

# FEASIBILITY STUDY TO IMPROVE THE PRODUCTIVITY OF PRE-ASSEMBLY MAKE-OR-BUY ANALYSIS

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<p>Abstract</p> <p>The objective of the thesis was to clarify the possibilities of improving the productivity of pre-assembly by using an external service provider to deliver complete assemblies to the assigner company. The study was performed for the assembly of driveline units that were assembled in-house. The research included identification of the reserved resources that were compared with the cost estimates quoted from the supplier candidates.</p> <p>The research methods used in this study were quantitative and qualitative. The assembly resource data was collected quantitatively from the ERP and PDM systems of the assigner company. Qualitative methods involved observations conducted at the pre-assembly place and the warehouse facilities. The key persons of different departments were interviewed. A request for quotation regarding the assembly process costs was sent to four supplier candidates.</p> <p>The results showed that the outsourcing of the driveline assembly is not reasonable. The materials management is very complex due to the large number of different assembly unit variants. The current operations model requires high flexibility, since the product specifications are changed at short notice. In addition, the materials management system and the current material structure model do not support the outsourcing. The quotations received from supplier candidates showed that there was no partner available that could perform the assembly process with higher efficiency.</p> <p>The study was assigned by a Finnish manufacturing company. Organizations looking for possibilities to improve their productivity will benefit from the results of the study. The thesis is relevant for different organizations in the field of manufacturing industry.</p>		
Keywords: Productivity, outsourcing, make-or-buy analysis, efficiency, inventory costs, manufacturing costs, cost calculation, materials management, request for quotation		
Miscellaneous: Cost and price data are enclosed in the appendices that are hidden in the published version.		

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## TERMINOLOGY

SKU	Stock Keeping Unit
RFQ	Request for Quotation
BOM	Bill of Materials
ERP	Enterprise Resource Planning
LCC	Low-Cost Countries
AGV	Automated Guided Vehicle
PDM	Product Data Management
MRP	Material Requirements Planning
OEM	Original Equipment Manufacturer

# 1 INTRODUCTION

*“One of the key issues to have emerged in manufacturing strategy has been the growing importance of make-or-buy decision.”*

Humphreys, McIvor and Huang (2002)

In the business world of today organizations are forced to reduce their range of operations and concentrate on the activities that generate the maximum amount of profit. Companies need to evaluate which functions are kept within the organization borders and which are moved to external suppliers in order to increase the productivity and the capability to respond to the fluctuations in demand.

The idea for the topic was found at the purchasing department of the assigner company. There was an urge to clarify if the productivity of the pre-assembly could be improved by moving the assembly work to an external service provider. The objective of the thesis is to give the assigner a justified proposal if it is reasonable to order pre-assemblies as complete units instead of purchasing single components and performing the assembly work in-house.

The study includes definition of the in-house cost structure of the pre-assembly. The cost structure model was created by choosing suitable parameters for the evaluation. The in-house process costs were compared to the cost estimation given by the supplier candidates. A request for quotation was prepared and sent to four supplier candidates in order to get cost estimations for the comparison. In addition to the financial evaluation, feasibility of the outsourcing was studied from the materials management aspect.

The study part of the thesis is supported by three theoretical themes: operations management, outsourcing and make-or-buy decision. The operations management theme includes discussion about performance and inventory management. The outsourcing theme concentrates to give an overall review about the concept. In the final part of the theory framework, make-or-buy decision, topics such as concept



definition, reasoning, costs and the generic process model are discussed. Theoretical themes were selected in order to give a theoretical insight to the issues that are handled in the study.

The fifth and sixth chapters include the main study part of the thesis. The study project is explained from the definition of the current state followed by the feasibility study and ending in the observation of the results of the study. In the final part the entire thesis is concluded.

## **1.1 Company Description**

The study was performed in the machinery industry. The host company delivers vehicles and services to its customers in a niche market. Services include process support, training, rental, rebuilding, maintenance and spare part service during the whole life cycle of the product. The company has its headquarters and main production facilities in Finland, but it has operations and branches in every continent. The host company in this study is referred as MCO (Manufacturing company).

