

FROM PRODUCT ASSORTMENT TO INVENTORY PLANNING

Case: Company X

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Abstract

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| Title of publication From product assortment to inventory planning Case: Company X | | |
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| <p>Abstract</p> <p>Level of internal profitability is a result from process management. Product assortment and inventory value have an effect on internal profitability.</p> <p>Product assortment is the number and type of products that company provides to customers: wide of different products and depth of one product. Company has to evaluate its business model functionality and make strategic choices with customer and heading of business.</p> <p>Logistics concept consists material and product flow activities from supplier to customer. Primary logistics activities are customer service, transportation, inventory management and order processing. Support activities are purchasing, warehousing, materials handling, production scheduling, packaging and information maintenance. In inventory management, lot sizing is an important issue. Sum of ordering cost and holding cost should be minimized. Production scheduling is conducted to ensure production of batches in planned time schedule. Product costing and inventory valuation depend on each other.</p> <p>Process can be measured with key performance indicators. They can be used in evaluating critical actions and in progress towards long-term organizational goals.</p> <p>This thesis is about improving internal profitability of an organization and it was made as a part of the project implemented in Company X. Goal of the project was to optimize the process and thus decrease inventory value. Project concentrated on product assortment and logistics activities: purchasing, production and inventories.</p> <p>Process was investigated and many changes were conducted. Inventory turnover improved during this project, but not as much as hoped. Implemented changes give results gradually. KPIs are used to measure process performance in order to see whether improvements are taking place. Well-organized process decreases inventory value and increases profitability. Improvement of internal profitability requires commitment from everybody in the company. It is an ongoing process.</p> | | |
| <p>Keywords</p> <p>Product assortment, process management, inventory value, inventory turnover, lot size, production capacity, production cost, key performance indicator.</p> | | |

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LIST OF ABBREVIATIONS

| | |
|------|--|
| ABC | Activity based costing |
| BPM | Business process management |
| CI | Continual improvement |
| DD | Due date |
| EBQ | Economic batch quantity |
| EMQ | Economic manufacturing quantity |
| EOQ | Economic order quantity |
| FIFO | First-in, first-out |
| GAAP | Generally accepted accounting principles |
| KPI | Key performance indicator |
| LIFO | Last-in, first-out |
| MRO | Maintenance and repairs |
| POQ | Production order quantity |
| QC | Quality control |
| ROA | Return on assets |
| ROI | Return on investment |
| ROP | Reorder point |
| SCM | Supply chain management |
| TOC | Theory of constraints accounting |
| WAC | Weighted average cost |
| WIP | Work-in-process |

1 INTRODUCTION

1.1 Purpose of the thesis

This research is about improving internal profitability of a company: From product assortment to inventory planning. This thesis was made as a part of the project implemented in Company X. Goal of the project was to improve company's internal profitability by decreasing inventory value. Project concentrated on product assortment and logistics activities: purchasing, production and inventories. Company X is expanding and trying to become an international company. Internal processes and profitability have to be well organized when activities grow.

1.2 Background and research methods

This thesis examined internal processes and profitability of a manufacturing company. In Company X, there were two parts in the company, which needed research: product assortment and logistics activities (purchasing, production and inventories).

Goal of the project was to improve company's internal profitability by decreasing inventory value. This project was quite experimental so it was not possible to set an exact research method for this. In addition, this project was divided into several parts, so there would have been many different research questions to answer. Many decisions were done based on discussions with sales managers and with production, purchasing and quality control managers. Background for decisions was found from the literature, which is introduced in this thesis. Some parts of the projects were possible to define with research methods from literature (purchasing, production and stock amounts) or at least tell, why they were not able to be used.

Product assortment is the number and type of products that company provides to customers. Company has to evaluate its business model

functionality and make strategic choices with customer choices and heading of business. (Investopedia 2018; Rouné & Joki-Korpela 2008, 27) Product assortment in Company X is very wide. However, major part of sales come from a small part of the products. Company X needs to evaluate its business model and make strategic choices regarding the product assortment. No exact research methods were found from literature to evaluate product assortment profitability. However, for example Pareto Principle (80/20 rule) (Investopedia 2018) could work in investigation of sales quantities. Small products could be wise to remove from the assortment. Research question for product assortment is: Which products are profitable for the company and which products should be stopped?

The logistics concept consists materials and product flow activity from supply point to customers. Primary logistics activities are customer service, transportation, inventory management and order processing. There are also many supporting activities: purchasing, warehousing, materials handling, production scheduling, packaging and information maintenance. (Lai & Cheng 2009, 35-38) These topics have to be discussed with case Company X in order to improve the process.

Inventory is a large asset for manufacturing company and inventory has a direct impact on profitability and committed capital. Inventory valuation affects to cash flows because of the direct effect on net income. (Hermanson, Edwards & Maher 2005, 258; Suviolahti 2009, 8) Inventory value is high in Company X, because products are manufactured and stored in the company. Business has concentrated on few big products and there are many products that are manufactured and sold quite rarely. Inventory turnover is quite slow with these kinds of items. With inventory, research question is: How inventory value can be decreased and inventory turnover increased? In the literature, there can be found exact formulas to calculate these figures, but there are no exact method for the improvement. Methods consist from several different things and they need to be applied with different ways in different companies.

It is necessary to have a good estimate about order amounts in order to satisfy demand and to know how long it will take to deliver goods. In inventory management, lot sizing is an important issue. Sum of ordering cost and holding cost should be minimized. (Stevenson 2014, 509, 553) In Company X part of the products are manufactured and part are bought from Company Y. It is important to have raw materials and finished products in the warehouse in order to satisfy the demand. At the same time, inventory value should be as low as possible. Order amounts has to be well estimated. With order amounts the research question is: How to optimize the purchasing activities? The economic order quantity (EOQ) model can be used to calculate fixed order sizes (Slack, Chambers & Johnston 2010). However, in Company X's business area this research method cannot be applied because of unstable consumption. Order amounts need to be estimate with more experimental way and with taking the historical information into account.

Batch process is used in specialty products manufacturing. In batch process, several products are manufactured in wanted order with same production equipment. Production planning and scheduling is conducted to ensure production of batches in planned time schedule. (Smith 2014, 4, 692) Company X products are manufactured with batch process. Manufacturing equipment and large product assortment bring challenges to the production and affect to the stock amounts. Size of some batches needs to be evaluated in order to decrease the inventory value. In batch process the research question is: How to optimize production quantities? Batch size can be calculated by using the economic batch size model (Slack, Chambers and Johnston 2010). Besides this research method, variety of different products needs to be taken into account. Sometimes change of product causes more costs than production of several batches of one product. That is why economical batch size model needs to be applied.

Product costing and inventory valuation depend on each other. Changes in product costing affect on changes in inventory valuation. Inventory

valuation has big direct and indirect effect on cash flow. Use of company's resources are represented many times wrong, because costs are distributed into simplistic measures. Accurate costs for individual products cannot be determined, which leads to misguided decisions about product pricing. Because of incorrect product costs, unprofitable products might be produced. (Suviolahti 2009, 7-8; Reinstein & Bayou 1997; Lea & Fredendall 2002) Product costing has to be evaluated again in Company X. Now, cost of each product is not specified enough. Inventory valuation may be a bit inaccurate because of this and it might be that there are unprofitable products in production.

Process performance indicates how well process meets the requirements of a product (Kuusisto 2017). Process performance can be understood by measuring it (Mendelssohn 2015). Key performance indicator (KPI) is a performance measure that can be used in evaluating critical actions and in progress towards long-term organizational goals (Raynus 2011, 126-127). Company X has started to use performance measures in order to see whether there are improvements happening in the process. Measures are made from each major part of the process. Well-organized process should decrease the value of inventory and increase profitability. These key performance indicators work as research methods in Company X process. Results from these process measurements give answers to research questions.

When product assortment and process improvements are done, final research question in this thesis is: Has the process improved in Company X and has the inventory value and turnover in days decreased?

1.3 Structure of the thesis

This thesis is divided into two main parts: Literature part in chapters 2-8 and project part in chapters 9-14. In literature part topics related to internal profitability, product assortment, process performance, logistics, inventory, purchasing, production and product quality are discussed.

Based on this literature review, a framework for the project part is constructed. Chapter 9 introduces Company X and the background for the project. Chapters 10-13 investigate different parts of the process in Company X. Results from the project are introduced and main conclusions based on the literature part are made in chapter 14.

2 PRODUCT ASSORTMENT

2.1 Product range

Product range is the number and type of products that company provides to customers. Two major parts of an assortment strategy are the width of the product variety and the depth of products. Variety notifies the range of distinct products offered - also referred as breadth. Depth measures how many options there are available from each distinct product (colors, sizes and other variations). Wide variety and a deep assortment require large space. (Investopedia 2018; Business Dictionary 2018; Celect 2018)

Deep product range may attract customers, but if the assortment is too large, customers may have difficulties to find the right item. Too many options can discourage customer engagement. (Investopedia 2018)

Pareto Analysis is a statistical technique where limited number of tasks are selected to produce significant result. According the Pareto Principle (80/20 rule) with 20% of the work it is possible to gain 80% of the benefit. Vice versa in terms of quality, large amount of problems (80%) is coming from a few key causes (20%). (Investopedia 2018)

This 80/20 rule can be applied in product assortment: 20% of products make 80% of the profit, 20% of sales-force produces 80% of company's revenues, 80% of customer claims come from 20% of the products, 20% of system defects cause 80% of its problems. (Investopedia 2018)

2.2 Strategic choices

Company has strategic development challenges in which company needs to evaluate its business model functionality and make strategic reelection. Those reelections can be related to customer choices and heading of business, developing operative strengths or revenue logic for example. (Roune & Joki-Korpela 2008, 27-28)

Product assortment strategy decisions are made based on buying trends, historical demand from the market and expected choices that customers make when buying a product. These customer choices differ across product features and styles, distribution channels and geographic locations. This information has a direct impact on assortment strategy. (Celect 2018)

Should company continue with learned, customer friendly business model? Challenge in this is managing product variation, continuous and expensive customer-oriented development and individual support. Cost of the result and amount of individual support limits the possible customer base. (Roune & Joki-Korpela 2008, 28)

Alternatively, should organization take R&D risk and productize cumulative expertise into solution, which consists from clearly selected properties and limits the amount of variations. As a counterbalance to R&D risk, there are many eligible benefits: Cost interest in the implementation of customer projects, reduction of support for different product versions, and therefore possibility to extend customer base outside existing one. With productized solutions, there could be possibility to offer these to completely new customer base, for solution suppliers who offer bigger entireties. (Roune & Joki-Korpela 2008, 28-29)

Many times, clear strategic product and customer choices are difficult to make, because no customers and sales want to be lost. (Roune & Joki-Korpela 2008, 29)

2.3 Customer satisfaction versus standardization

Products have three aspects: concept, package and process. Concept defines the nature, use and value of the product; a package of the product provides those benefits defined in the concept; process defines the way in which the product is created and delivered. (Slack, Chambers & Johnston 2010, 115)

Organizations sometimes reduce the costs by standardizing their products or processes. Usually standardization is seen in the output of the process. As an alternative, they would need to provide a customized service. Both options would have a notable impact on costs. Organizations have improved their profitability by cautious variety reduction. Customers may be offered alternative products with similar values, in order to overcome loss of business. (Slack, Chambers & Johnston 2010, 124)

In order to achieve customer centricity, companies have to understand customers' processes and when necessary, change interaction with them. Customers' needs should be the starting point, when process redesign effort is taken (Chen, Daugherty & Landry 2009). (Trkman, Mertens, Viaene & Gemmel 2015) If organization wants to satisfy their customers and offer right products, they need to listen and take ideas from them and keep track competitors' activities. (Slack, Chambers & Johnston 2010, 118)

Before starting the customer centricity, organization can investigate the current customer satisfaction (Flint, Larsson, Gammelgaard & Mentzer 2005). Based on the results, companies may have to re-design their business processes (Lee, Huang, Barnes & Kao 2010). If customer satisfaction is on good level, it might be that companies don't know how customers use their products in their processes and how companies' processes interact with customers' processes. When a company is trying to move from producer to solution-provider with services, the difference between customer satisfaction and the actual use of a product is even more important (Biege, Lay & Buschak 2012; Gebauer, Paiola & Saccani 2013; Mahapatra, Das & Narasimhan 2012). This service aspect can be difficult to deal with for manufacturing companies because of the different process nature (Bitner, Ostrom & Morgan 2008). (Trkman, Mertens, Viaene & Gemmel 2015)

It is difficult to balance between standardization and flexibility. Products have to be customized to a certain degree in order to satisfy customers.

