TAMPERE UNIVERSITY
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SUPPLY CHAIN PLANNING ATTRIBUTES FOR A NEW PRODUCT

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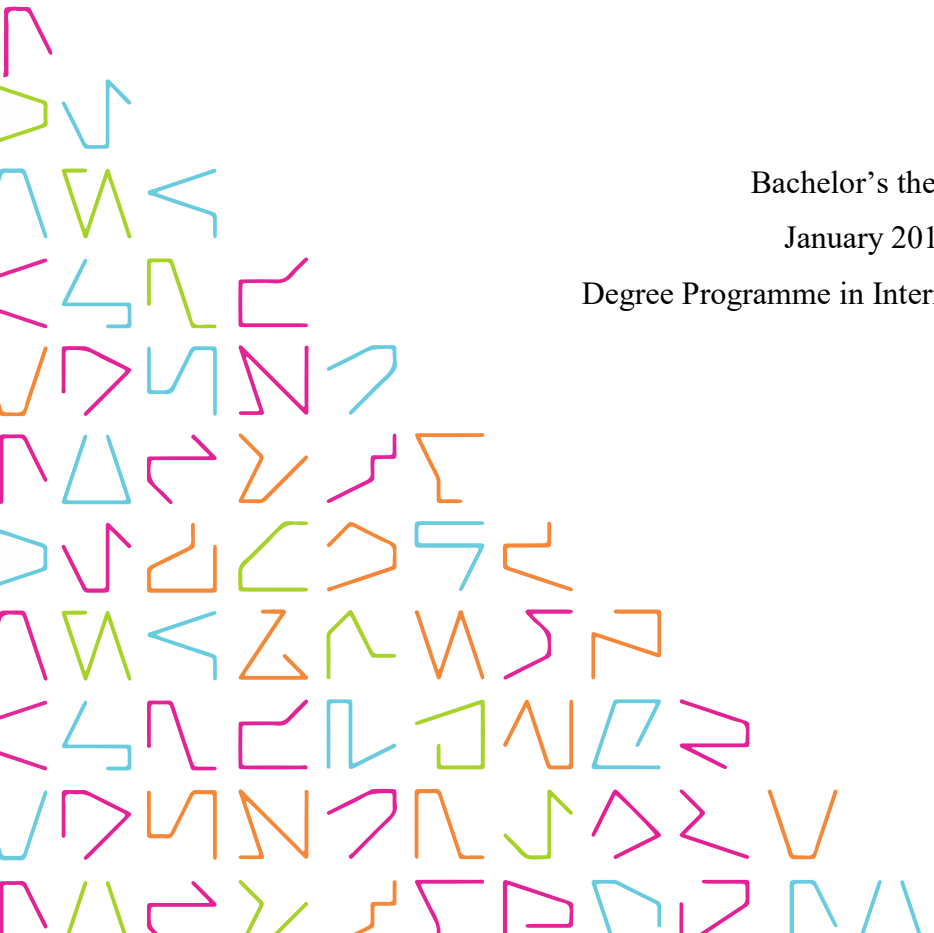

Bachelor's thesis

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ABSTRACT

Tampereen ammattikorkeakoulu
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Supply Chain Planning Attributes for a New Product

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The primary aim of this thesis was to describe tools and attributes required to plan and analyze supply chains for a new product. The new product is an aerosol filter that has been designed by Tampere University of Applied Sciences' engineering group, to control metal exhaust ventilation in metal working factories. The points that needed to be addressed were mainly the business model for the new product, alternative market entry mode, and logistics strategy and analysis.

To answer the research problem except for online sources and academic literature, a small interview and a survey were conducted. The interview and survey participants were; the engineering group, commissioner, and maintenance group. The results showed the product criteria and function, end users, possible suppliers and partners, and production planning for the future.

Based on data retrieved from a variety of sources, the business model for the new product was formed. Moreover, logistics strategy and analysis methods were defined. At the end, in conclusion part, procedures which are helpful in planning a supply chain for a new product were summarized.

Key words: supply chain, logistics strategy, business model, entry mode

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ABBREVIATIONS AND TERMS

DC	Distribution Centre
FMEA	Failure Mode Effective Analysis
HRM	Human Resource Management
IoT	Internet of Things
PDM	Precedence Diagramming Method
PLC	Product Life Cycle
PLM	Product Life Management
RPN	Risk Priority Number
RQ1	Research Question 1
RQ2	Research Question 2
RQ3	Research Question 3
SCM	Supply Chain Management
TAMK	Tampere University of Applied Sciences
U	Utilization

1 INTRODUCTION

1.1 Thesis Topic

The requirements and attributes which are needed to plan a supply chain for a new product are described in this thesis. The study was made for the Tampere University of Applied Sciences' (TAMK) engineering group. The business sector noticed the need to enter their new product into the market and compete with other manufacturers. This study will be focused on TAMK engineering group's product, but the tools and methods could be applied to similar cases as well.

1.2 Background

This thesis is made for a Service Development branch of Engineering group at Tampere University of Applied Sciences, that have designed a new aerosol filter, for controlling metal exhaust ventilation in metal working factories. The product has the protection of utility models since 2016, and the efficiency and accuracy have been tested by Finland's Occupational Health Institute. Different kinds of filters have been designed for protecting workers against harmful aerosols and particles. Current solutions for controlling particles are; 3Nine, Nederman, Absolent, Dantherm, Losma, and PPT-Filter. The main advantages of the new product are better exhaust air purification, fewer health issues, material efficiency, maintenance efficiency, better fire safety and reduced hazardous waste.

1.3 Research Objective

The primary aim of this thesis has been to describe parameters and attributes for planning supply chains for a new product, and the requirements for maintenance and customer service in two markets within the geographical boundaries of Finland and Germany. In additions, the thesis has been aimed at describing the business model and framework for the product and defining the main players in the supply chain process.

1.4 Problem Formulation

The company's research objective has been divided into two bachelor's theses. The first one investigates the current approach of the supply chain for air filters. The second one, which this thesis focuses on, is about the potential supply chain for the new product, customer service, delivery and market entry approach. The problem definition is formulated below:

What are the parameters and requirements for Planning supply chain for a new product?

1.5 Research Questions

The two research questions in this report are obtained from the problem definition and the theoretical framework. The problem definition will be answered by addressing the research questions. The first research question deals with the business model framework and defining different market entry modes for a new product. The second research question explores supply chain strategy and analysis methods for the new product. The research strategy and pattern is based on Donald Water's logistics book 2003 which have categorized the different parts of supply chain strategy. The research questions are formulated as follows:

Research question 1:

- **What are the business model framework and possible entry modes to the market for a new product?**

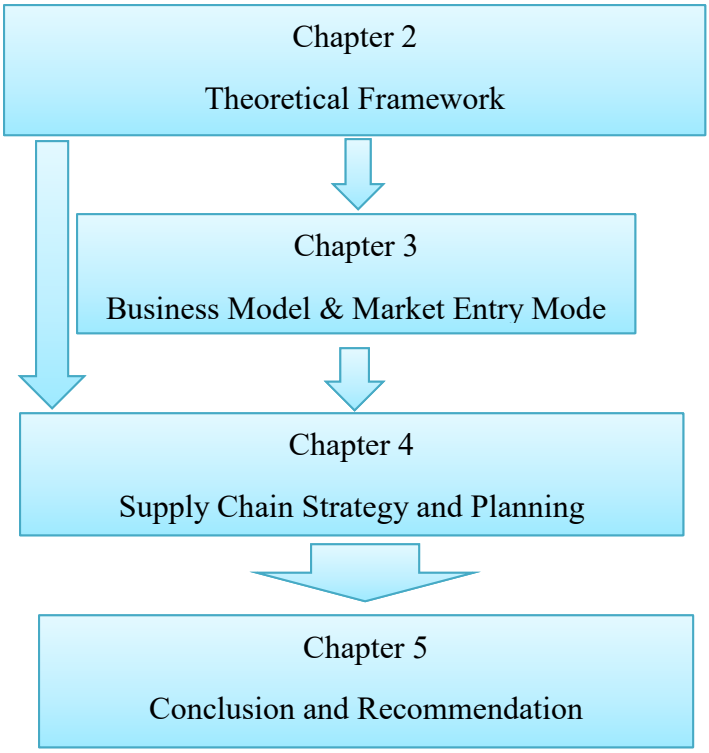
Research question 2:

- **What kind of supply chain strategy and analysis are required for a new product?**

1.6 Thesis Structure

This thesis is structured as follows. Chapter 2 includes the theoretical framework. The first research question (RQ1) will be addressed in chapter 3 by introducing the product in detail including the product design process, functional side of product, product market,

and explaining the business model structure for the product. In chapter 4, which is the main chapter, research question two (RQ2) will be investigated by extending the supply chain strategy for the product. In this chapter, parameters for planning the supply chain for the product will be defined. Moreover, delivery lead time, transportation mode, customer service, supply chain analysis, supply chain risk management, and measuring performance will be explained. The results from chapter 3 and 4 will help in putting forward recommendations in chapter 5. The research structure is illustrated in the flowchart below.



2 THEORETICAL FRAMEWORK

In this thesis, the key concepts are; value chain, logistics, supply chain management, supply chain design, transportation and distribution centers, information and material flow, lead time, supply chain risk management and product life cycle. The above-mentioned concepts have been explained in this chapter.