MCO has a long history in providing high quality products to meet customers' requirements. The strategic strength of MCO is the capability to offer highly tailored products to serve its customers' needs.

On the other hand high rate tailoring is a great challenge at MCO. Tailoring causes lot of additional work at the design department since the drawings and designs might be required to be changed according to customer. Design changes affect the Bill of materials and therefore high number of new SKUs is added annually. This generates great challenges for different departments. Sudden changes in BOM complicate purchasing operations because many crucial components have relatively long lead times. The operations model also complicates engineering and production due to the amount of variance in products.

During the past few years, MCO has increased its business at very high rate. Operations of the company have been growing by 30 percent annually and this direction has been expected to continue also in the future.

## **1.2 Research Goals and Questions**

In this study the purpose was to find out possibilities to improve the productivity of pre-assembly by increasing the delivery content. The study was chosen to be performed for the assembly of driveline units.

Following research question were studied in this thesis:

1. Is it reasonable to perform the driveline assembly work by an external party?
  - Does there exist suppliers who would be interested and capable to perform the assembly work?
  - Are there some internal limitations for the delivery of complete driveline units?
  - Does the current operations model support outsourcing of pre-assembly?
2. Is it possible to utilize the reserved assembly space more efficiently?
  - Is it possible to add capacity of the final assembly by freeing up space from the pre-assembly hall?

## **1.3 Focus and Limitation**

In this study the focus was put on the assembly of driveline units that includes the diesel engine, transmission, radiator and supporting components. Driveline unit is a mechanical assembly that generates the power of the vehicle. Analysis was done for three driveline units that are among the most common units used in final assembly.

The purpose was to find out what resources are required to perform pre-assembly at MCO and compare the figures with cost estimates received from the supplier

candidates. This included collection of data from different cost factors that contribute to aggregate assembly costs.

The study was limited to the comparison of the assembly process costs between MCO and supplier candidates. The total cost of outsourcing was not studied. Supplier candidates were not asked to give quotations that would include the compensation of inventory costs and purchasing of needed SKUs. Comparison included observation of throughput times and the cost of assembly hours in order to find out, if suppliers with more efficient assembly processes were available.

## **1.4 Research Methods**

The study included both quantitative and qualitative research. Quantitative research was based on figures and values that were collected from the ERP and PDM system. These were throughput times, inventory data and materials lists of studied assemblies. The study included also practical measurements of distances and visual observations at the assembly place.

Qualitative methods included interviews of key persons: supervisors, planners, designers, purchasers and mechanics. Information was gathered from several different departments; purchasing, design, human resource, production, facility management, financing and warehousing. Request for quotations were sent to four supplier candidates in order to get information about their interests and capabilities to conduct the assembly work at their premises.

## 2 OPERATIONS MANAGEMENT

The purpose of this chapter is to describe topics concerning operations management. The discussion is focused on two operations management themes that are closely related to the study part of the thesis. The topics included in the chapter are the concepts of performance and inventory management.

### 2.1 Concept of Performance

This part of handles the concept of performance measurement and improvement. Traditional performance measures, productivity, efficiency and effectiveness are discussed here.

#### 2.1.1 Productivity

Productivity is a measure used to define the relationship between the produced output and utilized inputs. Output can be either a produced item or a service that is provided. Input consists of the wages, the cost of equipment and other resources. Performance is measured with productivity at both national and organizational level. (Krajewski & Ritzman 2002, 14; Greasley 2009, 511)



$$\text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

FIGURE 1. Productivity formula (Greasley 2009, 511)

A higher level of productivity is seen as beneficial since it contributes to reducing the costs of production and lowering the selling price of an item. With a good productivity, an organization is more capable to expand markets and compete in global markets. It also improves margins, which leads to higher profitability and

better salaries. In a larger scope the entire wellbeing and economic strength of the nation is determined by production and productivity. (Roy 2007, 2)

Roy (2007, 2) states that productivity consists of waste reduction of e.g. labor, materials, time, equipment, energy, space and capital. Productivity growth requires a desire to find better, cheaper, quicker, safer and simpler methods to perform a certain function. The aim of the productivity is to maximize the utilization of resources. This leads to the maximized amount of items or services produced at the lowest cost and resources. (Op. cit. p. 2)