However, standardization is important for producer (Vargo & Lusch 2004, 2008). Companies need to consider carefully in order to balance reasonably, which processes should be standardized and where flexibility should be used (Hall & Johnson 2009). (Trkman, Mertens, Viaene & Gemmel 2015)

Even that process standardization is wanted to gain technical options, improved customer confidence and regulation compliance, it also brings usual standardization problems (Wüllenweber, Beimborn, Weitzel & König 2008). Standardization is difficult to make in specific processes, and in those cases, organization must convince customers of the value transfers to new process (Kauffman & Tsai 2010). (Trkman, Mertens, Viaene & Gemmel 2015)

Customized product categories with higher differentiation have higher prices and lower sales levels compared to standardized product categories. Customized product categories have wider margins and this favors larger assortment because category sales rise with assortment depth. (Hamilton & Richards 2009)

2.4 Research and development

Mission of development group is to improve product assortment. In good product assortment, products are related to each other in a sensible way. They support each other and there is no duplication. In R&D work, product quality versus costs play very important role. With R&D activities, company can take a role of pioneer or be a follower and compete with price. (Company X 2018)

Many specialty products must perform in a certain way. If product is modified forward from this, customers may choose it over other ones from competitors and possibly pay more. Task of development group is to invent product enhancements, produce these enhanced products for customer tests and then scale the product into the production. In many

businesses, forecasting of products in production after one year is difficult. (Smith 2014, 31)

Combining product development process with environment aspects is important from the environmental, but also from the business perspective. Considering eco-design principles and determining optimal production volumes are significant steps to solve environmental and economic problems and towards more sustainable society. Ecofriendly development projects have shown that besides helping the environmental improvement, also financial benefits are achieved. (Badida, Sobotova, Kralikova, Badidova, Hurajt & Konkoly 2016)

Research and development activities differ from most activities performed by a company. Expectation or goal of immediate profit is not typically demand from the research and/or development activities. Focus is on long-term profitability. Companies with large departments of research and development, commit substantial capital to the effort. The risk-adjusted return from R&D costs has to be estimated, as no payoff is expected right away and the general return on investment (ROI) can be uncertain. Amount of capital spent on R&D determines the risk. (Investopedia 2018)

3 LOGISTICS

The logistics concept consists materials and product flow activity from supplier to customer. A logistics system comprises many organizational areas and consists of many supporting activities. Organizational structure must support the coordination efforts among units, because logistics includes activities across different functional units. (Lai & Cheng 2009, 35-38)

Planning, implementation and control provide organizations to perform the required logistics activities to create time, place and reduction of cost. These logistics activities can be categorized, according to their importance to logistics management, into primary and supporting activities (Ballou 2004). Four activities are found to have primary importance in logistics: customer service, transportation, inventory management and order processing. These four activities are very important part of logistics costs and efficient coordination and completion of logistics tasks. (Lai & Cheng 2009, 35-38)

There are many additional logistics activities to support these primary activities: purchasing, warehousing, materials handling, production scheduling, packaging and information maintenance. These additional logistics activities are supplementary to key activities involved to organization's logistics even that they can be as important as the key activities in cost reduction and service improvement. Figure 1 shows the relationships of logistics activities in an organization. Among these activities, there are some activities, which don't participate in every logistics process in a supply chain and activities, which are not used in every organization's logistics activity. (Lai & Cheng 2009, 35-38)

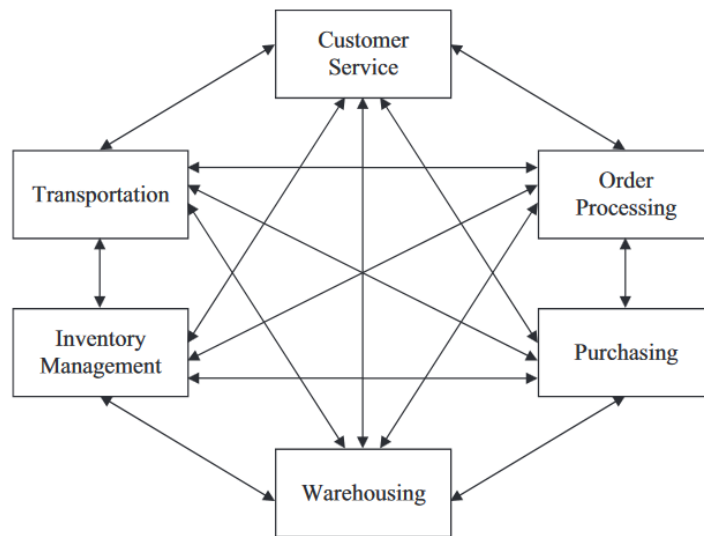


FIGURE 1. Relationships of logistics activities (Lai & Cheng 2009, 37)

Organization's objective is to maximize long-term profitability. Managing the logistics activities as an integrated system is one way to achieve this. Besides logistics activities, organization should also integrate their flows of products from the system perspective. Heskett, Glaskowsky & Ivie (1973) made following observations from logistics systems:

1. Logistics system controls many interrelated parts.
2. Performance parts are affected with each other.
3. Subcomponents cannot be analyzed in isolation.
4. Some subcomponent alternation develops more change in system behavior than others do.
5. The balance achieved among the subcomponents determines the overall system performance.
6. The upper bound of system performance is often determined by the weakest subcomponent.
7. Optimum system performance requires balance and coordination among each subcomponent.

(Lai & Cheng 2009, 36-37)

Organizations have to examine trade-off alternatives and reduce total costs of logistics activities. By integrating logistics-related activities;

customer service, transportation, warehousing, inventory investment, order processing and information systems, production planning and purchasing; total logistics costs can be reduced. Without this system approach, logistics could become an uncoordinated set of activities in various organizational functions with individual budgets, set of priorities and performance measures. Total cost of all the activities should be reduced instead of isolate activities. (Lai & Cheng 2009, 35-38)

Without a consistent objective for logistics, different departments in the organization are trying to achieve their own good:

1. Purchasing management is trying to achieve lowest possible per-unit costs for raw materials and supplies.
2. Production department is trying to achieve the lowest possible per-unit production costs.
3. Sales wants large inventories of products to be as close to the customer as possible. By this way, sales can minimize the forecasting difficulties with customer needs and offer the shortest possible delivery time.
4. Transportation managers want to ship products in large amounts (truckloads or railcars) in order to obtain the lowest possible freight rates. Increased inventories at both origin and destinations are required for large shipments of products.
5. Customers and retailers can reduce their inventories by purchasing more often. Manufacture has to pay the inventory and associated carrying costs of this reduction.

(Lai & Cheng 2009, 35-38)

In logistics activities of organization's immediate supply chain, there are two aspects: inbound logistics (materials management) and outbound logistics (physical distribution). In inbound logistics, products are moving into a company rather than away from it. The purpose of inbound logistics is to satisfy the operations needs of the manufacturing and therefore the inbound logistics activities involve receiving, storing and distributing inputs

to the operations areas. The main activities of outbound logistics are mainly concerned with finished and semi-finished products: products, which company is selling, and for products, which company plans not to process further. Outbound logistics activities involve movement, storing and processing of orders for an organization's outputs. (Ballou 2004, Lai & Cheng 2009, 38-39)

In inbound logistics, the goal is to meet the needs of incoming items in an orderly, efficient and low-cost manner. In outbound logistics, on the other hand, the goal is to minimize the cost involved in moving and storing the products from production point to the delivered point without losing the specified level of customer service. The logistics activities, except purchasing, are quite similar in inbound and outbound logistics. In logistics, the objective is to serve end markets in the most cost-effective manner by integrating and coordinating all the organizational actors in materials management and physical distribution. (Lai & Cheng 2009, 38-39)

3.1 Logistics management

Four core elements of effective logistics management are customer service, order processing, inventory management and transportation. These elements are either essential to the effective coordination and completion of logistics tasks or they cause most to the total cost of logistics. (Lai & Cheng 2009, 39)

In customer service, right products are tried to deliver to the right customer at the right place, at the right time with right condition and at the lowest possible cost. Customer service reflects the quality of flow of goods and services and it includes all the order-related performance values offered to customers. Customer service represents the output of the logistics systems, because the customers directly experience the products and services provided there. Customer service plays an important role in

creating, developing and maintaining customer loyalty and satisfaction. (Lai & Cheng 2009, 39)

Order processing includes collecting, checking, entering and transmitting sales-order information activities. Organization is able to exchange order information with suppliers and use it to provide useful data for market analysis, logistics operations, production and financial estimation. Order processing is a primary logistics activity. It triggers product movement and service delivery, in order to get goods and services to customers in a critical time element. In competitive business environment, order cycle time; from time when customer transmits an order to the time receiving that order; is a critical point in product/service differentiation. (Lai & Cheng 2009, 39)

In inventory management, stock levels should be as low as possible, but still serve customer's demand with desired level of stock available. Logistics costs can be reduced with efficient inventory control. Inventory has an impact on customers, suppliers and major functional departments, because it is directly related to all movement and information flows in an organization. (Lai & Cheng 2009, 39)

Transportation management selects and utilizes appropriate modes, routings. Without transportation, organization cannot operate and provide movement for raw materials and/or finished products. Improved transportation can increase sales, get bigger market shares and therefore increase profit contribution and growth (Ballou 2004). (Lai & Cheng 2009, 39)

3.2 Supply chain management

Supply chains have to be well managed for fast product introduction and service innovations to the markets. Global supply chains have been taken into use to obtain cost and service advantages. To compete at the supply chain level, it is important to develop the knowledge, skills and strategies. Supply chain management (SCM) has a scope in logistics operations to

improve cost and service performance and has multiple relationships across the supply chain. Supplier-customer relationships and customer value delivery is SCM's one most important issue and requires coordination and integration of internal and external business processes. Efficient SCM reduces lead times and materials costs and improves product quality (Lai, Ngai & Cheng 2002). (Lambert 2001, 99-126; Christopher 2005; Wang & Cheng 2007; Lai & Cheng 2009, 40-41)

Core processes of SCM include:

1. Customer relationship management
2. Customer service management
3. Demand management
4. Order fulfillment
5. Manufacturing flow management
6. Supplier relationship management
7. Product relationship management
8. Returns management

(Croxtton, Carcia-Dastugue & Lambert 2001)

This management approach offers the opportunity for greater cost reduction and service improvement in multiple businesses and relationships. In SCM work processes suppliers, manufacturers, transporters, retailers and customers are brought together to a supply chain that adds value to customers and other stakeholders (Lambert, Cooper & Pagh 1998). (Lai & Cheng 2009, 40-41)

4 INVENTORY

4.1 Inventory management

Inventories are a part of supply chains and many parts of inventory are important for supply chain management. Inventory location is an important factor for efficient material flow through the production chain and order actualization. To lower overall inventory, centralized inventories can be used. With decentralized inventories, one location may be understocked and another one overstocked. On the other hand, decentralized locations can provide faster delivery with lower transport costs. (Stevenson 2014, 670) There are different kinds of inventories: Raw materials and other purchased parts, work-in-process (WIP), finished-goods, tools and supplies, maintenance and repairs (MRO) and goods-in-transit to warehouses, distributors, or customers. (Stevenson 2014, 548-549)

There are eight functions for inventories:

1. To be prepared for customers demand.
2. To make production possible and smooth it's requirements. In many companies, there are seasonal patterns in demand where inventory has to be built before the overly high requirements during seasonal periods come.
3. To decouple operations. Manufacturing firms have used inventories as buffers. If operations encounter equipment breakdowns or accidents, which temporarily shut down operations, these inventories have allowed other operations to continue while the problem is solved. Buffer inventories are used also with raw materials to insulate production, when there have been problems with the deliveries. With finished goods, inventory buffers have been used to protect sales operations from manufacturing disruptions. However, these buffer inventories require space and cause costs. Instead of having the buffer, it would better to find and eliminate the sources of disruptions.