2.1 Value Chain

According to Porter's competitive advantage (1998, 38), in competitive terms, a value is the amount buyers are willing to pay for what a firm provides them with. The value chain shows the total value of an organization including *value activities* and *margin*. Value activities are distinct activities an organization performs such as design, production, marketing, delivery, and services. The margin is the difference between *total value* and the collective cost of performing the value activities. Value activities can be divided into *primary activities* and *support activities*. Primary activities are the activities involved in the physical creation of the product. Support activities give assistance to the primary activities by providing purchased inputs, technologies, human resources, and other firm related functions. The Figure below presents different parts of value chain activities and

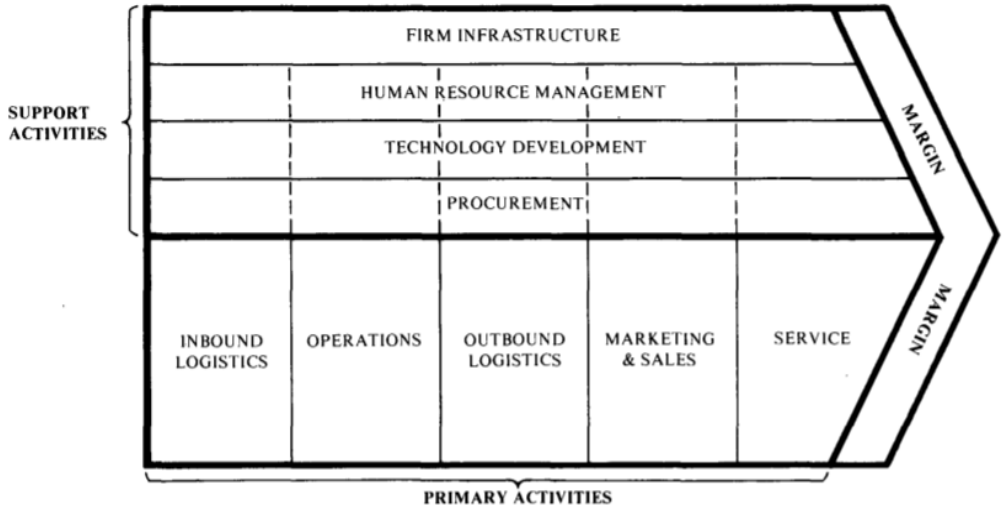


FIGURE 1. Porter's value chain

margin. Value chain divides an organization into its strategically relevant activities to define the behavior of costs and the potential sources of product differentiation. This means, an organization gains competitive advantage by performing these important activities cheaper or better than its competitors (Porter 1998,33). Indeed, how value activities are performed determines whether an organization is high or low cost compared to competitors. It will also determine the organization's contribution to buyer needs and its differentiation (Porter 1998, 39).

2.2 Logistics

According to Figure 2, either goods or services are delivered to the customers by organizations. There are operations at the heart of an organization that create and deliver the products to the customers. As shown in Figure 2 the inputs are raw materials, people, component equipment, information, money and the other resources (Waters 2003, 4).

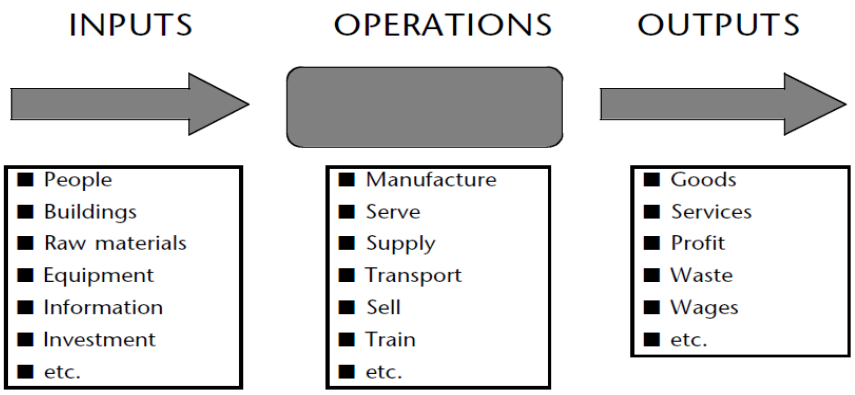


FIGURE 2. Output created by operation (Waters 2003, 5)

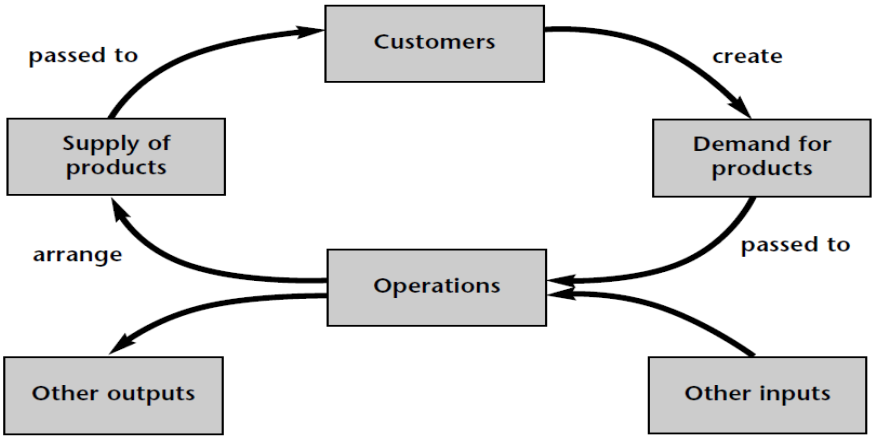


FIGURE 3. The cycle of supply and demand. (Water 2003, figure 1.3)

The products created by an organization are passed to the customers. Figure 3 shows the interaction between operations and customers and how the customers create demand and

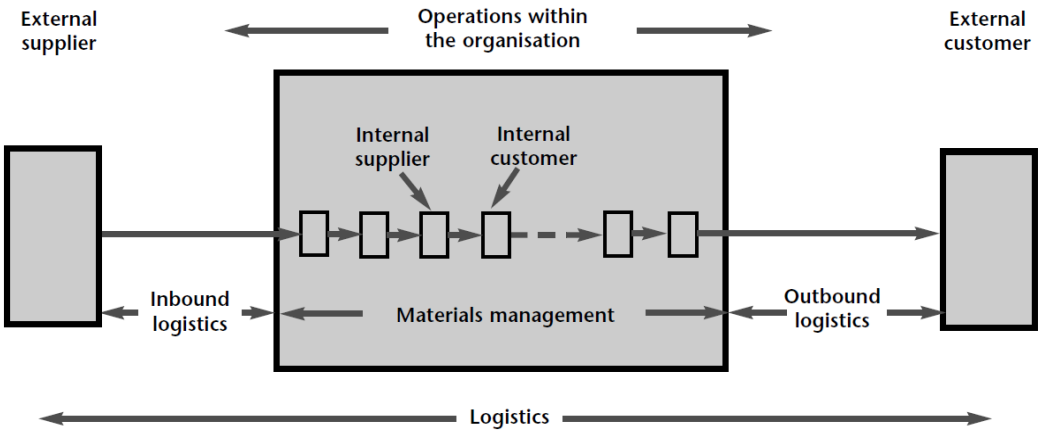


FIGURE 4. The role of logistics (Water 2003, figure 1.4)

how the operations use their resources to make products. In an organization, logistics play a crucial role. It moves materials through the different parts of an organization, collecting from the suppliers and delivering to the customers, as shown in figure 4 (Water 2003, 6).

2.3 Supply Chain and Supply Chain Management

A supply chain consists of a series of activities and organizations in which materials move through their journey from initial supplier to final customers (Lu 2011, 9). In supply chain first, materials move into, through and out of the organization. Second, materials contribute to an efficient flow through the whole supply chain (Waters 2003, 6). Supply chain management is the active management of supply chain activities to maximize customer satisfaction by providing a high-quality service with acceptable cost (Waters 2003, 17).

2.4 Supply Network Design

No operation exists in isolation. Every operation is part of a large and interconnected network of the operations which will include suppliers and customers (Slack et al. 2010, 138). A supply network design is defined as setting an operation which is interacted by the other operations. Network design starts with setting the network's strategic objectives. Strategic objectives help the operation to decide how the overall shape of organization's network should be, the location of each operation and how overall capacity should be managed within the network. The Figure below illustrates the supply chain network design in an operation (Slack et al. 2010, 138).

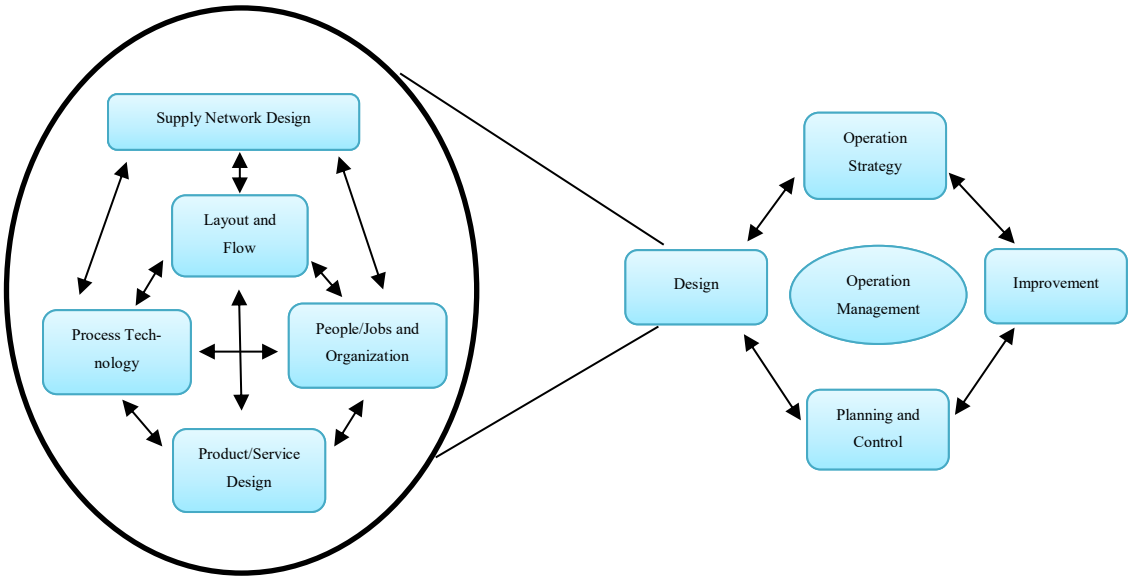


FIGURE 5. Supply network design

2.5 Distribution Center (DC) & Distribution Channel

Distribution centers (DC) are advanced, technologically fulfilled logistics centers which offer distribution services, warehousing spaces, working surface, and all other logistics services which bring added value in this area. The examples of value-added services are; labeling, customizing, blending and mixing, installation, repairing, etc.

A distribution channel is a chain of businesses or intermediaries through which a good or a service passes until it reaches the end consumer. It can include wholesalers, retailers, distributors and even the internet itself (Szopa & Pakala 2012, 143). In this definition of the distribution channel, the word internet means using the internet of things (IoT) in the distribution process. Indeed, IoT provides the ability of transforming data over a network without requiring human-to-human or human-to-computer interaction (whatls.com).