There are many possible methods to measure productivity. All of the measures are usually rough estimations. The value used for output can be e.g. the price that the customer pays or the number of customers served. Alternatively, the number of the produced items can be used as an output. (Krajewski & Ritzman 2002, 14)

Typically there are several parameters that are selected to measure the productivity of a certain activity. In an insurance company, productivity might be measured by monitoring how many insurance policies are processed weekly by one employee, whereas in a facility service company productivity might be measured as a number of square meters cleaned per hour. These kinds of measures indicate labor productivity, i.e. the output per person. Same kind of measuring is also used for productivity of machinery, with the difference that the number of machines is used as a denominator. (Op. cit. p. 14)

$$\text{Labor Productivity} = \frac{\text{Policies processed}}{\text{Employee hours}}$$

FIGURE 2. Labor productivity formula (Krajewski & Ritzman 2002, 14)

Multifactor productivity is used to measure productivity when there are multiple numbers of inputs. The total input might be composed of labor, materials and

overhead costs. It is important that the different inputs are converted to the same form. (Op. cit. p. 14)

$$\text{Multifactor Productivity} = \frac{\text{Quantity at standard cost}}{\text{Labor cost} + \text{Material cost} + \text{Overhead costs}}$$

FIGURE 3. Multifactor productivity formula (Krajewski & Ritzman 2002, 14)

According to Panneerselvam (2006, 8) the minimum ratio for the productivity is one. An organization is in a comfortable position if the rate is higher than one. An organization should aim to improve the level of productivity to reach as high a level as possible. Improvements can be achieved by using several different strategies:

1. Constant input for increased output
2. Constant output for decreased input
3. Relatively higher increase in output against increase in input
4. Relatively lower decrease in input against decrease in output
5. Simultaneous decrease in input and increase in output.

(Panneerselvam 2006, 8)

**Constant input for increased output** With such a strategy, productivity is improved by increasing the output without increasing the input. Typical example of this kind of improvement is a production layout development where output is increased by relocating processes into optimal positions. Waste time is minimized, which leads to a higher volume produced per hour.

**Constant output for decreased input** The strategy aims to increase profitability by decreasing the input without decreasing the output. This might be achieved by decreasing the costs of input. In practice, the company must seek a supplier that delivers raw materials and components at a lower price. Hence, the ratio of the productivity increases because the same output is reached with smaller cost.

**Relatively higher increase in output against increase in the input** This kind of strategy involves reforming of the existing product mix within the organization. In a situation where organization facilities are not entirely utilized, the productivity could be improved by adding a product with good market potential to the product range. The unused facilities could be used for producing the new product. The added product would increase revenues, but on the other hand it would also increase manufacturing costs. In order to increase the productivity ratio, this example requires that the increase in revenues is relatively higher.

**Relatively lower decrease in input against decrease in the output** This strategy refers to the previous strategy example. In this case an uneconomical product is dropped from the product mix. This action results in that the revenues of the organization are decreased because of the decreased number of sold products. On the other hand, manufacturing costs are decreased. In this strategy, the savings received from manufacturing costs must be higher than the lost revenues.

**Simultaneous decrease in input and increase in output** A practical example of this strategy is a manufacturing organization, which increases the output by increasing the use of automation and high technology, such as robots and AGV systems. This kind of development reduces operation costs drastically. Such systems require great investments, but in the long run the cost savings break even the investment. The use of technology may also lead to an increased output, which increases the productivity ratio along with the operation costs savings. (Panneerselvam 2006, 8).

### **2.1.2 Efficiency and Effectiveness**

The term efficiency refers to the relation between input and output, where a certain output is generated with the minimum amount of inputs. High efficiency requires an organization to minimize downtimes (machine failures, waiting time, breaks, etc). On the other hand, the probability of occurrence of defective products may rise because of the increased fatigue. Hence, manufacturing systems may produce defective products efficiently. According to Roy (2007) efficiency is doing things right.

Operational efficiency can be measured by comparing the ratio of output and inputs, such as facilities, capital and personnel. (Roy 2007, 3).