4. To diminish the risk of stock outs. Risk of shortages increase, if deliveries delayed or demand increases.
5. To take advantage of order cycles. Companies can buy larger amounts than immediate needed in order to minimize purchasing costs. However, purchased amounts have to be stored for later use. Same idea can be used in production. It is usually more economical to produce larger quantities instead of small ones. Also now, the excess output has to be stored. Inventory makes it possible to buy and produce economic lot sizes without the problem of matching purchase - production demand requirements in the short run.
6. To avoid price increases. When companies suspect price increase to occur, they can beat it by purchasing larger amounts than needed.
7. Enable operations. In production operations, there are work-in-process inventory, intermediate stocking of goods (raw materials, semi-finished items and finished goods) at production sites and finished goods in warehouses. Inventories are needed throughout whole production-distribution system.
8. To benefit from quantity discounts. Unit price for larger order amount can be cheaper.
(Stevenson 2014, 549-550)

In inventory management, there are two basic functions: Establish a system to calculate items in inventory and decide when to order and how much. To execute this, management needs to have information about:

1. Inventory amounts on hand and on order.
2. A reliable forecast of demand with possible forecast error.
3. Information about lead times and lead-time variability.
4. Information about inventory holding costs, ordering costs and shortage costs.
5. Classification of stored items. (Stevenson 2014, 551)

In inventory counting, two kind of systems can be used: periodic or perpetual. In a periodic system, counting of items is made at periodic, fixed intervals (e.g. weekly, monthly), and decide how much to order of each item. In perpetual inventory system (a continuous review system) removals from inventory are tracked on a continuous basic. System is able to provide real time information about inventory levels of each item. When the amount in stock reaches a predetermined minimum, a fixed quantity (Q) is ordered. (Stevenson 2014, 551)

4.2 Inventory costs

With inventories, there are four basic costs: purchase, holding, ordering and shortage costs. Purchase cost is the amount paid from the inventory to supplier. Usually this is the largest inventory cost. Holding costs are paid from transport into storage. Costs include interest, insurance, taxes, depreciation, obsolescence, deterioration, spoilage, pilferage, breakage, tracking, picking and warehousing costs.

Holding costs are expressed in either as a percentage of unit or as a currency amount per unit. (Stevenson 2014, 553) Ordering costs occur with the actual placement of an order. These costs include order quantity determination, invoice preparation, quality inspection of goods when they arrive and moving the goods to storage. Ordering costs are stated as a fixed currency amount per order, regardless of order size.

Shortage costs are caused by exceed demand compared to supply of inventory. These costs include among other things opportunity cost of not able to sell goods, loss of customer goodwill, late charges and backorder costs. (Stevenson 2014, 554)

4.3 Inventory valuation method

Inventory is probably the biggest asset that manufacturing company has and inventory has a direct impact on profitability and committed capital.

Appropriate expenses must correspond with revenues in each accounting period in order to determine appropriate income. Cost of sold goods that should be reduced from sales are included in inventory accounting. Because of this, net income depends directly on inventory valuation. (Hermanson, Edwards & Maher 2005, 258) Inventory valuation affects cash flows because of the direct effect on net income.

Companies use GAAP (Generally accepted accounting principles) to compile their financial statements. GAAP means accounting principles, standards and procedures, which are in use. There are four common GAAP cost flow assumptions: specific identification, first-in, first-out (FIFO), last-in, first-out (LIFO) and weighted average cost (Bragg 2007; Suviolahti 2009, 23)

In specific identification method, each item is sold with its actual costs. Stored items are specifically set to cost the total costs of ending inventory. This method is functional in businesses selling a few high priced items, but it is not practical with high volume, low priced items. Keeping up with different purchase prices is difficult in raw material or other high volume material accounting and not convenient in specific identification. (Suviolahti 2009, 23)

In first-in, first-out (FIFO) method first goods purchased are also the first goods sold. With this method risk of items getting old decreases (Visma 2018). Remained goods are accounted with the most recently incurred costs. In this way inventory assets on the balance sheet, are quite close to the most recent costs. On the contrary, FIFO also results in older costs being matched against current revenues and put in the cost of goods sold. In this case the gross margin does not necessarily match properly between revenues and costs. The FIFO method gives same results either with periodic or perpetual inventory systems. (Bragg 2017; Slack, Chambers & Johnston 2010, 282)

Last-in, first-out (LIFO) method assumes that the newest items received in the inventory are the first ones sold (Murray 2017). With this method,

management assumes that the newest items in stock are sold first regardless of which goods are actually sold first and are recorded properly in to the accounting. If the purchase cost or the production price of these items was different from the current price, these items will be accounted with the most recent value – not with the previous one. (Debitoor 2018)

Weighted average cost (WAC) method values inventory by using the amount of inventory before current period, the purchase price and the amount in current period:

$$WAC(t) = \frac{WAC(t - 1) * Inv(t - 1) + pup(t) * pu(t)}{In(t)}$$

where WAC(t) is the weighted average cost at time t, Inv(t) is the inventory in units at time t, pup(t) is the purchase price at time t, pu(t) is the purchases at time t and t is time in periods (Chadwick 2002, 194). (Suviolahti 2009, 26)

In WAC method only the latest weighted average cost is used in calculating cost flow out. This method doesn't need a database to remember all the other earlier weighted average cost calculated. They are included in the latest one. (Bragg 2005, 119–120; Suviolahti 2009, 26-27)

In some perspectives weighted average cost method is in the middle of FIFO and LIFO. With inventory value, FIFO is most up-to-date, but weighted average cost is better approximation than LIFO. With costs of goods sold and tax advantages weighted average cost method is also in the middle of LIFO and FIFO. (Hermanson, Edwards & Maher 2005, 274) Weighted average cost method gives same benefits than LIFO, but has the same simplicity that FIFO has. Weighted average cost method can be reasonable to use if inventory is relatively homogenous and physical flow of inventory is difficult to measure. (Suviolahti 2009, 26-27)

Additional methods for inventory cost accounting are standard price and price of the day. In standard price method a single standard price, which

should reflect the market price, determines cost flow. Price is defined from long-term development of prices. In the price of the day method latest purchase price determines the cost flow of inventory. Previous purchase is the determinant, but it can be several days or months old. (Neilimo & Uusi-Rauva 2005, 93; Suviolahti 2009, 30)

4.4 Inventory turnover

Inventory turnover defines how many times inventory is sold and replaced over a measurement period (Stevenson 2014, 551; Bragg 2017; Investopedia 2018). With higher turnover, inventories are used with more effective way. Desirable turnover depends on the industry and profit margins. With high profit margin, lower turnover is acceptable. Products with long manufacturing or selling time have a low turnover rate. (Stevenson 2014, 551) Inventory turnover is usually compared with industry averages (Investopedia 2018).

Inventory turnover = Annual cost of goods sold ÷ Inventory (Bragg 2017).

Following issues have an effect on inventory turnover:

1. Seasonal build: Inventory is built up before selling season.
2. Obsolescence: Inventory cannot be sold if it is ruined.
3. Cost accounting: The inventory accounting method used together with inventory price changes can cause significant swings in the reported amount of inventory.
4. Flow method used: There is a clear difference in inventory amount with demand manufacture and estimated demand manufacture.
5. Purchasing practices: Bigger purchasing amounts increase the investment in inventory, even that they bring purchase discounts. (Bragg 2017)

Low rate of inventory turnover suggests that purchasing system is flawed with too many items bought, or that inventories were increased in anticipation of sales that did not occur. With low rate of inventory turnover, there is a high risk of inventory aging. Inventory becomes obsolete and has small residual value. (Bragg 2017)

High rate of inventory turnover suggests that the purchasing function is well managed. On the other hand, it might mean that a company cannot maintain normal inventory levels because of low cash reserves. This might turn away prospective sales. (Bragg 2017)

The days in the period can be divided by the inventory turnover formula to indicate the expected number of days of sales that can be delivered with the existing inventory. High number of days implies on weak sales and excess inventory or poor inventory planning (Bragg 2017). Low number suggests either strong sales or large discounts and risk of running out of stock. (Investopedia 2018, Stevenson 2014, 551)

Inventory turnover can be used in evaluating inventory management performance: it is a critical measure. Besides profitability, inventory turnover is used in calculation for return on assets (ROA). High turnover is meaningless without a profit from each sale. (Investopedia 2018)

5 PURCHASING

It is necessary to have a good estimate about order amounts in order to satisfy demand and know how long it will take to deliver goods. Also, lead time (the time between submitting an order and receiving it) variation has to be known. The wider the potential variability, the greater the need for additional stock to avoid a shortage between deliveries. (Stevenson 2014, 553)

5.1 Order costs

With decision, how much to order, costs affected from this decision, have to be identified. There are different kind of costs, which are directly associated with order size (Slack, Chambers & Johnston 2010, 347)

1. Placing an order: A number of transactions are needed when an order is placed: documentation of preparing the order, arranging the delivery and payment to the supplier for the delivery and information keeping transactions. All these transactions cause costs to the company. (Slack, Chambers & Johnston 2010, 347)
2. Price discount costs: With large quantities, there might be discounts on the normal purchase price. On the other hand, small orders might impose extra costs. (Slack, Chambers & Johnston 2010, 347; Stevenson 2014, 564)
3. Stock-out costs: If inventory runs out of stock because of too small order-quantity, there will be costs caused by failing to supply order to the customer. In these situations, external customer may take their business elsewhere. With internal customer, stock-out can delay the next process and in the end, disappoint external customers.
4. Working capital costs: After order has arrived, the supplier will demand payment for their goods. At some point, when ready-made product is supplied, payment will be received from the customer. Usually, there is a lag between paying the supplier and receiving

payment from the customer. During this time, working capital costs are caused, because company has to pay interest for the bank for borrowing money or the opportunity costs of not been able to invest money elsewhere.

5. Storage costs: Physical storing of the goods causes costs like heating and lighting or renting the warehouse. Also insuring the inventory causes costs.
6. Obsolescence costs: With large order quantities, stocked items spent a long time in inventory. There is a risk that the items become unusable.
7. Operating inefficiency costs: High inventory levels might prevent to see the problems in the operation.

(Slack, Chambers & Johnston 2010, 347)

First three costs decrease when order size increases. Other costs usually increase with bigger order size. These costs don't hold consignment stock. Organization may deliver large quantities of inventory to customers to store, but charges for the goods only after they are used. Before the payment, goods are supplier's property so they don't have to be financed by the customer. Customer, however, provides storage facilities. (Slack, Chambers & Johnston 2010, 347)

5.2 Lot size

Determining a lot size to order is called lot sizing. In inventory management, this is an important issue for both independent- and dependent-demand items. With independent-demand items, economic order sizes are often used. With dependent-demand systems, wider variety of plans has to be used to determine lot sizes. With different systems, there are no clear advantages against others. Both with independent- and dependent-demand systems is important to minimize the sum of ordering cost and holding cost. Independent demand can be distributed constantly throughout the planning frame. Sometimes, when

demand varies and the planning frame becomes shorter, economic lot size is more difficult to determine. (Stevenson 2014, 509)

Frequent recalculation and updating of lot sizes is needed in uneven period demand with relatively short planning frame. Methods to handle lot size vary from systems including all relevant costs to very simple, easy to use and understand systems. (Stevenson 2014, 509)

In lot-for-lot ordering method order size for each period is set equal to demand for that period. This system eliminates holding costs for parts carried over to other periods and minimizes investment in inventory. Drawbacks with this system are that it cannot take advantages of the economic of fixed order size because of different order sizes and it requires a new setup for each production run. This method may estimate a minimum-cost lot size, if setup costs can be significantly reduced. (Stevenson 2014, 509)

Grouping orders can lead to savings, if the additional cost caused from holding the extra units until they are used, are smaller than setup or ordering cost. Period demands gathered into a single order, especially with middle-level or end-item order, effect down through the product tree. In addition, items at lower levels in the tree need to be grouped and include their setup and holding costs into the decision. (Stevenson 2014, 509)

The economic order quantity (EOQ) model is used to calculate a fixed order size, which will minimize annual costs of holding inventory and ordering inventory. It usually finds good balance between the advantages and disadvantages of holding a stock (Slack, Chambers & Johnston 2010). Purchase cost is included in the total cost only, if order sizes bring quantity discounts. If holding costs are stated as a percentage of unit cost, then purchase cost per unit is indirectly included in the total cost as a part of holding costs. (Stevenson 2014, 557-559) EOQ model leads to minimum costs if usage is uniform. This works for lower-level items, which are common to different products. With uneven demand, there is a risk of mismatch in supply and leftover inventories. (Stevenson, W. J. 2014, 509)

EOQ models tells how much to order, but not when to order. The reorder point (ROP) is reached when the quantity of stored goods drops to a predetermined amount. This amount usually includes expected demand during lead time and an extra stock to prevent stock out during lead time. Perpetual inventory monitoring is required in order to know when the reorder point has been reached. New order should be placed at the moment when the hands on inventory is large enough to satisfy customer demand during the time waiting the order to arrive, not before, but not too late. Four things determinates the reorder point quantity: forecasted rate of demand, lead time, demand and/or lead time variability extent and acceptable degree of stock out risk. (Stevenson 2014, 569)