There are two types of distribution channel. First, direct distribution channel which allows the customers to buy their products from the manufacturers. Second, an indirect channel which allows the customers to buy the goods from wholesalers or retailers. (Szopa & Pakala 2012, 144). The conventional distribution model has three components, which are the producer, the wholesaler, and the retailer. The figure below shows the direct and in-direct form of the distribution channel.

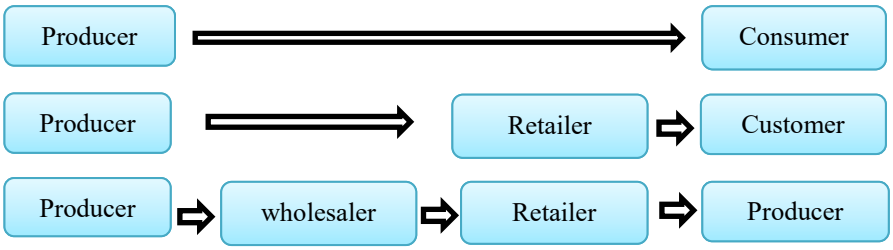


FIGURE 6. Direct and indirect form of distribution channel

2.6 Information Flow and Material Flow

Logistics is the management of the flow of materials and information. Material flow is the description of the transportation of raw materials, components, and final products. Information flow is the flow of demand data from end customers to suppliers and supply chain information from suppliers to end customers (TPsynergy 2014).

2.7 Lead Time

According to "An Introduction to Supply Chain Management" (Waters 2003,31), lead time is the total time between ordering materials and having them delivered and available for use. Lead time reduction is an important part of supply chain management which maximize customer satisfaction and cash flow (Flinchbaugh 2012).

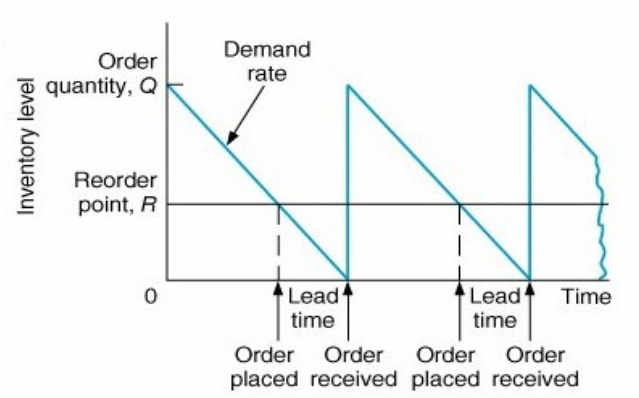


FIGURE 7. Lead time (flylib.com)

2.8 Product Life Cycle and Product Life Cycle Management

The product life cycle (PLC) is the period over which an item is developed, brought to market and finally removed from the market. Figure 8 shows the main stages of product life cycle (Graeme 2001, 165).

Introduction: when the product brought to the market.

Growth: when sales are increasing at their fastest rate.

Maturity: in this stage, sales are near their highest, but the rate of growth is slowing down because of, for example, new competitions in the market

Decline: it is the final stage of the cycle when sales begin to fall.

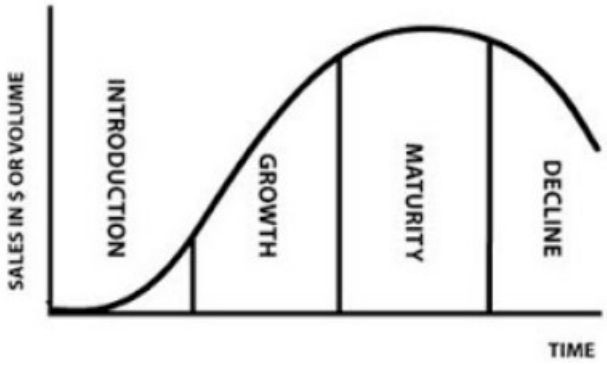


FIGURE 8. Product life cycle (plcanalysis.blogspot.fi)

Product life cycle Management (PLM) is the observation of a product as it moves through the stages of development, growth, maturity, and decline. The main components of PLM are data management, program and project management, cooperation and quality management (Littell 2015, 87).

2.9 Supply Chain Risk Management

Supply chain risk management (SCRM) is applying risk management process tools to deal with risks and uncertainties caused by logistics related activities or resources in the supply chain. There are four sets of activities for managing supply chain risks. The first step is what kind of risks would potentially occur in the organization. The second step is examining methods of preventing risks. The third is risk mitigation, which means reducing the negative consequences of risk. The final step is risk recovery, which means considering procedures that will help the operation recovery failure (Slack et al. 2010, 573).

3 PRODUCT INTRODUCTION

Metal working fluids are used to reduce heat and remove metal particles in the metal working industry. Laborers in metal working factories are potentially exposed by breathing aerosols generated in the machining process. Therefore, exposure to metal working fluids may cause a variety of health issues. Different kinds of filters have been designed for protecting workers against aerosols and particles. There are prefilters with small holes around the drums (drum designed to rotate with high speed), which assist the uniting process and filter out particles with different sizes. There is a centrifugal force which pushes oils to the bottom part of filters and returns it to the machine for reuse or collection. The clean air also returns to the workplace through the top of the unit. Filter's pads require changing from time to time and the frequency depends on the amount of filters' usage (Filtermist.com). Tampere University of Applied Sciences has a new technical solution in which aerosol and particles can be controlled more efficiently. The main advantages of this innovation are better exhaust air purification, fewer health issues, material efficiency, maintenance efficiency, better fire safety and reducing hazardous waste. Different parts of the product are; prefilter, central, afterfilters unit and other standard parts for installation like pipes and equipment for mooring the product into the machinery. The estimated dimension for the unit of one machining tool is 1.1×1.1 meters, height 1.7 meters and the weight is 50 Kg.

3.1 New Product Design and Production Process

To reach the final design of the product, the design activity passed through five stages. The steps are described in the order which usually occur for designing a new product. As demonstrated in figure 9, the first step is developing an overall concept for the product which is called concept generation. The concepts need to be screened to have a better evaluation of ideas and eliminate concepts that do not have high potential in practice. Then the agreed concepts will be turned into the preliminary design. The process of preliminary design is building a prototype, testing the prototype, and revising the design. Apart from testing the product for performance, market testing could be conducted to verify the acceptability of the product in the defined market and customer group. The

final step is process plan which consists of instructions for manufacture like necessary equipment and tooling (Kashyap, 2016).

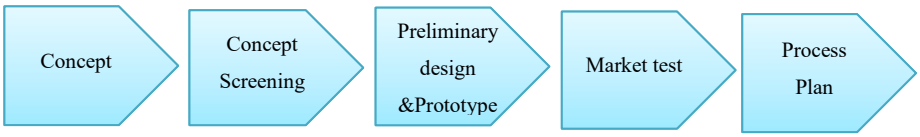


FIGURE 9. The stages of product design

The design of the filters has passed all the above stages. The prefilter prototype was built and tested at TAMK laboratory. The whole prototype was also tested in the field by being installed in two machining factories.

3.2 Functional Side of the Product

The functional side of the product is divided into four parts including measuring, monitoring, filtering, and fluid recycling. The product monitors the number of aerosols and particles in the air. The other functions are filtering aerosols and particles as well as returning fluid and fresh air into the machine and environment respectively. This feature leads to energy and fluid saving, and giving the competitive advantage to the product. Additionally, there is a possibility of remote controlling the product.

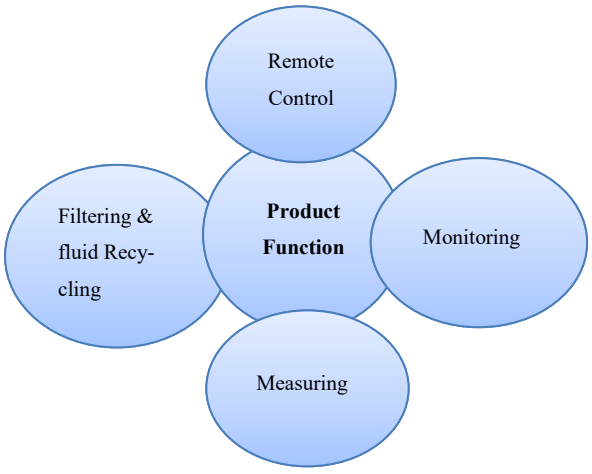


FIGURE 10. Functional sides of new product

3.3 Product Market

The market for the product could not be wide at first because of a range of competitors. By increasing the importance of workers' health conditions and emerging new big machining factories there is a greater chance of selling the products. In general, there are three types of customers for this product. First, machining factories in target countries which are Finland and Germany. Second, it could be sold to retailers and the retailers provide the product to the end customers. The other possibility is to sell the product to the technology companies and they will sell it to the end customers. Figure 11 shows the summary of the possible customers and sales' channels.

