotteiden suunnittelusta
 - b) Tuotannon suunnittelusta
 - c) Valmistuksesta
 - d) Tietyistä kustannuseristä, esim. henkilöstö, logistiikka, ja asennus.
- c) Tuleeko mieleesi esimerkkitapaus, jota voisi pohtia design-to-cost kohteena projektissamme?

6) Muuta

- a) Tarkasteltaessa tuotekehityksen yhteistyötä yrityksen muiden funktioiden kanssa, missä näet keskeisimmät kehityksen kohteet?
- b) Tuleeko mieleesi jotain muuta haastattelun aiheeseen liittyvää tai lisättävää?

APPENDIX 3: Questioning frame for production

1) Haastateltavan taustatiedot

- a) Mikä on toimenkuvasi ja keskeiset tehtäväsi?
- b) Kuinka pitkään ja missä tehtävissä olet työskennellyt Valmetilla tai sen edeltäjissä?
- c) Millainen rooli hankinnalla on työssäsi?

2) Tuotanto

- a) Mikä tuoteryhmä tai tuote on teitä lähimpänä? Voitko kuvailla lyhyesti sen tuotantoa tai kokoonpanoa?
 - a) Missä siinä olisi merkittävin paikka vähentää kustannuksia tuotannon näkökulmasta?
 - b) Huomioidaanko mielestäsi tuotantoon liittyviä kustannuksia tuotteiden uudelleensuunnittelussa?
- b) Miten ennakoitte tuotteeseen tehtäviä muutoksia tuotannossanne?
- c) Onko tuotannon edustaja mukana tuotekehityksen projektitiimissä? Jos on, onko tarvelähtöisesti vai pysyvämmin?
- d) Hyödynnetäänkö tuottamissanne/kokoonpanemissanne tuotteissa modularisointia tai standardisointia?
 - a) Jos ei, miksi? Näetkö modularisoinnissa haasteita? Entä potentiaalisia hyötyjä modularisoinnissa tai standardisoinnissa yleisemmin?
 - b) Jos kyllä,
 - (a) Kuka tekee päätöksiä modularisointiin liittyen? Kuinka tuotteessa hyödynnetään standardoituja osia tai modularisointia, pystytkö antamaan esimerkkejä?
- e) Miten modularisointi on vaikuttanut tuotannon kustannuksiin?
 - a) Valmistuksen kustannukset
 - b) Varastokustannukset
 - c) Materiaali ja komponentti kustannukset
 - d) Hankintakustannukset
 - e) Suunnittelukustannukset
 - f) Elinkaarikustannukset
 - g) muut kustannukset, mitkä?
- f) Miten modularisointi on vaikuttanut tuotannon toteutukseen?
 - a) Uusia kokoonpanolinjoja
 - b) Ulkoistaminen
 - c) Lyhyemmät kokoonpano-, tuotanto- ja tuotekehitysajat
 - d) muulla tavoin, miten?

3) Toimittajat

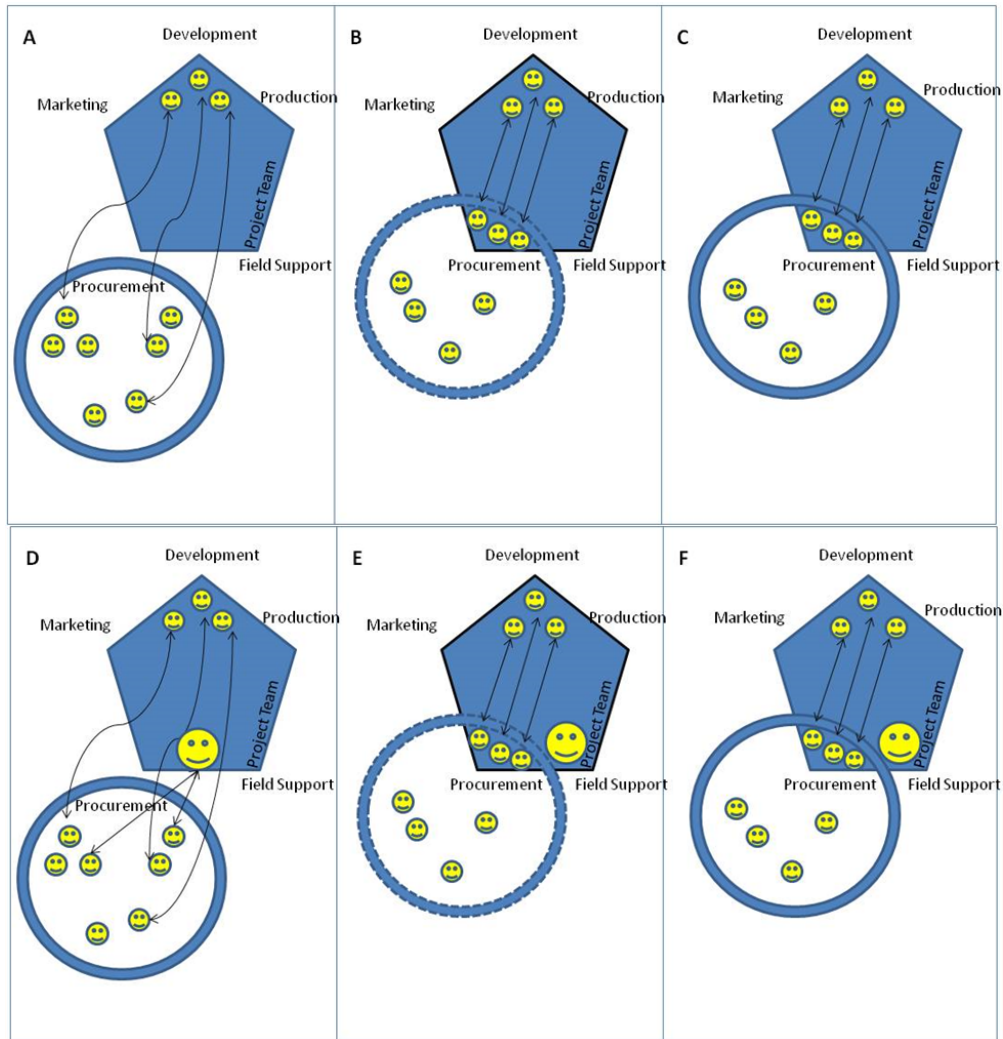
- a) Onko yhteisiä kehityshankkeita toimittajien kanssa tai onko tällaisia suunnitteilla? Minkälaisia?
- b) Kuka olisi potentiaalinen toimittaja, jonka kanssa olisi hyvä käydä tiivistä vuoropuhelua? Miksi?
 - a. Kuka olisi mielestäsi sopivin P&E ja paperin yhteinen toimittaja projektin haastattelukohteeksi?
- c) Mitkä asiat ratkaisevat kuinka tiiviistä yhteistyötä projektissa tehdään toimittajan kanssa?
 - a. Mietitäänkö aina projektikohtaisesti toimittajan kanssa tehtävästä yhteistyömuodosta?
- d) Mietitäänkö toimittajan kanssa tehtävää yhteistyötä projektikohtaisesti vai pidemmälle aikajänteelle?
- e) Onko toimittajien sitouttamisessa tuotantoon ollut ongelmia? Millaisia?
- f) Millaiset keskustelusuhteet ovat toimittajien kanssa?
 - a. Kenen kanssa toimittajat ovat mielestäsi yleisimmin tekemisissä; hankinnan, tuotannon tai tuotekehityksen? Onko tilanne sinusta tällä hetkellä kunnossa, vai pitäisikö jotain parantaa?
- g) Koetteko, että joidenkin toimittajien asema on vahva?
 - a. Mistä toimittajan vahva asema johtuu ja aiheuttaako se jotain haasteita?