To find out how to minimize the total cost of stocking the item, further information is needed: total cost of holding one unit in stock for a period of time (C_h) and the total costs of placing an order (C_o). Usually holding costs include working capital costs, storage costs and obsolescence risk costs. Order costs include cost of placing an order and price discount costs:

$$\text{Holding costs} = \text{holding cost / unit} \times \text{average inventory} = C_h * \frac{Q}{2}$$

$$\text{Order costs} = \text{order cost} \times \text{number of orders per period} = C_o * \frac{D}{Q}$$

$$\text{Total cost } C_t = \frac{C_h Q}{2} + \frac{C_o D}{Q}$$

(Slack, Chambers & Johnston 2010, 349)

Slack, Chambers and Johnston (2010) show another way to calculate EOQ by derive its general expression:

$$\text{Total cost} = \text{holding cost} + \text{order cost: } C_t = \frac{C_h Q}{2} + \frac{C_o D}{Q}$$

The rate of change of total cost is given by the first differential of C_t with respect to Q :

$$\frac{dC_t}{dQ} = \frac{C_h}{2} - \frac{C_0 D}{Q^2}$$

The lowest cost will occur when $dC_t/dQ = 0$, that is:

$$0 = \frac{C_h}{2} - \frac{C_0 D}{Q_0^2} \text{ where } Q_0 = \text{the EOQ.}$$

$$\text{Rearranging this expression gives: } Q_0 = \text{EOQ} = \sqrt{\frac{2C_0 D}{C_h}}$$

When using the EOQ:

$$\text{Time between orders} = \frac{\text{EOQ}}{D}, \text{ order frequency} = \frac{D}{\text{EOQ}} \text{ per period.}$$

(Slack, Chambers & Johnston 2010, 351)

Fixed-period ordering provides coverage for some predetermined amount of periods. Fixed period length can be determined with a review of historical demand patterns or simply arbitrarily. However, order has to cover a two-period interval. (Stevenson, W. J. 2014, 509)

There are also other models used in lot sizing, such as the part-period model and the Wagner-Whitin model. (Stevenson, W. J. 2014, 509)

5.3 Safety stock and lead time

Both demand and order lead-time can vary. In these situations, reorder should be done earlier than with stable consumption. When the replenishment order arrives and there is still some stock left in the inventory, it is called safety stock. Because of the variability of both lead time and demand rate, level of safety stock is sometimes higher than average and sometimes lower. Safety stock is usually set not to run out of stock before new order arrives. (Slack, Chambers & Johnston 2010, 358)

Safety stock should not be needed, because precise usage quantities should be able to forecast once the master stock schedule has been established. In these cases, demand is not variable. However, exceptions like bottlenecks may occur. In addition, there might be shortages due to late order or longer production time than expected. To maintain smooth operations, safety stocks are used. Problem becomes bigger with complicated items, because a component shortage will prevent manufacture of the final product. (Stevenson 2014, 508)

For operations that are able to vary, extent of the variability has to be determined. Safety time instead of safety stock can be used when lead times are variable. In order to use safety time, scheduling of arrivals needs to be enough ahead of the time so that production or deliveries don't have to wait for those items. If needed quantities vary a lot, some safety stock may be an option. Cost of extra stock have to be then carefully weighted. (Stevenson 2014, 508)

It is important to make sure that lead times are precise, especially with item arriving shortly before their use. On-hand inventory and carrying costs are increased from early arrives, but all following operations are delayed from late arrivals. If safety stock is decided to use, for designated components, planned-order release amounts can be increased by the safety stock quantities. (Stevenson 2014, 508-509)

5.4 Suppliers

Choice of good suppliers should be done carefully. Decision is rarely self-evident, because suppliers aren't clearly superior against their competitors. Many times organizations use some kind of supplier scoring procedure with different factors with short-term and longer-term ability to supply. When choosing a supplier, all these factors should be considered. (Slack, Chambers & Johnston 2010, 379)

Short-term ability to supply: Range of products provided, quality of products, ability to supply in the required quantity responsiveness,

dependability of supply, delivery and volume flexibility and total cost of being supplied. (Slack, Chambers & Johnston 2010, 379)

Longer-term ability to supply: Long-term commitment to supply, potential for innovation, ease of doing business, operations capability, financial capability, willingness to share risk, ability to transfer knowledge as well as products, technical capability and managerial capability. (Slack, Chambers & Johnston 2010, 379)

In purchasing, amount of supplier have to be decided. Whether to source each product from one or several suppliers: single-source or multi-source. Advantages and disadvantages of single- and multi-sourcing: (Slack, Chambers & Johnston 2010, 380)

Advantages:

- Single-sourcing: Potentially better quality, stronger and more durable relationships with better communication, higher confidentiality and commitment, easier cooperation with product development.
- Multi-sourcing: Prices can be driven down with competition, supply source can be easily switch if supply failures, wide sources of knowledge and expertise are available.

(Slack, Chambers & Johnston 2010, 380)

Disadvantages:

- Single-sourcing: If supply failures, organization is more vulnerable to disruption, prices are easier to raise by a supplier if no alternative supplier is available, one supplier is more affected by volume fluctuations.
- Multi-sourcing: Supplier commitment is more difficult to get, communication is more difficult, suppliers don't want to invest in new processes, scale economies are more difficult to obtain.

(Slack, Chambers & Johnston 2010, 380)

6 PRODUCTION

6.1 Production capacity

Organizations may operate below their maximum processing capacity. Reasons for this are usually either insufficient demand completely to fill the capacity or a deliberate policy, where operation can respond quickly to new orders. Sometimes, some parts of the production operate below the capacity while other parts operate at full capacity. In capacity planning, effective capacity of the operation is set to respond to the demands placed upon it. At this point, management should decide, how operations should react to fluctuations in demand. (Slack, Chambers & Johnston 2010, 299)

Besides established long-term capacity, also medium term operation capacity has to be adjusted. This is usually done with demand forecasts for next two to eight months, for time period in which planned output can vary. However, forecasts are seldom that accurate and many operations have to know the changes in demand on a shorter timescale. (Slack, Chambers & Johnston 2010, 300)

Capacity decisions are among the most important of all the design decisions in the companies:

1. Capacity decisions impact to meet future demands for products: possible output rate depends of capacity.
2. Operating costs are depending of capacity decisions. Ideally, capacity and demand requirements match with each other and operating costs decrease. Many times this doesn't happen, because actual demand either differs from expected demand or varies. Decisions made are usually made in order to balance the costs of over and under capacity.
3. Capacity determinants initial costs. Productive units with bigger capacity have bigger costs. However, unit price is usually smaller with larger units.

4. Capacity decisions cause long-term commitment of resources. It can be very difficult to change those decisions without creating major costs.
5. Good capacity affects to delivery speed. This can be a competitive advantage, because it serves a barrier to other companies to entry.
6. With appropriate capacity, management is easier.
7. Importance and complexity of capacity decisions has increased by globalization. Far-flung supply chains add uncertainty to capacity.
8. Financial and other resources needs to be considered well in advance for capacity decisions. (Stevenson 2014, 187)

There are at least eight determinants, which have an influence on capacity: facilities, product factors, process factors, human factors, policy factors, operational factors, supply chain factors and external factors. (Stevenson 2014, 190-191)

The design of facilities is very important. Size and layout of the work area need to be well designed in order to work effectively. Heating, lighting and ventilation has to be well executed. Energy sources and provision for expansion needs to be considered in design. Location of the factory impacts on transportation costs, distance to market and labor supply. (Stevenson 2014, 190-191)

When items in production are similar, the ability of the system to produce them is usually much higher than with ununiformed items. Product design can have a significant influence on capacity if items, methods and materials can be standardized. (Stevenson 2014, 190-191) It is a common practice to use same components across the product range (Slack, Chambers & Johnston 2010, 124).

In a process, quantity of items is an obvious determinant of capacity, but also the process factors has to be set right for good output quality. If the quality does not meet standards, items have to be inspected and possible reworked. Productivity and capacity decrease. Process improvements

increase quality and productivity increases capacity. (Stevenson 2014, 190-191)

Human factors both with employees and with management affect on capacity. With employees, the variety of activities involved in their job, skills, experience and training have an impact on the output. Employee motivation has a linear relationship to capacity. When basic issues are in order, capacity is higher. Management can increase capacity by allowing or not allowing overtime or second shifts. These decisions can affect also to employees. (Stevenson 2014, 190-191)

In operations, many factors have an influence on capacity. Scheduling problems may occur with different equipment capabilities or job requirements. Inventory decisions, purchase requirements, late deliveries and quality inspection procedures also affect on capacity. Capacity can experience a total bottleneck, if inventory is short of even one component of an assembled item. (Stevenson 2014, 190-191)

If capacity is changing, supply chain factors have to be taken into account in capacity planning. This change has an influence on suppliers, distributors, transportation and warehousing. If capacity increases, these elements in the supply chain needs to be handled. Also, if capacity decreases, loss of business affects to the supply chain. (Stevenson 2014, 190-191)

External factors like product and performance standards can restrict capacity increasing. In addition, pollution standards on products and paperwork required by government regulatory agencies often reduce effective capacity by engaging employees in nonproductive activities. (Stevenson 2014, 190-191)

6.2 Batch process

Batch process is used in specialty products manufacturing when continues process is not possible because of lower production volumes. In batch

process, several products are manufactured in wanted order with same production equipment. Usually these products has something in common, for example same raw materials are used in many of these products. (Smith 2014, 4)

Batches should be produced in optimum time to maximize the capacity utilization of the facility (Barker & Rawtani 2005, 48). In batch process, cost estimation is routine and cost per unit moderate. Fixed and variable costs are moderate. Equipment used in batch process are for general purpose, they need to work with all produced batches. Sometimes scheduling can be complex. It depends on products and equipment available. Work-in-process inventory is high with batch process. (Stevenson 2014, 241)

6.3 Production planning and scheduling

Production planning and scheduling is conducted to ensure production of batches in planned time schedule. Market demand is taken care with timely batch production and deliveries. Production planning and scheduling contains decisions about products and quantities to be manufactured, production sites where the manufacturing is to be carried out, sequencing and timing of operations and determining the raw material and equipment availability (Stevenson 2014, 692, 700). Bottleneck recourses are taken into account in planning. In addition, equipment has limitations and these affect on the schedule. Production scheduling is responsible to set the sequence, quantity and quality right. (Barker & Rawtani 2005, 50, 95) Setup cost between orders have to be properly considered. Setup costs depend on process schedule; similar products require less setup between orders. (Stevenson 2014, 692, 700) Scheduling decisions made are usually based on medium- and long-term production planning and schedule is made regularly: monthly, weekly or daily. (Barker & Rawtani 2005, 50, 95)

Due date (DD): Work is sequenced according to when it is 'due' for delivery, not according to the size or the importance of a customer. Operation delivery reliability and average delivery speed are usually improved by due date sequencing, but optimal productivity is not achieved. Efficient sequencing of work probably reduces better total costs. Due date work sequencing can be flexible when new, urgent work has to be done. (Slack, Chambers & Johnston 2010, 281)

Volume of system output defines the scheduling of production. High-volume systems require different approaches than low-volume systems. Besides these two approaches, project scheduling requires different approaches. (Stevenson 2014, 690)

High-volume systems use standardized equipment and activities that provide identical or highly similar operations. The goal is to get a high utilization of equipment and labor. (Stevenson 2014, 690)

Low-volume systems differ quite a lot from high-volume systems; products are made to order. Products usually differ from each other in terms of raw materials, processing requirements and time. In process scheduling two issues have to be considered: workload distribution among workstations and process sequence. (Stevenson 2014, 693) Flexibility of the production facility is more important than efficiency with low-volume systems (Smith 2014, 31).

Intermediate-volume systems are between standardized type of output and made-to-order output. Intermediate-volume systems usually produce standard outputs. In manufacturing processes, products are made for stock rather than for special order, but are not considered continuous production. It is more economical to process intermediate-volume items intermittently. Compared to made-to-order products, batch sizes are larger.