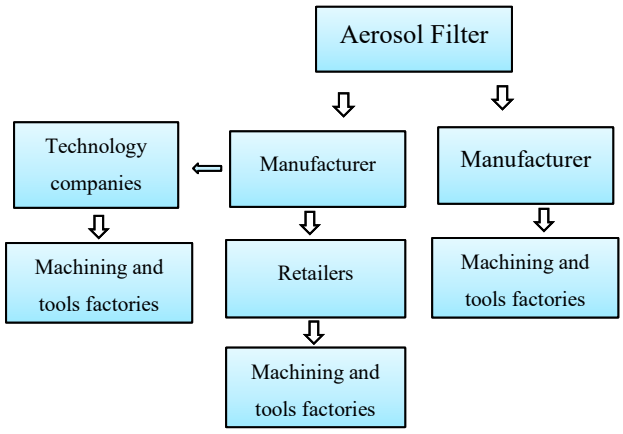


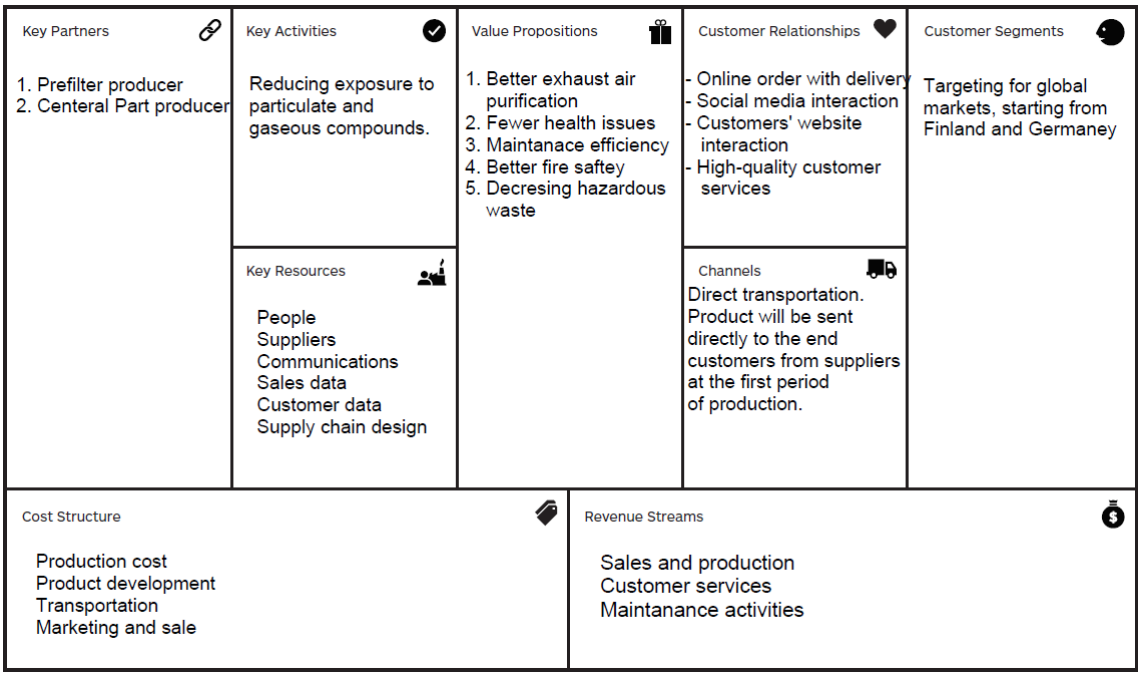
FIGURE 11. New product sales channel

3.4 Business Model and Business Concept

Business model is a plan that describes how products generate revenues and make profit. It explains what products or services the business plans to manufacture. The elements of a business model are key partners, key activities, value propositions, customer relationships, customer segments, key resources, channels, cost structure, and revenue stream (Andonova 2011, 3). The table below shows briefly, the business model of the product with consulting services. One of the partners could be a prefilter producer company in Finland which develops indoor climate ventilation equipment and services. Another key partner could be an air handling company in Finland which produces the central unit of the product. High-quality services and maintenance activities should be considered to

maximize customer satisfaction and build a long relationship with customers. As mentioned above, the end customers are machining and tool factories. The product with consulting services can be delivered to the end customers directly by manufacturer or indirectly by retailers or technology companies.

Table 1. Business model for the innovation



3.5 Market Entry Mode Selection for the Product

Deciding about market entry of a new product can directly affect the organization's performance. However, the accurate entry mode selection does not guarantee success, the wrong selection will certainly guarantee failure. Companies that want to enter a new market have a variety of entry modes to choose from including licensing and franchising, exporting, local distribution and sales, local assembly and finishing, and full local production.

3.6 Licensing/Franchising

Licensing refers to a business agreement where manufacturer (the licensor) of a product with a proprietary right over certain technology, patents, know-how or trademarks, grants permission to another group or individual to manufacture the product in return for a specified royalty or other payment (entrepreneur.com). Franchising is a form of licensing in which the franchiser sells an intangible property to the franchisee and insists on rules to conduct the business. It represents the same idea as licensing, but it is normally used in service industries (Hill,2005).

3.7 Exporting

Here, the company makes the product in the existing facilities and sells it to distributors who work in a new market (Waters 2003, 107). There are direct and indirect approaches to exporting. Direct exporting is straight forward, and the company makes a commitment to market overseas on its own. On the other hand, the organization can employ a home country agency which handles exporting on organization's behalf to get the product into an overseas market (Marketing teacher Ltd, 2000).

3.8 Local Assembly and Packaging

Assembly and packaging generally refer to the final assembly of components into finished products and packaging for shipment. Local assembly and packaging refers to customization of products for a local market, and adding value at the local level (answers.com). In other words, the company makes the products in its existing facilities, but opens limited facilities in the new market to finish or assemble the final product locally (Waters, 2003,107). Moreover, the company could make the products in its existing facility but set up its own distribution and sales forces into the market (Waters 2003, 107).

The best choice of entry mode depends on the many factors, such as the capital available, target return on investment, time scale, transport costs, tariffs, trade restriction, and available workforce (Waters 2003,108). The straightforward method is determining fixed annual payment (for rent, electricity, and other overheads) and a variable cost (depends on

inputs like handling, depreciation, staff etc.) for each entry mode. Then, by Computing the fixed and variable cost, the entry mode with the lowest Total Cost (fixed cost + variable cost) can be chosen as the best one.

4 LOGISTCS STRATEGY

Logistics is an essential part of every organization. Without logistics, no material moves no products are delivered and no customer is served. Not only is logistics essential, but also it is expensive (Waters 2003,19).

*"*The logistics strategy of an organization consists of all the strategic decisions, plans, and culture relating to the management of its supply chain*"* (Waters 2003,60).

Making logistics' costs as low as possible is a goal for logistics' managers, since they want to remain competitive and the users pay less. Here, the considerable point is that companies need to maintain their service level while trying to decrease logistics' costs. (Waters 2003, 31).

According to Waters (2003,60), research on supply chains has been divided into two parts. First, by the segment of supply chain study. For example, production, inventory, distribution, and warehouse. Second, by the kind of decisions made which are strategic and operational. Strategic decisions consist of decisions about the number and location of facilities and the size and technology used at the facilities. All these decisions have a lifelong decision on the supply chain system. Operational decisions are about determining the safety stock level, size, and frequency of production bunches (Butler 2003, 2).

According to Waters (2003, 64), logistics strategy is most likely to emphasize factors like cost, customer service, lead time, quality, product flexibility, and technology. In the following sections, all these elements will be explained.

4.1 Facing with Unknown Parameters

Since there is no history behind the new designed product, supply chain strategy faces some issues and unknown parameters. these issues are; demand forecasting, uncertainty in the number of suppliers, market prices, lead time and supplier reliability, changing market situation and risks. The tools to solve these uncertainties and issues, are defining

all possible ways and choosing the system that works well in many situations (Butler 2003,1).

Table 2 displays unknown parameters that are applicable in planning supply chain for a new product and making a precise decision. The final objectives of categorizing these parameters are first; choosing the best supply chain which maximizes the revenue and profit associated with products. Second, increasing the number of customers and demand for the next period. These parameters have been divided into three categories: (1) sets, (2) costs, and (3) demand and lead time. In this table, subscriptions present the three levels of (1) factory level, (2) DC level, and (3) customer level.

TABLE 2. Unknown parameters for planning supply chain for a new product

Sets	**Costs**	**Other parameters**	**Decision variables**
The number of products expected to sell annually. (A)	Selling price per unit in period t (S)	Forecasted demand (FD) of products A for Cn during period t	Demand for product A from customer 1 in period t
The number of plants (P)	Production costs per unit of product A made on P1 in period t	Lead time for equipment purchase, refurbishment or certification of machine.	Units of products made by plants 1 in period t (X^1)
The number of distribution centres (DC)	Unit handling costs of products A at the DC(n) in period t	Lead time for distribution centre construction at location DC(n)	The number of product A shipped from Plant1 to DC 1 in period t by mode M(X^2)
Set of transportation modes (M)	Transportation Costs per unit of product A from P(n) to DC(n) by mode M(n) in period t ((T^2))	Lead time from DC(n) to customer(n)	Units of product A shipped from DC to customer 1 in period t by mode m (X^3)
Sets of customers (L)	Transportation cost per units of product A from DC(n) to customer(n) by mode M in period t ((T^3))		Units of product in inventory at the plant1 at the end of period t
			Cumulative net profit after period (t)

4.2 Set

The supply chain process starts with the supplier and ends with the end customers. Therefore, having information about the customers and suppliers will be significantly useful in designing supply chain for a product. In addition, having knowledge about other sets like

the sets of mode of transportation, and the sets of distribution centers are worthwhile. Additionally, geographic segmentation is helpful in defining the sets of mode of transportation and distribution center. This means, by gathering information about suppliers' and customers' location, the location of distribution center and the mode of transportation can be selected.

4.3 Lead time

"the total time between ordering materials and having them delivered and available for use" (Water 2003,31).

It is obvious that customers desire to receive products quickly and in a shorter lead time. There are approaches for keeping the lead time near zero. One of them is *Synchronized Material Movement.* In this method, the goal is to harmonize the material flow to coordinate material flows by both volume and time (Waters 2003, 31). One of the most important synchronization principles is just-in-time (JIT) supply where parts of delivery process are synchronized (Klug 2013, 2).

4.4 Demand Forecasting

Accurate forecasting is critical for customers demand. The factors that directly affect customer demands are; the business cycle (recovery, inflation, recession, and depression), product life cycle, competition, advertising, product reputation, quality and price, and product performance (Blocher & Mabert & Soni 2004, 2). For example, competitors try to take a bigger share of market and increase the demand by cutting the price or introducing a new version of the product. According to operation Management (Slack & et al 2010, 170), There are two main approaches to demand forecasting; qualitative and quantitative.

Qualitative methods are based on opinions, and experience. The best-known qualitative method for demand forecasting is *Delphi method*. In this method, a questionnaire or survey is sent to the panel of experts. Then, the replies are analyzed and returned to all experts anonymously. This process is repeated several times and concludes with a narrow

range of decisions (Slack & et al 2010, 171). One of the primary characteristics of Delphi method is the ability to provide anonymity to respondents, a controlled feedback process, and the suitability of the variety of statistical analysis techniques to clarify the data (Dalkey 1971, 65).