4) Design-to-cost ajatteluun soveltuvien kohteiden tunnistaminen

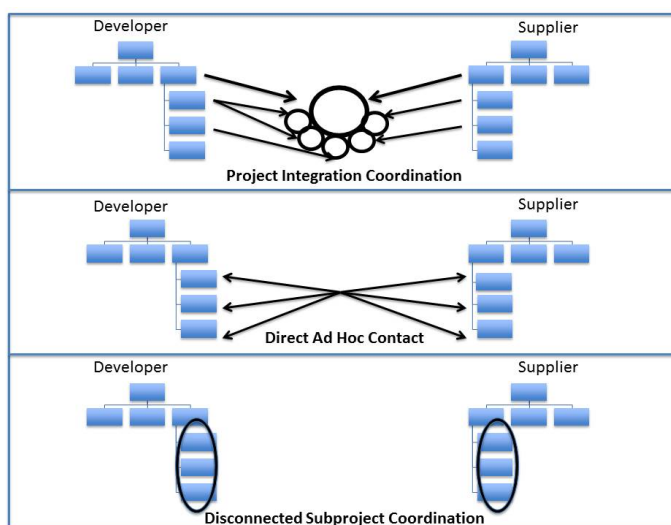
- a) DTC ajattelussa pyritään säästämään tuotteen valmistuskustannuksissa
 - a) Minkä tai mitkä seuraavista vaihtoehdoista näkisit teidän tapauksessa mahdollisiksi (anna esimerkkejä):
 - a) Kustannukset pienenevät, ja tuotteen ominaisuuksia heikennetään joiltain osin. Esimerkiksi lyhyempi elinkaari tietyille komponentille
 - b) Kustannukset laskevat ja tuotteen ominaisuudet pysyvät samoina
 - c) Kustannukset laskevat ja tuotteen ominaisuuksiin saadaan parannuksia
 - d) Kustannukset pysyvät samana tai jopa nousevat ja ominaisuudet paranevat
 - b) Mistä löytyy mielestäsi selkein potentiaali kustannussäästöihin, mikäli hankintakustannuksia ei oteta huomioon?
 - a) Tuotteiden suunnittelusta
 - b) Tuotannon suunnittelusta
 - c) Tietyistä kustannuseristä, esim. henkilöstö, logistiikka, ja asennus.
 - c) Tuleeko mieleesi esimerkkitapaus, jota voisi pohtia design-to-cost kohteena projektissamme?

5) Muuta

- a) Tarkasteltaessa tuotannon yhteistyötä yrityksen muiden funktioiden kanssa, missä näet keskeisimmät kehityksen kohteet?
- b) Tuleeko mieleesi jotain muuta haastattelun aiheeseen liittyvää tai lisättävää?



Kuva 1. Hankinnan sitouttaminen tuotekehitysprojektiin (muokattu lähteestä Lakemond et al. 2001)



Kuva 2. Toimittajien sitouttaminen tuotekehitysprojektiin (muokattu lähteestä Lakemond et al. 2006)