Batch size can be calculated by using the economic batch size model. Minimum-cost batch quantity is called the economic batch quantity (EBQ),

the economic manufacturing quantity (EMQ) or the production order quantity (POQ). Slack, Chambers and Johnston (2010) determines it as follows:

Maximum stock level = M, slope of inventory build-up = P-D

$$\text{Slope of inventory build-up } M + \frac{Q}{P} = \frac{MP}{Q}$$

$$\text{So, } \frac{MP}{Q} = P - D \Rightarrow M = \frac{Q(P - D)}{P}$$

$$\text{Average inventory level} = \frac{M}{2} = \frac{Q(P - D)}{2P}$$

Total cost = holding cost + order cost

$$C_t = \frac{C_h Q(P - D)}{2P} + \frac{C_0 D}{Q}$$

$$\frac{dC_t}{dQ} = \frac{C(P - D)}{2P} - \frac{C_0 D}{Q^2}$$

When equation is zero, Q gives the minimum-cost batch quantity EBQ:

$$EBQ = \sqrt{\frac{2C_0 D}{C_h \left(1 - \left(\frac{D}{P}\right)\right)}}$$

(Slack, Chambers & Johnston 2010, 353)

The batch schedule is provided to process management. Real-time manufacture information goes to the process management and schedules can be updated within a short horizon. Feasible schedule reducing lead times and costs is often difficult to create. Problems in the process industries are usually so complex that general concepts for production planning and scheduling are hard to find. Production information management collects and controls batch production information and

maintains batch histories. This information is used among other things for batch analysis and reporting. (Barker & Rawtani 2005, 95)

The recipe management takes care of general, site and master recipes, where recipes are created, stored and maintained. Master recipes are made to be available for process management, which uses the master recipe to create control recipe. (Barker & Rawtani 2005, 95)

6.4 Production costs

Inventory valuation has high direct and indirect effects on cash flows. Use of company's resources are represented many times wrong, because costs are distributed into simplistic measures. Accurate costs for individual products cannot be determined, which leads to misguided decisions about product pricing, product sourcing and product mix. If total demand is higher than production capacity and product costs are not calculated right, it might be that product mix is not beneficial. Because of incorrect product costs, unprofitable products might be produced. Business performance can be clearly improved by carefully choosing right product costing system. (Suviolahti 2009, 7; Johnson & Kaplan 1991, 2; Reinstein & Bayou 1997; Lea & Fredendall 2002)

Product costing and inventory valuation depend on each other. Changes in product costing affects on the changes in inventory valuation: If product costs increase, inventory value decreases and on the contrary. Because of this dependency, also inventory valuation has to be covered, when talking about product costs. (Suviolahti 2009, 8)

There are a number of methods to calculate production costs, each with their own benefits and drawbacks. Costing methods calculate product costs differently and are suitable in different situations. To recognize the best costing method, different aspects of product costing are important to understand. The goal with product costing methods is to set the costs as near as possible to real costs, but this is rarely possible due to lack of data. (LillyWorks 2018; Suviolahti 2009, 18)

There are different production costing approaches like direct costing, job costing, standard costing, target costing, process costing, activity based costing (ABC) and theory of constraints accounting (TOC). (LillyWorks 2018; Suviolahti 2009, 21)

Direct costing only uses variable costs to make decisions. Fixed costs are not considered. Direct costing has been used to short-term pricing decisions. The advantage with direct costing is that it helps achieving quite accurate minimum price that is required in selling incremental units of a product. It is not good to use for long-term decision, because it does not include all costs that may apply in longer-term. For long-term pricing, overhead costs have to be handled. (Bragg 2017; LillyWorks 2018)

Job costing (make-to-order) keeps an account of direct and indirect costs: materials, labor and overhead accumulating them to a production process. Direct costs are easy to calculate for a product. Accurate pricing and desired profit margin for the product are easy to calculate, if organization has good control on their variable and overhead costs. To find an accurate costing for a product, many transaction level activities are required to track all the different costs continually related to the process. (LillyWorks 2018; Business dictionary 2018)

In standard costing method, “standard” rates for materials and labor that are used to produce a single unit, have to be determined. Organization can produce products to a set of standards and when actual rates or duration varies, they can be monitored and compared by analyzing variances recorded at the production level. With standard costing, it takes time and expense to set and maintain standards assigned to production activities and when they are implemented, standards already becomes obsolete. The biggest problem with standard costing is how to determine that standard. (LillyWorks 2018)

Target costing attempts to predict future price points, product costs and margins for a new product. If a product cannot be manufactured with this price estimation, project can be stopped. Target costing can be used to

monitor products from the design phase to product life cycles. This costing method requires management and employees to keep track of future trends. It makes target costing more costly to be developed and it can extend a product development cycle time. (Bragg 2017; LillyWorks 2018)

Activity-based costing (ABC) (Kaplan & Bruns 1987) method identifies activities that form overhead costs and charges each product for the quantity of each activity it consumed. ABC evaluates the profitability of the company's product lines and customer base by providing more accurate information of product costs (Kee & Schmidt 2000). ABC can help to clarify which products are profitable and which are not, and to identify areas where process improvement could improve products. To determine proper allocations, it is quite difficult to obtain accurate information from that (Hundal 1997). ABC requires detailed activity analysis and it needs significant changes in cost accounting systems. (Suviolahti 2009, 21-22; LillyWorks 2018)

Theory of constraints (TOC) (Cox & Goldratt 2016) states that organizations have a constraint or bottleneck that prevent them from achieving their goals. Additional throughput cannot be generated if the capacity of the constraint is not increased. In TOC accounting, bottlenecks are efficiently organized to improve company's performance, because use of constraints are taken into account in TOC when forming product costs (Kee & Schmidt 2000). With TOC accounting revenue increases because of higher volume of production and cost per unit decreases by maximizing efficiency of the bottleneck. In this system, product structure is ignored and support function costs are not allocated in products. (Suviolahti 2009, 21-22; Bragg 2017)

Costing method choice is a cost-benefit relationship decision and there is no single method recommended to be used in all situations. The choice of method depends on overall situation. (Kee & Schmidt 2000) Companies that produce only few products or make-to-order products, job costing or direct costing could be a right choice. Prior cost information is updated

quite often and they are able to use current costs. In addition, historical costs should be quite accurate. Companies with wider product assortment or mass production with similar products, achieving direct cost association to a specific product can be very difficult. For these companies standard costing or ABC would be recommended. (LillyWorks 2018)

7 PRODUCT QUALITY

High quality is very important thing in a process and operations. Figure 2 shows how quality improvements affect on operations performance. Costs decrease by improved efficiencies, productivity and the use of capital. At the same time, revenues can be increased by better sales and prices in the market. Operation has to be sure it offers its customers, internal and external, good quality. (Slack, Chambers & Johnston 2010, 497)

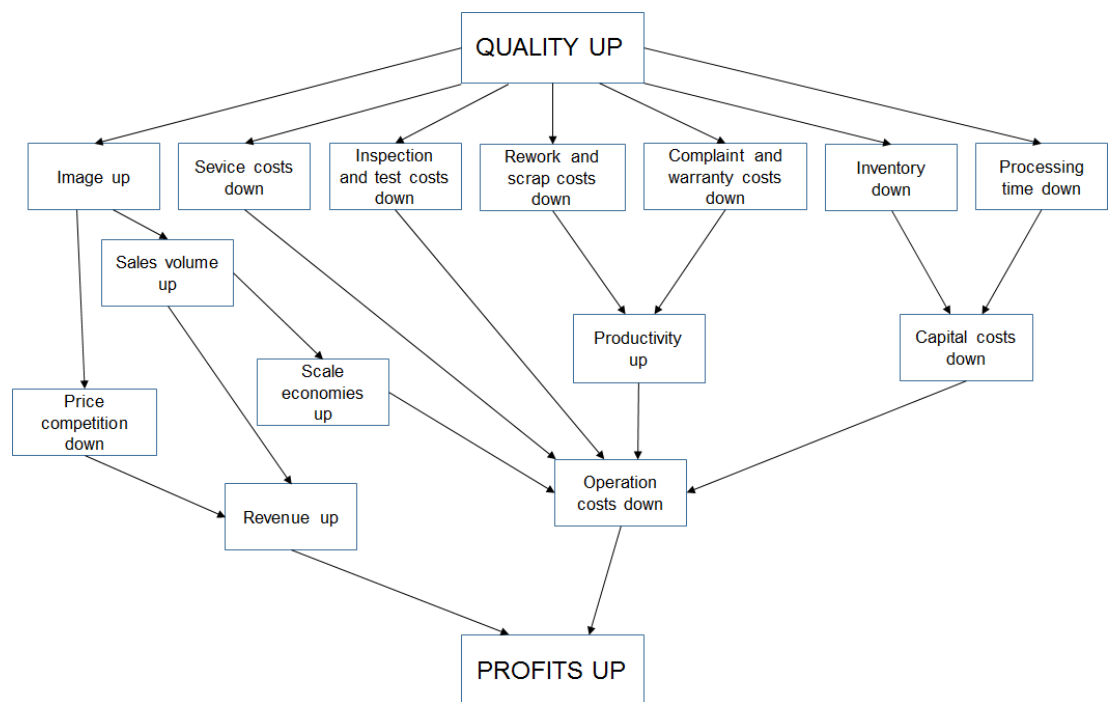


FIGURE 2. Importance of quality in operations (Slack, Chambers & Johnston 2010, 497)

Quality management requires understanding of various aspects of quality: definition of quality in operational terms, costs and benefits of quality, consequences of poor quality and recognition the need for ethical behavior. Quality measures the performance of a product to meet customer expectations. If performance and expectations are equal, the product expectations have been fulfilled. If the difference is negative, expectations have not been met. With positive difference, product

performance has exceeded customer expectations. Product quality includes different dimensions of quality: performance, conformance, reliability, durability, perceived quality, serviceability and consistency. (Stevenson 2014, 372)

7.1 Costs of quality

Costs associated with quality must take into account when dealing with quality issues. There are three different kind of cost categories with quality: appraisal, prevention and failure costs. Appraisal and prevention costs are investments for achieving good quality. Failure costs (internal and external) relate to poor quality. (Stevenson 2014, 378-379)

Appraisal costs relate to activities uncovering defective products, or to assure that there are none. These include inspection and testing activities. Appraisal costs include the cost of inspectors, labs, test equipment, testing, quality audits and field testing. (Stevenson 2014, 378-379)

Quality management tries to prevent defects to occur. Preventing costs include costs of planning and administration systems, surveillance in design and production phases to decrease the probability of defective occupational skills, quality control procedures, working with dealer and training. (Stevenson 2014, 378-379) Quality control (QC) measurements are made on a sample taken from the process. QC measurements are performed to determine whether the product meets the specifications or to provide data on which the process operators can make decisions during the manufacture process. (Smith 2014, 31)

Failure costs are caused from bad raw materials, defective parts or products. Internal failures are discovered during the production process and external failures after the delivery to the customer. Internal failures can be conducted from defective material from supplier, wrong material handling procedures, faulty equipment or incorrect equipment settings, incorrect methods or processing and carelessness. Internal failure costs include lost production time, investigation costs, possible equipment

damage, rework and possible employee injuries. Rework costs include the additional resources for the rework and employee salaries. In addition, disruption of schedules, the added costs of parts and raw materials in inventory waiting for reworked parts, inspection of reworked parts and the paperwork needed are also causing costs. (Stevenson 2014, 378-379)

External failures are not detected during production. Compared to internal failure costs, external failure costs are usually much higher on a per-unit basis. External costs include handling of claims, warranty work, compensation or discount to customer, possible litigation, loss of customer goodwill and opportunity costs related to lost sales. (Stevenson 2014, 378-379)

7.2 Quality improvement

Quality improvement requires time and resources to make organizational changes. Quality management implementation requires a fundamental change in business management: Organizations are managed as systems where employees should focus on customers and on effective management techniques (Yeung, Cheng & Lai 2006, 156-170). After this has happened, employees are empowered, customer needs and expectations are concentrated and every department of the organization is ready for continual improvement (CI). (Lai & Cheng 2009, 116-117)

In quality improvement, these elements can be used as general guidelines in organizational actions:

1. Customer focus: It is important to stay close to customers and listen to their voice. Customer satisfaction can be improved with quality efforts with reasonable cost.
2. Continual improvement: A commitment is needed for all CI efforts where small and manageable improvements of processes are pursued continuously and persistently with focus both on process and on results. Improvements can be done by benchmarking and

adopting best practices. As a result, organizations may have to revise their strategic plans or processes.