Quantitative methods are based on mathematical models, and are objective in nature. One of the quantitative methods is the time series model. Time series models look at past patterns of data in a single phenomenon and attempt to predict the future based upon the underlying patterns contained within those data. (Slack & et al 2010, 172). For example, a company is attempting to predict the future demand of a product. Figure 12 shows the time series plot of the company based on the past four year's sales. It can be clearly seen that there is a pattern which is repeated once a year. This pattern helps the company in predicting future demand.

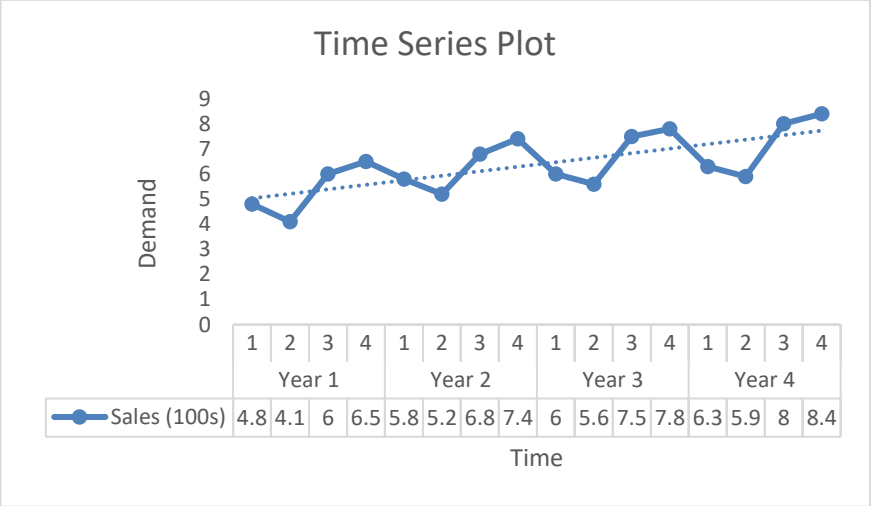


FIGURE 12. Time series plot for a company

4.5 Costs

As mentioned above, the final objectives of categorizing these variables are to maximize the revenue and profit, by maximizing the number of demands. Information about selling price per unit, production cost, transportation cost, and handling cost help the company in gaining the objective and establishing a balance between customer service and costs. there are three types of cost that should be calculated in the supply chain to outline the

best supply chain. These costs are; Manufacturing System Cost, Distribution Costs, and Transportation Cost which are explained below.

4.5.1 Manufacturing System Cost

The first component of the manufacturing cost is the variable costs of production. This includes the cost of raw material, labor, packaging, and storage. The formula for calculating manufacturing cost is $\sum_{a\,t} C^{1}\, x^{1}$ (Butler 2003, 20). (C^1 is production cost per unit in plant a in period t and X^1 is units of products made in plant a in period t).

4.5.2 Distribution System Cost

The distribution system incurs cost like the manufacturing system. It can be calculated by this formula: $(\sum_{k\,t\,m} H^2\, X^2)$ (Butler 2003, 21). H is unit handling cost of product in distribution center k in period t. X^2 is units of products shipped from plant to DC k in period t by transportation mode m.

4.5.3 Transportation Cost

A transportation fee is assessed in two parts: from the plant to the DC and from the DC to the customers. The transportation costs depend on the distance between origin and destination and on the mode used. The formula is: $\sum_{k\,t\,m} (T^2X^2) + \sum_{k\,t\,m\,l} (T^3X^3)$ (Butler 2003,21). T^2 is transportation cost per unit of product from plant to DC k by mode m in period t.

4.6 Revenue

Revenue generates when goods are shipped to customers. The formula for calculating revenue is $\sum_{k\,l\,m\,t} S\, X^3$ (Butler 2003,20). S is selling price per unit of product. X^3 is product shipped from DC to the customer.

4.7 Value Chain Activities for the Product

In Chapter 2, value chain and value chain activities were defined. As mentioned earlier, there are two types of value activities which can be generally classified as primary activities and support activities. Value activities and sub activities will be defined below.

According to Porter (1998,39), the *primary activities* are;

1. **Inbound logistics:** activities required to receive, sort, and manage inputs such as material handling, warehouse, inventory control, and returns to suppliers.
2. **Operations:** activities for transforming inputs to the product, such as machining, packaging, assembly, equipment maintenance, testing, printing, and facility operations.
3. **Outbound logistics:** activities required to collect, store, and distribute the output.
4. **Marketing and sale:** activities associated with informing buyers about product and services such as advertising, promotion, sales force, channel selection, channel relations, and pricing.
5. **Service:** activities that need to be done to enhance or maintain the value of products, such as installation, repair, training, part supply, and product adjustment.

Support activities are (Porter 1998, 41);

1. **Procurement:** the function of purchasing inputs used in the organization's value chain. Purchased inputs are not part of procurement. Purchased inputs include raw materials, supplies, and other consumable items which are associated with primary activities.
2. **Human resource management:** it consists of activities involved in the recruiting, hiring, training, development, and compensation of all types of personnel.
3. **Technological development:** it consists of a range of activities that can be grouped into efforts to improve the product and the process.
4. **Infrastructure:** firm infrastructure supports the entire chain and not individual activities. It consists of activities including general management, planning finance, accounting, regulations, government affairs, and quality management (Porter 1998, 43).

Figure below shows value chain for product. this figure consists of both value activities, primary and support activities:

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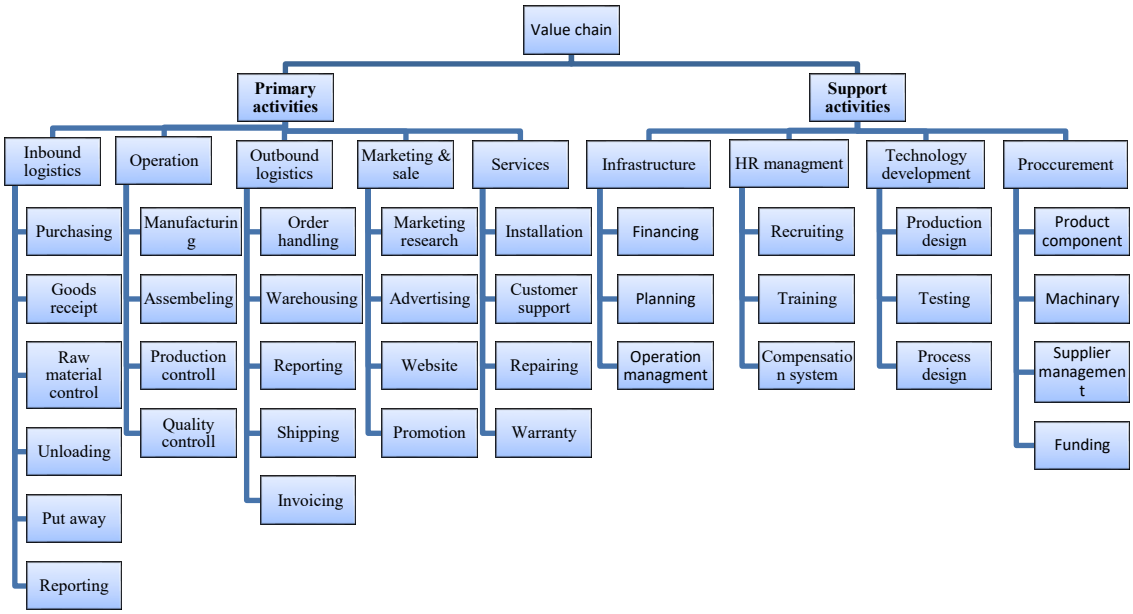
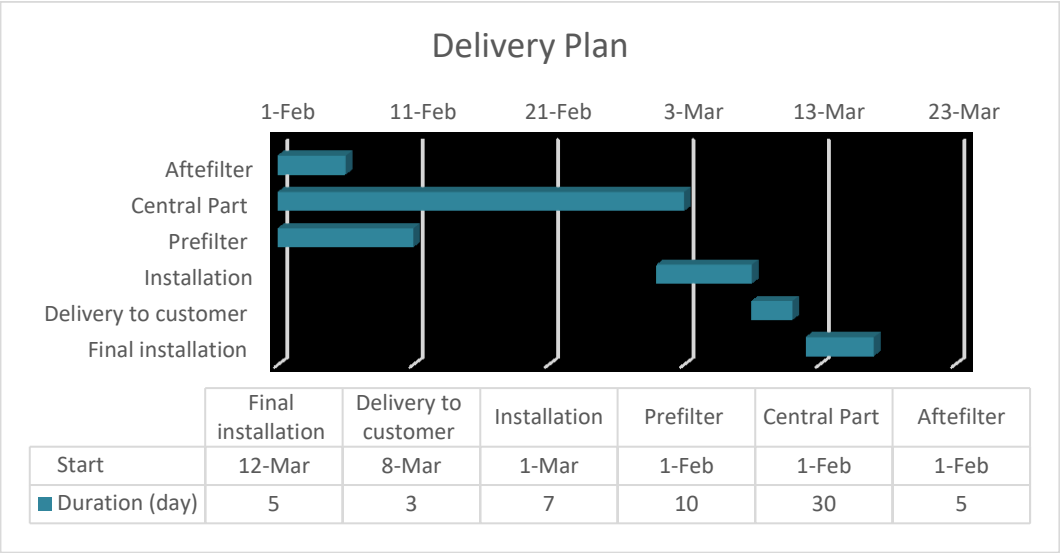


FIGURE 13. Value chain analysis for the product

4.8 Production Plan for the product

Estimating future production and delivery time is crucial to accurately estimate the time needed to fulfill the future demand. The chart below shows a project plan for preparing the product from production process until customer delivery. In this chart, a series of tasks, that are required for completion of the product are written. Moreover, estimated start and end dates with duration are defined. For example, filters are one of the parts that will be ordered from outside with a 5-day lead time duration.



	Final installation	Delivery to customer	Installation	Prefilter	Central Part	Aftefilter
Start	12-Mar	8-Mar	1-Mar	1-Feb	1-Feb	1-Feb
Duration (day)	5	3	7	10	30	5

FIGURE 14. Planning for successful product delivery with lead time duration

In addition, pre-planning allows the management group to conduct a more comprehensive evaluation of the required equipment, suppliers, and resources and put them into the organization's annual and long-term strategies (CME,2015).