3. **Prevention focus:** Poor quality in products can be prevented with quality improvement. Organizations with lack of process and inventory control will have poor quality. Returns for delivering quality products to customers against the costs should be done. Quality costs include warranties, waste, re-work, repair, return, problem prevention and monitoring.
4. **Employee involvement:** To make quality improvement successful, responsibility of that should be shared with every employee and they should believe in the improvement. To get employees to be involved, quality improvement efforts should be part of reward systems. It is essential to become aware that behavioral changes are needed in quality improvement. To get employees involved, training, team building and other work-life improvements need to be provided to them.
5. **Management commitment:** Besides employees, management should be committed to make quality improvement. To make quality improvement, management should fully understand the extent and nature of the fundamental changes required. In addition, individual efforts of employees should be recognized in management.
6. **Fact-based decision-making:** Basis for improvements are measurement based on reliable information, data and analysis, not on opinions. It is important to determine customer behavior. (Lai & Cheng 2009, 116-117)

8 PROCESS PERFORMANCE

8.1 Business process management

Process performance indicates how well process meets requirements of a product. Process performance can be related to productivity (time, money, flexibility) or satisfaction. Process performance can be measured for example with working hours / amount of products, turn over, profit or customer satisfaction. By reducing process throughout time and improving cost efficiency, productivity can be increased. (Kuusisto 2017)

With business process management (BPM), process is controlled to ensure a proper outcome (Mendelssohn 2015). BPM increases profitability by modeling, automating, managing and optimizing business processes. Usually focus is on improving internal organizational processes like project management, better communication and sufficient training (Karimi, Somers & Bhattacharjee 2007; Ram & Corkindale 2014; Trkman 2010). These factors focus on measurement and control in BPM-system. However, improvement of internal processes doesn't necessary mean that customer sees the improvement. (Trkman, Mertens, Viaene & Gemmel 2015)

In the eyes of customers, BPM improves service, offers transparent supplier and consistent repeatability. Inside the company BPM improves communication between functions, optimizes value chain and gives better customer focus. Operations can eliminate bottlenecks and productivity can be increased. For employees BPM gives more empowerment to manage cross-functional processes and better understanding of one's own role in process. (Kuusisto 2017)

There are five BPM issues for companies to improve their processes:

1. Identification of critical processes
2. Customer requirements validation
3. Process documentation
4. Development of process measurements

5. Management and improvement of their processes.

(Mendelssohn 2015)

Improvement and development of processes can provide breakthrough results and increased capacity. Company can meet customer requirements and achieve desired future state. (Mendelssohn 2015)

Customer requirements are very important. Also, customer feedback is important to receive in order to meet those requirements. Most processes are cross-functional. Suppliers must understand customer requirements, and customers must provide feedback to suppliers. (Mendelssohn 2015)

Process usually acts on many levels. An activity at one level is a process for lower level. Usually, process includes from five to eight activities, but lower levels might have more actions. On these different levels, someone owns the process. Process owner has process details to follow: Process tells what to do and work instructions how to do it. If some activity in the process doesn't work, customers may not get what they have ordered. (Mendelssohn 2015)

It is important for a company to identify critical processes. Usually these processes are core operational processes of delivering a product or a service to an external customer. If critical processes are not identified, customer expectations are not met. Finally, all critical processes have to be identified. Evaluation of process criticality can be done by evaluate how satisfied customers are and how organizational goals have been achieved. (Mendelssohn 2015)

In customer requirements validation two kind of customers have to be taken into consideration: external and internal customers. It is important to understand whole customer chain. In order to have good process performance, internal customers and their requirements have to be also considered. Customer requirements have to be reviewed with customers in order to be certain that they are specific and measurable and can be conducted in a reasonable period. Both for internal and external

customers, same criteria applies in validating requirements. (Mendelssohn 2015) Customer needs are increasingly different for each customer and therefore it is essential to understand them. Internal processes should be tailored to those needs, but many times BPM efforts can be too inadequate to meet customer expectations. (Homburg, Wieseke & Bornemann 2009; Trkman, Mertens, Viaene & Gemmel 2015; Rampersad 2003, 126)

Work processes have to be documented. Documentation makes them visible. All stages to achieve the final product must be written. Besides the flow of activities, also for example systems, people, information, materials, tools and equipment have to be considered to make different steps in the process to work. (Mendelssohn 2015)

Process stability has to be first gained. Then capacity issues can be addressed. Visual data (line graphs, bar charts, histograms and control charts) gives clearer understanding of what is happening in the process. Relationship between process indicators and the result indicators have to be understood in order to have good process control. (Mendelssohn 2015)

8.2 Productivity

Many factors affect on productivity:

1. Reducing variability by standardizing processes and procedures can improve both productivity and quality.
2. Productivity measurements can be distorted by quality differences.
3. Uncleaness and need of searching items waste time and decreases productivity.
4. Waste affects on productivity. Resources are in inefficient use.
5. Productivity of new employee is usually lower than seasoned employee´s. Productivity of growing company may be laged.
6. Accidents can lower productivity. Safety issues should be considered.

7. Productivity is affected by layoffs. Effect can be variable.
Productivity can increase after a layoff; fewer workers do the workload, which stayed the same. However, they have to work harder and longer to do it.
 8. Labor changes decrease productivity. New employee needs time to learn and become productive.
 9. Good workspace design can increase productivity.
 10. Productivity rewarding plans can boost productivity.
 11. Network viruses can lower productivity.
- (Stevenson 2014, 61)

Productivity can be improved in many ways:

1. Operations can be controlled by measuring them. Productivity measurements need to be developed.
 2. Critical operations need to be found. Overall productivity is important. Value of potential productivity improvements have to be estimated before execution.
 3. Methods to develop productivity improvements need to be invented. Ideas can come from employees or by examining other companies and learning from them.
 4. To gain results, reasonable goals have to be set for improvement.
 5. Management has to support productivity improvements.
 6. Improvements need to be measured and analyzed.
- (Stevenson 2014, 61-62)

8.3 Performance measurement

Process output is the result from process actions. If process doesn't meet customer requirements, activities may be right, but some parts might cause problems. Process performance can be understood by measuring it. When processes are measured, success and failure can be seen. Success can be rewarded and learned from. When failure is recognized, correcting actions and improvement can be done. (Lai & Cheng 2009, 155-157;

Mendelssohn 2015) Measurements are made based on issues that are important to the customer, not based on what are easy to measure.

Process indicator represents process owner's view and are used to show whether process is stabilized. They also alarm from unwanted outcomes that could affect on results. Process is incapable of achieving wanted results, if indicators show that targets are not met even that data shows that process is stable. Root causes of the problem have to be found and improvements to the process identified. (Mendelssohn 2015)

Key performance indicator (KPI) is a performance measure that can be used in evaluating critical actions and in progress towards long-term organizational goals. KPIs can be used where immediate improvements are needed. KPI tells how far organization is from its goals, sub-goals, strategies and priorities. When this difference is understood, organization can optimize areas by eliminating unnecessary tasks in the processes, allocating resources or changing processes. Goals can be based on executive expectations, customer needs or results from benchmark studies. Key performance meters and goals give timely signals to management. (Raynus 2011,126-127; Rampersad 2003, 94, 122-123)

Performance measurements are divided into individual (tactical), cross-functional (operational) and organizational (strategic) levels. Performance measurement model is shown in figure 3. In order to find essential processes, it is necessary to cut all business processes into sub processes and all the way to operational level. Key performance meter is a point related to critical success factor and strategic objective, which can be used to evaluate process activity. (Rampersad 2003, 94,122-123)

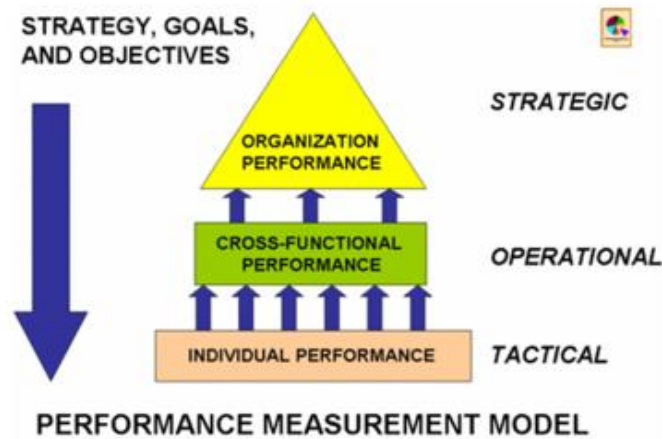


FIGURE 3. Performance measurement model (APQC 2003)

There are three major types of KPIs:

1. Success KPIs determine whether goals are achieved.
2. Progress KPIs monitor the progress and execution of defined tasks.
3. Analysis KPIs analyzes the results from the task.

(Raynus 2011, 127)

These three types of KPIs are divided into several types of KPIs:

1. Process KPIs measure the efficiency of productivity.
2. Input KPIs measure assets and resources invested into the process.
3. Output KPIs measure results and reveal success or loss after an investment is made.
4. Specific KPIs help in answering questions for specific objectives and goals set at the beginning.
5. Measurable KPIs help in tracking the progress. When deviations are found, corrective actions can be made.
6. Achievable KPIs are possible to carry out. Objectives should not be too far in the future.
7. Action oriented KPIs are defined in order to accomplish a goal.
8. Time-bound KPIs have deadline to achieve the goal. Time frames create rush and provokes action.

(Raynus 2011, 127-128)

This performance measurement model needs top down commitment, bottom up support, strategic focus and change tolerance from management. Improvements increase efficiency, eliminate duplication and reduce costs. (Kuusisto 2017)

8.4 Employee involvement

Employees from different departments are customers and suppliers to each other (Rampersad 2003, 126). Employees are the core of an organization capability. They provide the intellect, ability and empathy that are required to reduce waste and improve processes. Employee resistance in process development may cause the improvement to fail. There also has to be a process for employee training, motivation and caring in order to help people to achieve process goals. (Lai & Cheng 2009, 137-138)

Management practices where employees are involved, have to be put to use. Employees are encouraged and they are given a critical role in making operational decisions, planning, prioritizing, making improvements, setting goals and targets and observing performance. Employees, who are involved in the process development, must be aware of the processes of change that are taking place internally in the company. Unchanged management and employee behavior can become a barrier to improvement in the implementation process. Besides identifying improvement opportunities, management and reward systems should also be changed in order to encourage behavioral changes towards achieving organizational goals. As process implementation increases, employees are able to identify problems and suggest solutions that improve organizational performance. (Lai & Cheng 2009, 137-138)

9 COMPANY X

9.1 Company introduction

Company X is a manufacturing company producing items for industrial purposes. Company X is partly owned by one worldwide company Y. Company X sells products in Finland and in Eastern Europe. Share of export is about 40 %. Introduction of Company X is in appendix 1.

Table 1 (appendix 2) shows Company X's financial information from last five years. Business has stayed quite the same during this time.

Depression and raw material price changes can be seen in the results.

Last year number of employees increased. By this way, company prepares for the future.

Figure 4 (appendix 3) shows monthly sales from last year (2017). In Company X's business area, sales are not stable around the year.

Company X has always been a fast supplier to their customers. Large inventory has been the base for this. Company X is trying to expand and become more international company. In order to grow, product assortment has to be compact and internal profitability has to be good. To expand, company needs to be able to invest the assets elsewhere than in a large inventory. However, good customer service and reliability with deliveries has to be maintained.

9.2 Product assortment

Company X is selling over 120 different products. Majority is Company X's own products, but there are almost as much Company Y's products in the product assortment. Part of Company Y products Company X orders from Company Y, but the rest, Company X manufactures under license. In addition, there are small amounts of products outside the company that Company X sells. One of Company X's transaction is to manufacture items for one abroad company.

Company X has products in four different main groups. Besides these groups, there are some special systems available. In two largest product groups, there are components A and B for each product.

From each product, there are at least three different colors and from these different colors two different packaging sizes available. As a summary, depth of one product is at least six different items. With two component products, component B is also in several packaging sizes.

Figures 5-12 show the sales numbers for each product in different product groups sold last year (appendix 4). It can be seen, that almost every figure is exponential and that there are couple of products bringing most of the sales in that product group. Like Pareto analysis rule, 80 % of sales comes from 20 % of products. (Investopedia: Pareto Analysis 2018)

From different product groups, group one products are the biggest group sold. Second is group two with biggest product in the company. Compared to these groups other products are clearly smaller. Scale in all figures is same in order to notice this difference.

At the moment there are many duplications in the product assortment, but it is difficult to stop any products because of fear of losing customers. When stopping products, product system has to be thought through completely. Different products are related to each other and the company is selling product systems instead of separate products.

All products were discussed about with sales managers. Purpose of these discussions was to reduce the product assortment and make it more compact. Sales figures from last year were gone through in order to see and realize how large or small different products are in the assortment. In addition, future projects were gone through in order to know which products have to be in the assortment. After several meetings and strategic discussion, products were divided into four different categories:

1. Stock product
2. Order product with no stock

3. Stopped product after remained items have been sold
4. Stopped product

Until now, Company X had all products in the warehouse, but now, some products from category 1 were shifted to category 2: order product with no stock. Products transferred to this category were products that are mainly sold to the projects, which are planned well beforehand. Many products with small selling quantities or short self life were also transferred to this category.

Some products were decided to stop (3: stopped products after remained items have been sold). However, items left in the warehouse need to be sold first. This can take quite a long time. In Company X's ERP-system, there were still some old product codes left (4: stopped products). These codes were removed from the program.

When all products and depth of them were gone through, Company X had 1329 different selling items. Different categories and number of items in them are shown in table 2.

TABLE 2. Product categories and number of items in Company X

| | | |
|---|---|-----|
| 1 | Stock product | 586 |
| 2 | Order product with no stock | 233 |
| 3 | Stopped product after remained items have been sold | 76 |
| 4 | Stopped products | 434 |

9.3 Raw materials

To produce Company X products, five different kinds of raw materials are needed. Usually one product contains from 10 to 15 different raw materials. Number of raw materials in these five different groups are presented in table 3 (appendix 5).

Raw materials were discussed about with QC-, purchasing and production managers. Like with finished products, raw materials in each group were divided into different categories. In this case, there were five different

categories: products, which are continuing same way, needing changes, going to be stopped, stopped now and previously stopped. Table 4 represents number of raw materials in these five categories (appendix 5).

From these five categories, products needing changes and products will be stopped caused actions. Products continuing same way didn't cause any extensive actions now, but they need to be checked later. Products in this category had fast enough inventory turnover. Products stopped now were raw materials, which were not in the stock anymore and the codes could be removed from the ERP-system. This was made to clean the system. Products previously stopped were just listed for an information.

First step with raw materials was to go through the products, which will be stopped. In this category, there were products, which had already been obsolescence. Because of that, they were not able to be used, but had to be disposed. Part of the raw materials in this category were still good and they were tried to be used in some finished item or sell. Some products were going to be replaced with something else and the rest of the inventory needs to be used.

Actions needed with category 2: products needing changes, were related to inventory turnover. This category is discussed in the next chapter.

10 INVENTORY IN COMPANY X

10.1 Inventory functions

Company X has three different main inventories: Raw materials, work-in-process (WIP) and finished products. Being a production company, inventory of raw materials and finished products is large. It is the biggest investment in the company.

One reason for large inventory is the willingness to serve customers. This has been possible, because financial situation of the company is very good. Company X has always been able to deliver products at the same day. Inventory has been large with raw materials and both with products produced in Company X and with products bought from elsewhere.

At wintertime, sales are smaller than in summertime. Inventory becomes bigger then because of smaller sales figures, but also because of the preparation for summertime. With broad projects, raw materials are ordered earlier and production has been started beforehand. Also, if there is going to be a maintenance break in production, products are manufactured beforehand in order to protect sales operations. Sometimes larger amounts of raw materials has been bought because of delivery problems and by this way avoid production breaks.

Sometimes raw materials and even finished goods have to be bought in large amounts. Sometimes it brings purchase discounts, but sometimes it is done because of bad availability. In some cases, raw materials are bought in larger amounts to avoid future price increases.

10.2 Inventory valuation method

In Company X, inventory value has been calculated with weighted average cost method. Inventory is valued by using the amount and price of older inventory and the purchase or manufacture price and the amount of new

purchase lot or production batch. Earlier weighted average costs calculated are included in the latest one.

Company X inventory uses FIFO-method in order to avoid items getting old. Scope has been to sell those items first, which have been purchased or manufactured first. However, this has been difficult, because batch tracking hasn't been in use. Tracking has been made by hand. Risk of items getting old has been very high.

10.3 Inventory turnover

Company X wants to serve customers well and that requires large inventory. In Company X, inventory turnover has not been very effective. Some reasons for long turnover in days were already mentioned in previous chapter: seasonal build and bigger purchasing amounts because of discounts or bad availability and price increases in the future.

Beside these issues, there have been also other reasons for high turnover in days: smaller sales than expected, too big production quantities and purchasing lots. Inventory amounts have not been in line with demand. Because of these issues, there were many items in the inventory, which had obsolescenced.

To decrease the inventory turnover in days, obsolescenced inventory was disposed. There were both raw materials and finished products disposed. This caused expenses, but it brought more space into the warehouse. After this operation, inventory amounts of all finished goods and raw materials were gone through in order to avoid product obsolescence happening again in this scale and to decrease the inventory turnover in days.

10.3.1 Finished products

At the same time when Company X's finished products were divided into four different categories: stock product, order product with no stock,

stopped product after remained items have been sold and stopped products, information shown in table 5 was collected from each deliverable item.

TABLE 5. Finished product information

| | |
|------|------------------------------------|
| 1. | Type |
| 1.1. | Company X product manufactured |
| 1.2. | Company Y product manufactured |
| 1.3. | Compant Y product purchased |
| 1.4. | Subcontract product manufactured |
| 1.5. | Product purchased |
| 2. | Items sold in last 12 months |
| 3. | Items produced in last 12 months |
| 4. | Items purchased in last 12 months |
| 5. | Inventory turnover in days |
| 6. | Minimum stock (items) |
| 7. | Manufacture / purchase lot (items) |
| 8. | Stock up to (items) |

First, products were divided into five different groups according to company brand and manufacture place. In addition, sales quantities from last 12 months were collected here. According to the product type, production or purchase amounts were compared to sales quantities. Inventory turnover in days was used as a guide in determining new inventory levels. Products, which had high turnover in days, had very low sales quantities and bigger production or purchase amounts. Figures of turnovers are not shown here, because of the amount of the deliverable items. Turnovers varied from couple of days to thousands of days.

Determination of minimum stock, manufacture / purchase lot and stock up to -levels were done to products in category 1: stock product. Amounts

were determined from inventory perspective: How much stock is needed to serve customers fast enough.

In many cases, manufacture quantity is calculated with economical batch size model and purchase quantity with economical order quantity model. However, in Company X business area, sales volumes are not constant around the year. This is why minimum stock, manufacture / purchase lot and stock up to levels were determined with very simple and empirical way.

Minimum stock was determined according to the largest order amount of an item. Stock up to level was determined according to the inventory turnover and sales quantity from last 12 months. Scope was to determine stock up to level in that way that inventory would be replaced eight or nine times a year. Manufacture and purchase lot can be different each time, because minimum stock level alarms the ordering. If stock is smaller than minimum stock, purchasing lot is going to be larger in order to reach the stock up to level. However, in case of manufacture lot, this is not going to be executed that precisely. Manufacture lots are quite fixed.

In determination of manufacture / purchasing lot and stock up to, amount of items on a pallet had to be taken into account. It is more economical to order full pallets instead of half when freight cost is standard. Also, it's more economical to store full pallets.

10.3.2 Raw materials

With raw materials, purchasing amounts are quite fixed. Size of purchasing lots affects a lot to inventory turnover. Shelf lifes of raw materials vary quite a lot (appendix 6). They need to be considered in inventory quantities.

Inventory turnover and stock levels needed to be checked for raw materials in categories products, which need changes and for raw materials, which are continuing same way. From these categories, raw

materials needing changes were more important, but also the other group was checked. These raw materials might have problems with too fast inventory turnover, which could cause bottlenecks into to the production.

In the category products, which need changes, obsolete raw materials needed to be disposed and replaced with fresh ones. Some cases small amounts of new raw materials were ordered, but in some cases, no replacing raw material was bought. Main part of this group were products, which had too large inventory and slow turnover.

Information shown in table 6 related to inventory was collected from raw materials in these two categories. In order to determine new stock levels, annual consumption, packaging sizes and shelf lifes of these raw materials needed to be solved.

Table 6. Raw material information

| | |
|----|----------------------------|
| 1. | Annual consumption (kg) |
| 2. | Packaging sizes |
| 3. | Shelf life |
| 4. | Inventory turnover in days |
| 5. | Minimum stock (kg) |
| 6. | Purchase lot (kg) |
| 7. | Stock up to (kg) |

Figures 13-17 present annual consumption and turnover in days of each raw material used in Company X in five main groups (appendix 7). It can be seen from every figure that there are few big products used and annual consumption decreases in an exponential way. In many cases turnover in days increases when annual consumption decreases.

Like with finished products, minimum stock, purchase lot and stock up to levels were determined in order to improve inventory turnover. Annual consumption, packaging sizes and shelf lifes of these raw materials were

used as help in this process. With raw materials, it would be good, if inventory would change seven or eight times per year, but in many cases packaging sizes make it impossible. Because of this, inventory turnover in days will be bigger with many raw materials. Products with slower inventory turnover, shelf lifes need to be taken into account.

With raw materials, inventory amounts were not able to be determined as accurately as with finished products, because of these limitations in ordering amounts and packaging sizes.

Because usage of many raw materials is very small, it would good, if some raw materials could be replaced with another, more used raw material and by this way improve inventory turnover. In many cases, this is not that easy, because changes in product formula requires a lot of testing. It is a slow process to go through.

10.4 QR-Code

To make inventory management easier, Company X is starting to use QR-codes in finished products and in raw materials. As a first step, codes have been printed into manufactured items. However, code tracking is not yet in use. Next step is to start putting codes into purchased finished products and raw materials. This means that they need to be relabeled with Company X's own labels.

Batch tracking helps in dispatching of products (FIFO) and in preventing products and raw materials become obsolete. When batch tracking starts, follow-up of finished products and raw materials gets much easier.

11 PRODUCTION IN COMPANY X

11.1 Production equipment

Company X has over 320 different items to manufacture and products are produced in batch process. Information about production equipment is in appendix 8.

11.2 Production capacity and planning

Production capacity in Company X is much higher than production amounts have been during past few years. Because of this, company has been able to produce urgent orders right away. Long-term capacity is not very easy to forecast in Company X's business area. Larger deals are usually in the offing beforehand, but smaller deals are difficult to predict. Customers' projects and scheduling can vary and therefore products and quantities can vary.

Capacity usually depends more from raw material availability than production capacity. There are no maintenance stops in production. Because of batch process, maintenance can be done in apart for different equipment.

At springtime, business grows and production quantities are bigger than in winter. Capacity needs to be planned more closely. Human, equipment and raw material resources needs to be considered.

Process planning and scheduling is dependent from equipment sizes and their use. Long-term capacity is considered in scheduling, but production plan can change many times during workweek. Production schedule can be decided only for couple of days at a time, because there might become urgent orders, which have to be manufactured right away.

Work is sequenced according to due dates. There can occur bottlenecks, which cause difficulties in scheduling. Bottlenecks are usually related to

raw materials or production equipment. On average, first step of production takes about three hours and second part two hours. This means, that with one production equipment, 1.5 batches can be produced in one work shift. Whenever possible, same kind of items are produced after each other in order to avoid unnecessary preparation between batches.

11.3 Batch size optimization

In inventory planning, manufacture lots and stock up to – levels were determined according to the customer need. Next step was to transfer these actions to production. Many products are sold in different packaging sizes, so manufacture lots of all packaging sizes had to be combined into one production batch with right quantity.

However, there are some limitations with batch sizes. It is not possible to fix batch sizes as accurate as lot sizes for purchased items. In addition, raw material packaging sizes had to be considered when determining batch sizes. With full packaging sizes, manufacture is faster.

All 320 recipes for manufactured products were checked and corrections to the batch sizes were made. There were couple of recipes, where batch sizes were enlarged, but most of the cases batch sizes were diminished. These changes were made to recipes in order to improve inventory turnover.

11.4 Production costs

Company X uses standard costing in production. Production costs are same for all products even though some products require much more work than others do. When using standard costing, some products may have incorrect product cost. This means, that it is possible that Company X produces unprofitable products.

It would be good, if production department could use more realistic method in product costing. At this point, it is not possible, or it is not going to be executed, because product costing affects to the product prices and margins. Sales department is not ready for this change, even that it would balance profitability in the company.