4.9 Customer Services and Maintenance Activities

Customer service is an important factor in logistics' decisions since good customer service leads to a long-term relationship with customers. Also, the organization can get a long-term competitive advantage by concentrating the logistics' strategy on customer service. Different products and services require different customer service. Factors that can directly affect the service level are lead time and maintenance activities (Waters 2003, 73).

The competitors of the product are providing a wide range of high-quality maintenance activities and services. Filtermist, 3nine, and Absolent are examples of three main competitors which their services will be explained below. The companies were successful in providing services to the customers.

Filtermist provides local support in over 60 countries via professional distributor network. Hence, the customers know the people behind the product and the communication between customers and service group would be easier. Their customers have access to

spares and support whenever their machines are shipped around the globe. They also provide high standard after-sales services, including technical support and routine maintenance. In addition, competitors provide monitors which help their customers easily read indication of whether oil mist collection is working well or need servicing (Filtermist.com)

Absolent, as one of the successful companies in providing aerosol filters, provides services like lower cleaning cost, lower services cost for electrics damaged by oil mist, lower air conditioning, and lower heating cost. The company also provides regular after-sales services. They adapt their services visit to their specific environment and time plan which reduces the risk of disturbance. The service visit does not affect warranty and measuring the air quality from around the machine. They have one distributor in each country for supporting their customers locally (Absolent.com)

3Nine company, like others, has after-sales services. They provide services and maintenance with low cost. They also have distributors in Europe, North America, and Asia (3Nine.com).

The product can provide maintenance activities and services like changing a dusted filter with a clean one, measuring air quality, and changing parts if they are broken. As mentioned earlier, the current target countries are Finland and Germany. It is worth considering a local maintenance and service group that can increase the level of service. Local support leads to better customer service, which leads to availability of more personalized services.

4.10 Five Basic Operation Performance Objectives

In this part, five basics ‘performance objectives’ will be introduced, and they can be applied to all types of operation. The operation performance objectives in an organization are mainly quality, speed, dependability, flexibility, and cost. For example, if an organization would want to satisfy its customers by providing error-free products and services and reliable products and services, this will give a quality advantage to the organization. Each performance objective has potential internal and external benefits which have been shown in table 3. For example, being able to customize the products or being able to adapt

the operation's activities to respond better to unpredicted events gives a flexibility advantage to the operation (Slack & et al 2010, 40).

TABLE 3. Performance objectives with potential external and internal benefits

Potential Internal benefits	Performance objectives	Potential external benefits
• Error free processes • More internal reliability • Lower processing cost	**Quality**	• Error free products and services • Reliable product and services
• Faster throughput times • Less inventory • Lower processing cost	**Speed**	• Short delivery times • Fast response to orders
• More internal stability • Lower processing cost	**Dependability**	• High service level • Knowledge of delivery time
• Better response to unpredicted events	**Flexibility**	• Product customization • Wide range of services • Easier delivery adjustments • Easier volume adjustments
• Productive process • Higher margins	**Cost**	• Low price

4.11 The Impact of Product Life Cycle on Supply Chain Strategy

A good supply chain strategy can match product characteristics and customer requirements. As products proceed through their life cycles customer requirements dramatically change. Each stage of the product's life cycle has a significant impact on supply chain strategy. Analysis of the key order winners (standards that separate a product or services of one firm from another) and order qualifiers (competitive standards that make a firm's product viewed as fit for purchase by consumers), is important due to keeping the product in a competitive market (Aitken, Childerhouse, Towill 2002, 133). Since the product is in an introduction process of its life cycle, the key order winners can be service level and

the key market qualifiers are quality, cost, design, and lead time (Aitken et al. 2002, 134). This means decent service level is needed to be considered to compete in the market. Furthermore, products which are in the first stage of their life cycle, design and built, need more time for product development and order cycle time e.g. 6 months. Therefore, decreasing the order cycle time and product development by using life cycle management methods will help the product to enter the competitive market faster. The Figure below shows the supply chain process for the product.

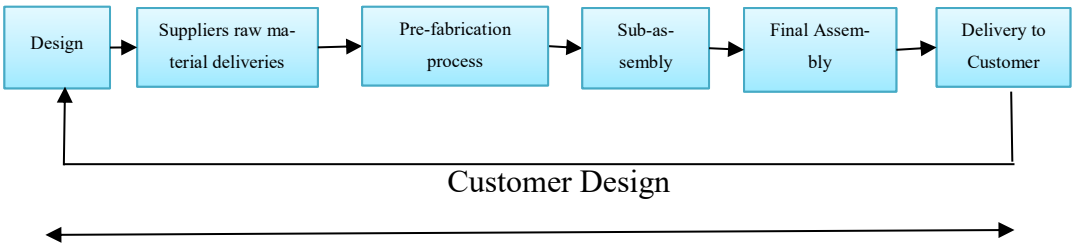


FIGURE 15. Product supply chain process in the first stage of order cycle.

4.12 Transportation Mode

As mentioned earlier, Germany and Finland are the initial target markets for the first period of commercialization. Moreover, it is assumed that the local manufacturing and assembly will be used at first. So, trucks or trains can be used to transport the products from manufacturer to machine factories inside Finland. Trucks can be used to transport the products from the manufacturer to the nearby airport and seaport. Then, the product can be transported to Germany (or other European countries) by airport or ship. Shipping by air costs significantly more than by sea, but the lead time is much shorter (Butler 2003, 78).

4.13 Measuring and Improving Performance

Measuring the performance of logistics is a crucial part of every organization, since supply chain needs to evolve. Taking supply chain measure gives the manager an idea on how well they are doing, what the future approach is, and whether they have met their targets or how they compare with competitors (Waters 2003, 197).

According to “An Introduction to Supply Chain Management” book, there are different ways of measuring logistics. One of them is indirect measures which are related to finance, such as return on assets and profits. There are also direct measures of logistics such as the number of products delivered, distance travelled, capacity utilization and productivity. (Waters 2003, 197). In the next paragraphs, capacity utilization and productivity will be explained both of which are general ways of measuring the performance of logistics.

Capacity utilization is a basic measurement method, which is defined as the measure of how a resource is being used to produce a good or service and is usually expressed as a percentage. Utilization is practically the ratio of the amount of capacity used for designed capacity (U = amount of capacity used/designed capacity). Designed capacity is the maximum capacity possible to use in an ideal condition (Waters 2003, 199). Therefore, the organizations usually aim to produce close to full capacity (100% utilization). There are several reasons why organization’s capacity utilization rate is less than 100% such as lower demand, inefficiency (poor maintenance, quality) or loss of sale because of production equipment deficiency (tutor2u, 2015).

Additionally, Productivity is one of the most commonly used measures of logistics’ performance. Productivity is the ratio of output from the operation to input from the operation. There are two types of productivity; single-factor productivity and multi-factor productivity. Single-factor productivity is the ratio of output from the operation to one input to the operation. This type of productivity is good for comparing different operations excluding the effect of input cost. Multi-factor productivity is the measure that includes all input factors. It is defined as the ratio of output from the operation to all inputs to the operation (Slack, Chambers & Johnston 2010, 50). For example, a company has five employees and processes 200 products per week. Each employee works 35 hours per week. The company’s total wage is 3,900€ and its total overhead expenses are 2,000€ per week. So, the single-factor labor productivity and multi-factor productivity for this company will be calculated as follow:
Labor productivity: 200/5 = 40 products/employee/week
Multi factor productivity: 200/ (3900+2000) = 0.0339 product/€

Concerning productivity improvement, one way is to reduce the cost of inputs while keeping the level of output constant (slack et al. 2010,62). The cost reduction of inputs can be

done by controlling operational performance objectives. As mentioned earlier, the operational performance objectives are; flexibility (refers to ability to change), speed (refers to short delivery lead time), quality (refers to error-free process) and dependability (refers to dependable delivery) and cost (low price, high margin or both) (Slack et al. 2010, 50).

4.14 Analysing the Supply Chain

Analyzing the supply chain helps the organization to look at the systems and operations and see exactly how they work. There are different forms of describing a supply chain to analyze the supply chain (Waters 2003, 210). One of them is *precedence diagramming method (PDM)*. This model consists of a network of a circle which represent activities and arrows which represent the relationship between activities. In this model, first activities related to the production and delivery process will be listed. Here, the activities are identifying the suppliers and assembly team, production of the central part and prefilter, ordering afterfilter from outside, assembling the product, product delivery and after-sale services. Then, each activity is designed by alphabet. Finally, the dependency of each activity to the previous activity will be defined. The table below represents the list of activities related to the product, designation, and preceding activity (Waters 2003, 212).

TABLE 4. Designation and dependency of activities related to the product

Activity	Designation	Dependency
Identifying the suppliers, assembly team	A	
Production (central part and prefilter)	B	A
Ordering afterfilters	C	B
Assembling the product	D	B, C
Product delivery	E	D
After sale services	F	D

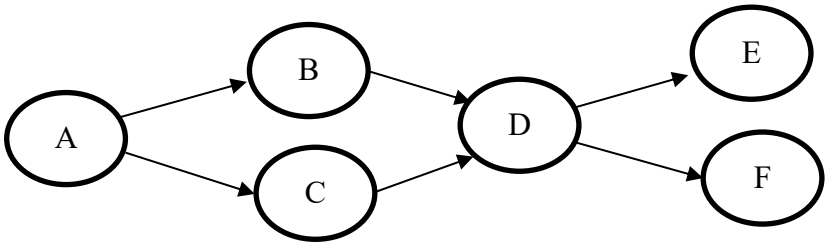


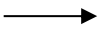
FIGURE 16. Precedence diagramming method

Figure 16 shows a precedence diagram for the product. It shows that activity A can be done right at the beginning. When activity A is finished, both activities B and C start. Activity D can be done after both activities B and C. Activity E and F can be done after activity D is finished. When this network has been drawn, improvement decisions can be started (waters 2003, 213). This model helps in problem rooting in different operations of an organization.

4.15 Business Process and Stakeholder Mapping

Stakeholder mapping is an important step to understand who the key stakeholders are and what are they looking for in relation to the business (BSR 2011, 1). Mapping means visualizing relationships to objectives and other stakeholders after identifying and listing relevant groups, organizations, and people (BSR 2011,2). In this part, stakeholder map has been drawn for the product. Before defining key partners and stakeholders, production and process mapping has been drawn below. Process mapping helps in improving the whole operation process and analyzing the whole operation. Table 5 presents the process mapping symbols.

TABLE 5. Symbols for product process mapping

	Data		Direction of Flow
	Transport		Operation Activities
	Storage		Decision

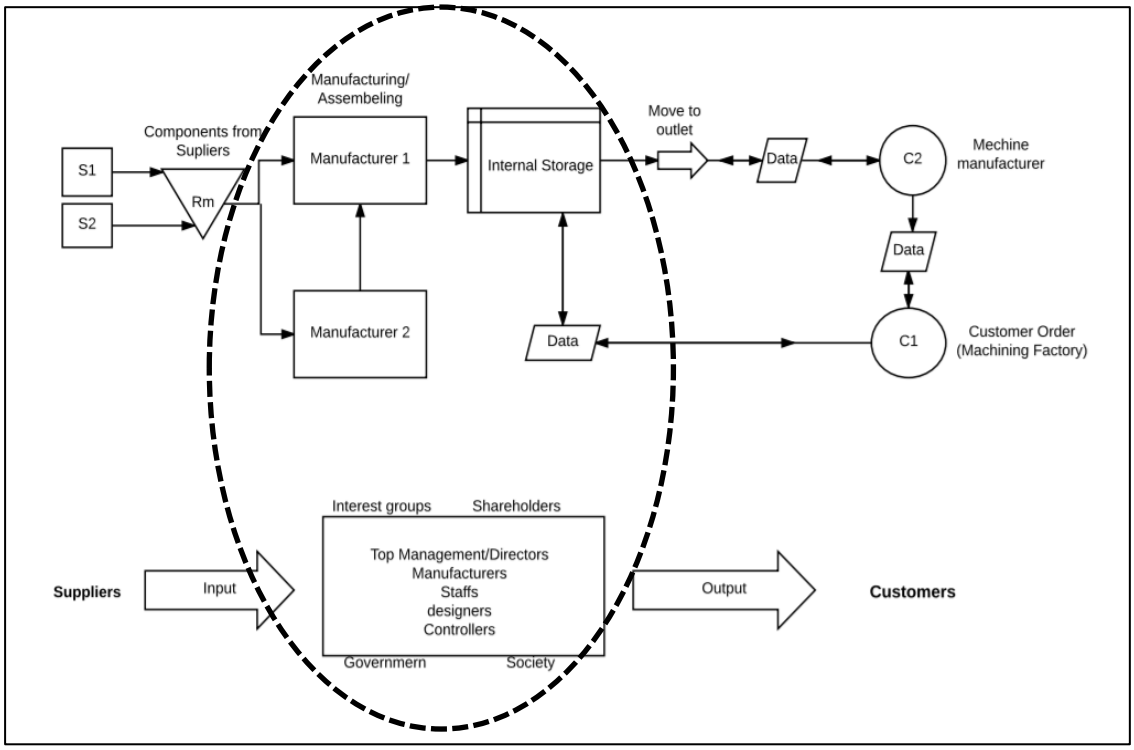


FIGURE 17. Business process flowchart with stakeholder group in operating activities

All operations in an organization have stakeholder groups. Some stakeholders are internal such as the operation employees, top management and directors, designers and quality controllers. Other stakeholders are external, like customers, society, and government (Scharioth & Huber 2003, 10).

4.16 Supply Chain Risk Management

Since risk management is about things going wrong and what operations can do to prevent them, understanding and managing risk in an operation can be considered as an improvement activity (slack et al. 2010, 573). There are some approaches to assessing the significance of failure. One of the best-known approaches is failure mode and effects analysis (FMEA). FMEA is an approach for identifying all possible failure and risks in a design, manufacturing or assembly process of a product or service (asq.org). FMEA provides a method for quantitative analysis of risk (slack et al. 2010, 584). Different steps of FMEA method are explained below.

4.16.1 FMEA Process

According to "Process Failure Mode and Effects Analysis" (Biswas 2015, 3), the first step is classifying modes of failures. Each process in an organization could be failed in different modes, as a result, different failure modes should be listed along with the effects those failures would have on the users. The next part of the FMEA spreadsheet is the list of potential causes for failures along with any controls that have been detected to prevent the failure.The level of risk will be quantified by using one-to-ten (1-10) scale. Here, the higher the number, the more risks processes have. Indeed, 1 means something that happens very rarely and 10 means something that has happened quite frequently. In the table below, there is a row for quantifying the risk which is called severity risk. The aim is to anticipate how severe the failure and its impact can be if they occur. According to the "Operation Management" (slack et al. 2010, 584), Risk Priority Number (RPN) calculated as SEV*OCC*DET that shows which failure mode is on priority and needed to be solved first. For example, in the table below the RPN of delivery time is 240. Therefore, priority is given to delivery time failure mode when attempting to eliminate the failure. The next step after defining RPN of each failure mode, is to define actions to reduce the occurrence of the failure or improve its detection.

TABLE 6. FMEA spreadsheet

Process step	Potential Failure Mode	SEV	Potential Cause(s)of failure	OCC	DET	RPN
Process Function	What might go wrong?	How sever the effect is?	How can the failure occur	How often the failure occurs?	How well the company can detect the failure?	SEV*OCC*DET
Production line	Problem with maintenance	6	No regular maintenance	7	5	210
Quality control	Poor products	7	No consciousness of quality control encouragement	6	4	168
Delivery time	Delay in product delivery	6	Delay in receiving raw material	5	8	240
After-sale services	Delay in providing services	5	No service vision yet	4	8	160

The Table below helps an organization in defining severity of effect (SEV), likelihood of occurrence (OCC) and likelihood of detecting failure (DEV) (Carlson 2012,32-38).

TABLE 7. SEV, OCC and DEV for FMEA analysis

	SEV	OCC	DEV
10-9	Hazardous without warning (Extreme)	Failure is almost inevitable (very high)	Very- no known controls available to detect failure mode (very low)
8-7	Hazardous with warning (High)	Process is not in control(high)	Control have a remote chance of detecting the failure (low)
6-4	Minor disruption of product (Moderate)	Process is in control but with isolated failures. (moderate)	Control may detect the existence of a failure (moderate)
4-3	Minor defect noticed by some customers (low)	Process is in control (Very low)	Control have a good chance of detecting the existence of failure (high)
2-1	No effect	Failure is unlikely.	The process automatically detect failure (very high)

5 CONCLUSIONS

In this chapter, the findings and contributions of this thesis will be summarized. In addition, recommendations will be presented at the end. This thesis has been done for a Service Development branch of Engineering Group at TAMK, who has designed a new aerosol filter for controlling metal exhaust ventilation in metal working factories. To enter the competitive market and commencing the business, supply chains must be planned. In addition, in an intensively competitive marketplace, a well-planned supply chain plays a crucial role in maintaining customer satisfaction. Therefore, before entering the market, it is necessary to study and design the most suitable supply chain strategy.

The thesis addressed (1) business model and market entry options for the product, (2) the supply chain strategy, analysis and improvement of the product, (3) and supply chain risk management for the product. The thesis has been divided into 5 chapters. In chapter 2 theoretical frameworks were described. Chapter 3 was mainly about the market entry mode of the new product. It contained new product design process and development, business model by using CANVAS template, as well as the functional side of the product and alternative market entry modes for the new product. Chapter 4 was the main chapter that directly provided solutions for research question 2; “What kind of supply chain strategy and analysis are required for a new product?”. This chapter started with defining unknown parameters for planning and analyzing supply chains for the innovation. Additionally, production plan and delivery time were scheduled in this chapter. After production plan, customer services and maintenance were described. Moreover, precedence diagram and productivity measurement have been used for supply chain analysis and improvement respectively. The final part of chapter 4 addressed supply chain risk management by using FMEA analysis. This analysis helps the company in finding all possible failures in design, manufacturing or assembly process of the product. It is worth mentioning that, all the information about the product’s features and functions, sales and production line, customer services and maintenance were gathered by designing 2 questionnaires. The questionnaires have been sent to the engineering group and maintenance group and correspondingly answered.

To conclude, to plan a supply chain for a new product considering procedures explained below could be beneficial:

The first step is to explicate the business process and goals as a roadmap. Drawing a clear picture of the business and creating a business model is crucial initially. Planning the fundamentals of business helps the company to create a realistic evaluation of the potential success of the business. In addition, the business model shows the company how to handle the business in a way that the company can generate revenue and make profit. By perceiving the way to do business, a market entry mode can be selected. For the products with no history behind them, it is better to choose local production and local assembly initially, to understand the potential customers and conducting market test. After local production and distribution, exporting and licensing entry mode can be chosen to expand the market and grow revenue and profit.

Business model and market entry mode selection are the nutshell of the business which gives general information about the business and the partners. The next step is planning a supply chain for the innovation. Unknown parameters such as end customers, partners, the number of customer demands, delivery time and lead time, plant and DC locations, transportation mode, and distribution channel should be determined (refer to unknown parameters table page 24). Then, a simulation of supply chain processes can be drawn to ease the detail planning and thinking process. Additionally, the customer service and maintenance should be organized to increase customer satisfaction. Indeed, providing the right after-sale services at the right time for customers enhance competitive advantage to the organization. Furthermore, by expanding product market, the customer services needed to be expanded. Local customer services would be chosen as it helps to handle issues for the customer and do the best to ensure that the customers are satisfied.

Finally, supply chain analysis and supply chain risk management should be implemented due to assuring accuracy of designed supply chain in an organization and assessing each risk and determining which of them needs more attention respectively. Precedence diagramming is one of the analytic tools which helps in problem rooting in different operations of an organization. FMEA, also, is a common method for managing risks and failures which has been explained in this thesis.