If Company X would start to use for example activity based costing, actual cost of each product would become calculated. When actual cost is in the price, effect could probably be seen in sales numbers. Figures in chapter 9.2 present different product groups and their sales quantities in 2017. In all product groups, there are couple of main products, which bring the sales and rest of the products have small sales numbers. In many cases, products with small sales quantities are those, which are most expensive to manufacture. If the actual cost could be added to the product price, sales of those products would decrease more and it would be easier to stop them. This would clarify the product assortment and lack of those products in the warehouse would bring more space and decrease inventory value. Problem is that in some cases, sales would need to find substitution for these stopped products in order not to lose customers.

To change costing method, it would take a lot of time in the beginning to investigate and calculate actual costs of different products. It could be wise to move gradually to activity based costing. There are some clear differences in the first part of manufacture process between different products, which help in product costing. It could be possible to divide products into six different categories and calculate different costs for these different groups. Groups and cost comparisons between different groups are listed in appendix 9. In addition, number of products in these six groups are presented in table 7 in appendix 9.

In addition to first step of production of an item, second part of production affects also to product costing. When an item is packed into small selling size, it takes more time and causes more work than putting it into large packaging size. Packaging in different sizes should also be considered in

product pricing. Total price of an item would be a sum of costs from these two parts. With this method, product costing would become more accurate.

12 PURCHASING IN COMPANY X

In Company X, purchasing department buys both raw materials and finished products. Company Y is a big help in purchasing for Company X.

12.1 Order costs

Purchase of raw materials and finished products causes different kind of costs. Size of an order plays an important role in this. Some raw materials are purchased in large quantities in order to get price discounts. There can be a large price difference per kilogram between one barrel and four barrels. There are always extra costs in small orders. Usually they are related to freight costs.

If inventory runs out of stock because of too small order quantity, it causes costs in failing to supply order to the customer. This has happened very seldom. In these cases, orders have not been that urgent, so they have been supplied later. Batch process is quite flexible, so production schedule has been able to be fixed. Out of stock situations haven't caused that high costs to production and the company. Inventory levels of raw materials and finished products with high inventory turnover were checked because of this risk. Order quantities were increased.

Storage of raw materials and finished products requires space and right kind of temperature. Warehouses need to be heated. When larger lots have to be bought, meaning of storage increases.

With large order quantities, inventory turnover decreases. Usually large amounts have been bought because of price, but sometimes in afraid of running out of stock. Sometimes forecasts from sales can be incorrect. There is a risk that raw materials and finished products bought become obsolete, which has been a problem in Comapany X. Inventory levels have been checked and QR-code system is going to be established, so it should be easier to supervise this in the future.

12.2 Lot size

In Company X's business area, demand is uneven with purchased products and raw materials. Because of that, economical order quantity model cannot be used. After determining new inventory levels, lot sizes have been modified according to them. Reorder point is same as minimum stock level. Minimum stock acts also as a safety stock. Levels are determined in that way that there should be enough material before next order arrives. These situations assume that lead-times are accurate.

Lot sizing of finished products is easier than raw materials. With finished products, only couple of products have restrictions with order amount. With finished products, lot size affects to the amount of pallets in the lot and therefore freight cost per an item. With two component products, it is wise to order same amount both components A and B. With finished products, new inventory levels are quite easy to follow.

With raw materials, purchasing amounts and packaging sizes are quite fixed. Some raw materials are bought in 20 tons lots and some deliveries are from two to twenty tons. Other raw materials are bought usually in 1000-liter containers and 200-liter barrels. Some raw materials can be bought in smaller cans. Packaging sizes bring some challenges to lot sizes with new inventory levels. It is not possible to follow those levels that precise than it is with finished products.

Some times several raw materials are bought from same supplier. In these cases, orders are grouped. It is possible to order smaller amount of one item when pallets still become full and freight cost becomes smaller.

12.3 Suppliers

Company X uses hundreds of different raw materials and amount of suppliers is quite high. For many raw materials, there are more than one supplier to ensure that material is available. In addition, price competition becomes possible with more suppliers. If some supplier fails to supply, it is

easy to change to another supplier. With fewer suppliers, relationship and communication are probably better.

When choosing new suppliers, quality of their products determines their possibilities. Raw materials need to be compatible with the products produced in Company X. In addition, location of supplier has an influence. If they have storage close by, it is always a good thing. If products come far away, lead-times are long and freight costs probably more expensive.

Some suppliers are considered as short-term suppliers and some longer-term suppliers. If something is needed fast or cheap, these short-term suppliers are used. With longer-term suppliers, purchasing is more than just buying products. With them knowledge is shared and doing business is easy. Sometimes good service is more important than the lowest price. Company X has many longer-term suppliers, which are reliable in their actions.

13 QUALITY AND IMPROVEMENT

13.1 Quality management

One important part of improving internal profitability is quality. Company X follows ISO9001-2015 quality system. In this system, process and operations are audited every year and quality of the process is checked.

Company tries to improve quality by improving operation performance. Goal is to decrease costs and improve efficiencies, productivity and use of capital. When quality of the process is improved, inventory turnover will grow and value of stock will decrease. Quality improvement requires time and resources to make organizational changes. Management needs to be committed to that. Employees of Company X are committed to the process and quality improvement with a bonus-system. If company and departments can reach to their aims, extra bonuses are received.

To maintain the quality level, ongoing work needs to be done. If quality is not maintained, there will be costs from poor quality. Even that customers may not see internal quality of the process, when output is quite good, there are failure costs coming from the system. Large product range and long inventory turnover can be seen as quality costs. They are results from defective management and co-operation between different departments in the company. Activities are probably right, but some parts in them cause problems.

13.2 Performance measurements

Performance of the process and products needs to be measured in order to know whether customer expectations are met. Measurements should be done based on reliable data and analysis. If some failures are recognized, correcting actions can be done in order to improve the process.

Company X has started to use key performance indicators to evaluate critical actions in the process and improve the process and internal

profitability. Different departments have their own KPIs to be measured, but when it comes to inventory performance, actions of all departments have an impact on that. Already some results have been analyzed and some changes have been done.

Sales, production, purchasing and QC have their own measurements to execute. These KPIs are set for year 2018. Probably next year there is going to be different key process indicators to be measured. Some goals are quite fast to achieve, but some might take a long time to actualize. Improvement of inventory turnover will take some time. Probably some results can be seen next winter. Most challenging thing in the process is to get it to continue. It is not enough, that some changes and actions are made once. They need to be done continuously.

14 CONCLUSIONS

This thesis was part of the project implemented in Company X, where target was to improve internal profitability of the company. Literature from process management was used as help in the project. Main part of the project was to decrease inventory value. To do this, project concentrated on product assortment and logistics activities: inventories, production and purchasing. If Company X is going to grow, internal process needs to be well organized in order to survive with growing operations.

First part of the project was to decrease and optimize product assortment. Sales numbers from last year were used as help in this part. From sales amounts, it was quite easy to see, which products gave profit and which didn't. As a conclusion from this investigation, some products were stopped and some were changed to be an order product. Some products are going to be stopped in the future, but before that, ongoing projects need to be finished and stocks need to be sold. Amount of stopped products was smaller than expected. More strategic choices needs to be done to optimize the product assortment.

Second part of the project was to determine new stock levels for finished products. Amounts were determined from inventory perspective: How much stock is needed to serve customers fast enough. Earlier there was only minimum stock level, but not maximum level. Those were determined now. Some minimum levels were modified as well. Determination of these two limits meant that lot sizes were set in between of these two figures. With purchased products, lot sizes are quite easy to follow, but with manufactured products, it is not possible to follow them as precise. Second part of the project managed quite well. Results from these new inventory levels are going to be actualized gradually. From now on, stock levels need to be check regularly to meet future demand and to avoid too big inventories.

Third part was to check production quantities. Reasonable batch sizes in view of inventory levels were determined. Production equipment and

product features set some limits to batch sizes, but quite many changes were able to be made. In addition, results from batch size changes will actualize gradually. In addition to changing batch sizes, production cost method would be good to change. By moving towards ABC-system, actual cost of different products would be actualized. This might affect to sales of small products and they would be easier to stop, if margins decrease. This is not possible to execute now, because it would affect quite a lot to product prices.

Last part of the project was to optimize purchasing activities: both finished product and raw material procurement. With finished products, lot sizes were already determined with minimum and maximum stock levels. They were quite easy to start to follow. Also with raw materials, minimum and maximum stock levels and lot sizes needed to be determined. This was done according to yearly consumption. With raw materials, lot sizes could not be determined that accurately because of packaging sizes.

During the project, obsolete products and raw materials were disposed. This clean up improved inventory turnover significantly. However, this is not the right way to make improvements. After old items were disposed, it has to be ensured that there are not going to become old products or raw materials anymore.

Company X starts to use QR-code-system with raw materials and finished products. It should help in inventory and process management. When product batches are listed, raw materials and finished products should not be able to obsolete that easily.

14.1 Project result

Inventory turnover in days has changed during this project. However, it has not changed as much as hoped and there has become increases at times. Figure 18 shows the turnover in days from April 2017 to April 2018. Graph consist both finished products and raw materials (total inventory). In

Company X's business area, inventory is bigger in wintertime than in summertime. This can be seen from the figure. Turnover in days is still very high, even though that level in April 2018 is lower than it was in April 2017. Changes made during the project are going to give results gradually. In the future, there is going to be differences between winter- and summertime in this graph, but the goal is to get the annual average to decrease from last year value.

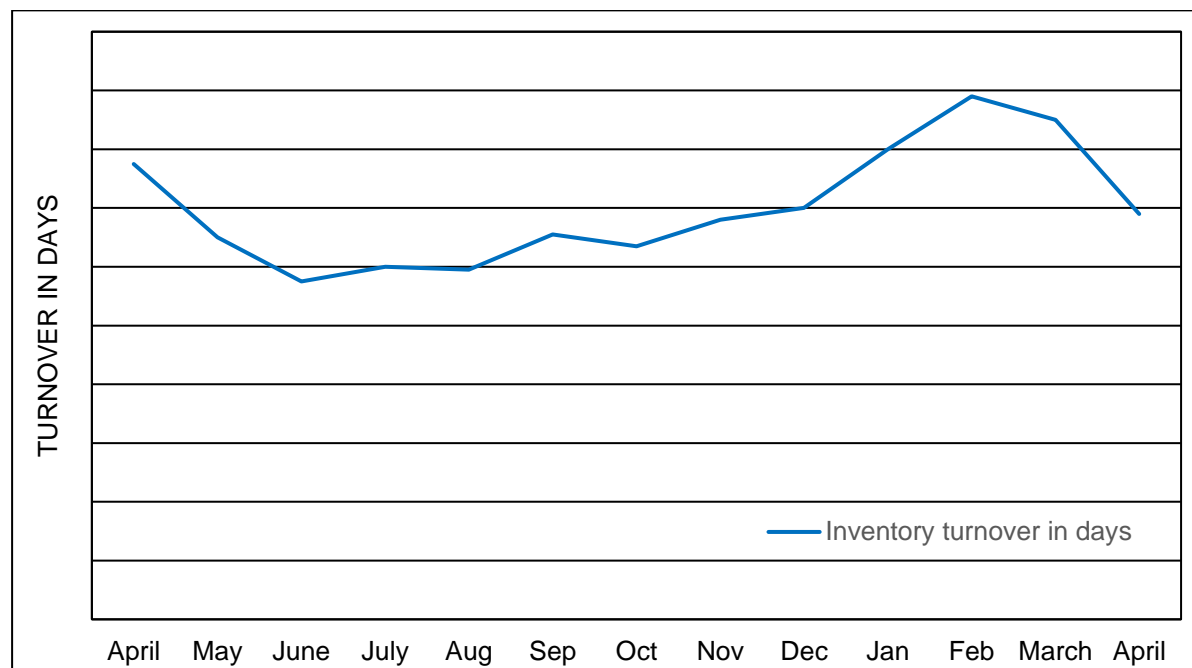


FIGURE 18. Inventory turnover in days from April 2017 to April 2018

Company X has started to use KPIs to measure process performance in order to see whether improvements are taking place. Well-organized process should decrease the value of inventory and increase profitability. Improvement of internal profitability is an ongoing process. It requires commitment from everybody and it never ends. Process and quality management should keep it going.

14.2 Reliability and success of the thesis

Topic of this thesis was very wide. Research was about the whole production process of Company X. Because of that wide research area,

thesis stays quite shallow. Both with theory and project part, more accurate examination would have given better results. It would have been a good idea to limit the thesis topic to be narrower.

After overview made in this thesis, next step with the project in Company X is to concentrate each part of the process more closely. More precise research methods can be used instead of experimental ways then. According to the results from this project and improvements done so far, this thesis has given reliable structure for the project to continue in Company X.

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APPENDICES

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