It would be inappropriate to conclude this thesis without referencing the question “what shall be done next?”. What follows is a set of key recommendations that has emerged from the author’s findings:

- It is recommended that the business sector determines which of the potential suppliers can help in producing the innovation in the form of products or go-to-market strategy. Business sector should also monitor the performance of all supply chain partners to keep on top of supplier network.
- It is recommended that the business sector analyzes the information related to customer's needs precisely. So, it is important to track which kind of products customers want and which ones they do not want as part of a supply chain strategy. Interacting with current or future customers by offering free or low-price products is a good way to find out if the products or services are meeting customer expectations.
- It is recommended that the business sector forms, trains, evaluates, and transforms a group of service providers within the various geographical segments of Finland and Germany. So, the customers will be directly in touch with the service group.

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APPENDICES

Appendix 1. FMEA Analysis Spreadsheet

Process / Product
Failure Modes and Effects Analysis
(FMEA)

Process or Product Name:		Prepared by:	Page ____ of ____
Responsible:		FMEA Date (Orig) _____ (Rev) _____	

Process Function	Potential Failure Mode	Potential Effects of Failure	SEV	Potential Cause(s)/ Mechanism(s) of Failure	OCC	Current Process Controls	DET	RPN	Recommended Action(s)	Responsibility and Completion Date	Action Results: Actions Taken	Action Results: SEV	Action Results: OCC	Action Results: DET	Action Results: RPN
The highest value process steps from the CAE matrix.	In what ways might the process potentially fail to meet the process requirements and/or design intent?	What is the effect of each failure mode on the outputs and/or customer requirements? The customer could be the next operation, subsequent operations, another division or the end user.	How Severe is the effect to the customer?	How can the failure occur? Describe in terms of something that can be corrected or controlled. Be specific. Try identify the causes that directly impacts the failure mode, i.e., root causes.	How Frequent does failure or failure mode occur?	What are the existing controls and procedures (inspection and test) that either prevent failure mode from occurring or detect the failure should it occur? **Should include an SOP number.**	How well can you detect cause or FM?	SEV x OCC x DET	What are the actions for reducing the occurrence, or improving detection, or for identifying the root cause if it is unknown? **Should have actions only on high RPN's or easy fixes.**	Who is responsible for the recommended action?	List the completed actions that are included in the recalculated RPN. Include the implementation date for any changes.	What is the new severity?	What is the new process control?	Is detection limit improved?	Recomputed. RPN after actions are complete.
								0							0
								0							0
								0							0
								0							0
								0							0
								0							0
								0							0

TABLE 2. FMEA form (www.isixsigma.com)

	Severity of Effect	Rating
Extreme	May endanger machine or operator. Hazardous **without** warning	10
	May endanger machine or operator. Hazardous **with** warning	9
High	Major disruption to production line. Loss of primary function, 100% scrap	8
	Reduced primary function performance. Product requires sorting, some scrapping	7
Moderate	Minor disruption of production. Some Scrap. Loss of secondary function performance	6
	Minor disruption to produciton. 100% Rework. Reduced secondary function performance.	5
	Minor defect noticed by most customers Product requires sorting and some reworked.	4
Low	Fit& Finish/Squeak & Rattle item. Minor defect noticed by some customers.	3
	Defects may be reworked on-line. Minor defect noticed by observant customers.	2
None	No effect	1

TABLE 3. Severity of effects for FMEA analysis (www.isixsigma.com)

	Likelihood of Occurrence	Failure Rate	Capability (Cpk)	Rating
Very High	Failure is almost inevitable	1 in 2	< .33	10
		1 in 3	> .33	9
High	Process is not in statistical control. Similar processes have experienced problems.	1 in 8	> .51	8
		1 in 20	> .67	7
Moderate	Process is in statistical control but with isolated failures. Previous processes have experienced occasional failures or out-of-control conditions.	1 in 80	> .83	6
		1 in 400	> 1.00	5
		1 in 2000	> 1.17	4
Low	Process is in statistical control.	1 in 15k	> 1.33	3
Very	Process is in statistical control. Only isolated failures associated with almost identical processes.	1 in 150k	> 1.50	2
Re-mote	Failure is unlikely. No known failures associated with almost identical processes.	1 in 1.5M	> 1.67	1

TABLE 4. Occurrence for FMEA analysis (www.isixsigma.com)

	Likelihood that control will detect failure	DPPM	Probability	Rating
Very	No known control(s) available to detect failure mode.	100,000	1 in 10	10
Low	Controls have a remote chance of detecting the failure.	50,000	1 in 20	9
		20,000	1 in 50	8
Moderate	Controls may detect the existence of a failure	10,000	1 in 100	7
		5,000	1 in 200	6
		2,000	1 in 500	5
High	Controls have a good chance of detecting the existance of a failure	1,000	1 in 1,000	4
		500	1 in 2,000	3
Very High	The process automatically detects failure. Controls will almost certainly detect the existence of a failure.	200	1 in 5,000	2
		100	1 in 10,000	1

Table 5. Failure detection for EMEA analysis (www.isixsigma.com)

Appendix 2. Questionnaire 1

"Questionnaire for TAMK'S Engineering Group about product feature and production plan"

Product features

1. What are different parts of the product?

2. What is the dimension and weight of each package[1] of the product?

Sales and Production

1. Where the prototype has been made, and tested first?

2. Who can be the possible manufacturers?

3. How much is the production cost per unit?

4. How many products do you expect to sell at the first period?

5. How much would be the selling price?

6. Who would be the possible end customers in Finland and Germany? (type of companies or factories who use the filter, location or the name of companies)

[1] Each unit of product packs before sending to end customers. Information about weight and dimension of package of each unit helps in planning supply chain.

7. Do you agree with **outsourcing**[2] part of production process? (For example: manufacturing some or whole parts of product in a lower cost location like China). If not, where would you prefer to produce the product?

Customer service

1. Is there any possibility of customizing the product? What kind of customization would be possible? (For example: to change the size for user's needs)

2. What kind of **maintenance activities**[3] would be provided for customers? (For example: changing the filter)

[2] Outsourcing parts of the manufacturing consists of transferring portions of work to outside manufacturers to assemble or build part of product.

[3] Set of actions performed in the product development process to solve user and market problems, arising from the introduction of a new good or service.

Appendix 3. Questionnaire 2

Questionnaire for Maintenance Group

1. How often does the customer need to change the filter and replace it with a new one?

2. What kind of services you can provide for the customers?

3. Which size of particles can the product separates?

4. How long does it take to make the different parts of product (prefilter, central part, afterfilters) ready when you receive a request from customer?

5. What is the process of production?

6. Do you want to license the products? How about license manufacturing?

7. Design a product has a process. This process has been drawn in below.

Concept generation >Concept screen> Preliminary design> Evaluation and improvement> Prototype and final design.

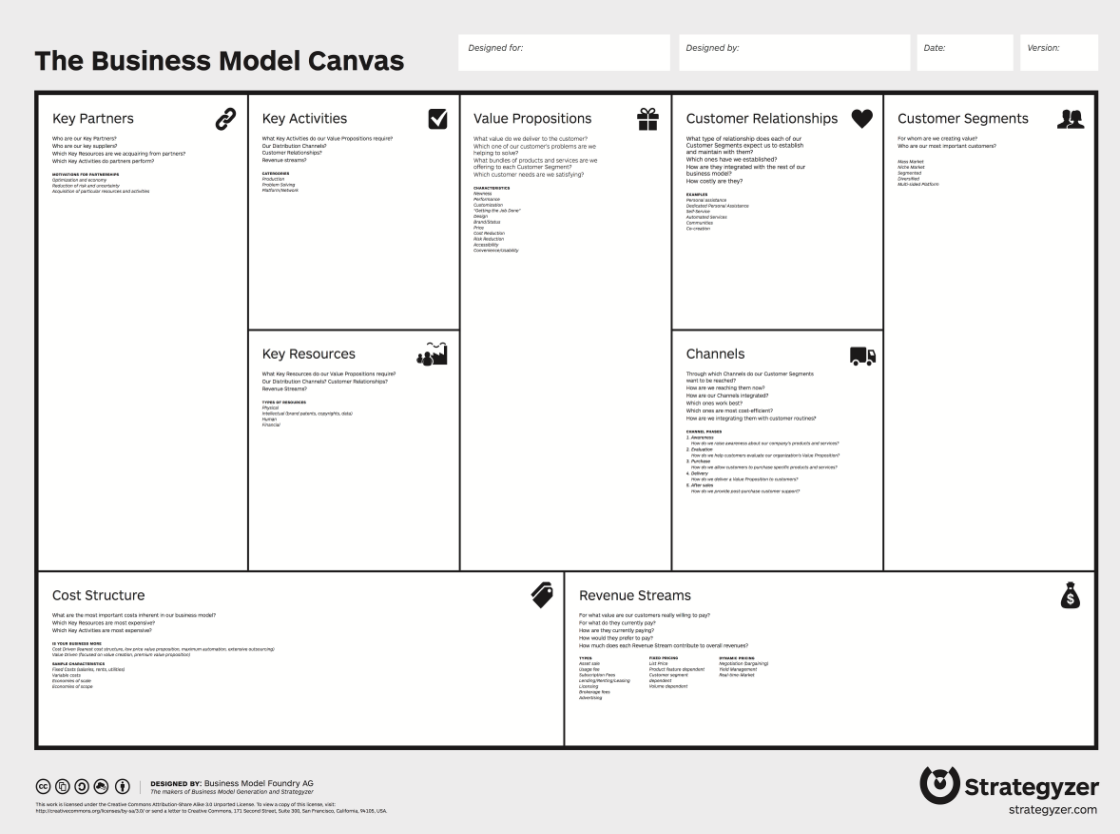
How did you Evaluate the product?

A. Based on the size of particles
B. Accuracy
C. Reliability
D. Easy to change filter

8. There are three prototypes: prefilter at TAMK and two others in the field. Did you get any negative feedback in order to improve product performance?

9. Who are the final customer?

Appendix 4. Canvas Business Model Template



Appendix 5. Pre-planning product delivery

Items	Responsible	Start	End	Dura-tion(day)
Afterfilters	X company	01-Feb	07-Feb	5
Central Part	X company	01-Feb	01-Mar	30
Prefilters	X company	01-Feb	10-Feb	10
Installation	X company	01-Mar	07-Mar	7
Delivery to customer	X company	08-Mar	12-Mar	3
Final installation	Service group	12-Mar	17-Mar	5