Greasley (2009) defines efficiency as a measure to identify what is the rate of the available capacity. This includes the capacity where planned factors like training and maintenance are subtracted from the total capacity. In a way, efficiency is a measure of availability. (Greasley 2009, 512)

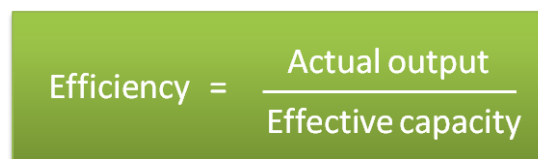
A green rectangular box containing the efficiency formula. The text inside the box is white and reads: Efficiency = Actual output / Effective capacity. The division is represented by a horizontal line between the numerator and the denominator.
$$\text{Efficiency} = \frac{\text{Actual output}}{\text{Effective capacity}}$$

FIGURE 4. Efficiency formula (Greasley 2009, 512)

Effectiveness refers to the rate how well the set of expected goals are accomplished and how the available resources are used. The rate of effectiveness is measured by the output quantities or achieved quality. Along with efficiency, effectiveness is also doing the right things. (Roy 2007, 3)

According to Greasley (2009, 512), effectiveness is the measure of customer satisfaction. Effectiveness defines how well the output fulfills the requirements set by the customer.

## 2.2 Inventory Management

Inventory management is considered one of the most challenging issues faced by operations managers. Normally a big portion of total assets of an organization is formed by inventories. On average, inventories form over 30% of the total assets and up to 90% of the working capital. The capital tied to inventories is directly connected into profitability of the organization. (Roy 2007, 100)



Inventory management aims to optimize the amount of inventory that is kept in stock. This involves decision-making concerning order sizes and replenishment intervals. (Russell & Taylor 2009, 529)

### **2.2.1 Elements**

Inventory consists of several elements. Quite a few people might think that inventory consists of final products that are waiting to be sold to the end customer. Although this is one of the most important reasons for inventory, there are recognized several different forms of inventory. (Russell & Taylor 2009, 529)

According to Russell and Taylor (2009, 529) in the field of industry typical forms of inventories are:

- Raw materials
- Purchased components and supplies
- WIP (work-in-process) items
- Transported items
- Equipment and tools
- Finished products.

The purpose of the inventory is to satisfy the need for materials. Demand can be generated by internal or external customers. Inventories can be seen in different forms in every kind of organizations. Shops and department stores keep the inventory of items and products they are selling to their customers. Manufacturing companies carry inventory in order to satisfy the demand created by production. Inventories can be found even in everyday personal life. Groceries, clothes and hygiene products are stored in family households, for instance. (Russell & Taylor 2009, 529)

Usually inventories can be divided into two different types of materials: materials with a dependent demand and materials with an independent demand. An inventory with a dependent demand includes items that are tied to some other items in the inventory. These are for example subassemblies and components that are utilized in some bigger entity. For example, the wheels of a car in the automobile factory can be

categorized into dependent items. The need for the tires depends on the number of the manufactured cars. End products and finished goods are items with an independent demand. These items are not affected by the demand for other items kept in inventory. The need for independent items is adjusted by circumstances in the market. This is a matter that cannot be controlled by the organization. (Shim & Siegel 1999, 269; Russell & Taylor 2009, 530)

### **2.2.2 Costs**

Inventory planning aims to decrease the cost of inventory by optimizing investments. By defining the optimal level of inventory it is possible to adjust cost factors of inventory on the level where total inventory cost is minimized. Shim & Siegel (1999, 269)

A typical way is to categorize costs related to inventory into three different classes. Shim and Siegel (1999, 269) along with Russell and Taylor (2009, 531) categorize costs into carrying costs, ordering costs and shortage costs. Greasley (2009, 331) divides costs into two classes: inventory held costs and inventory replacement costs. Inventory held costs consist of holding costs, carrying costs and storage costs. Inventory replacement costs include order costs, replenishment cost and delivery costs.

Shim and Siegel (1999, 269) state that carrying costs (alternatively holding costs) consist of inventory storage costs and the capital that is tied up in the inventory of goods. Russell and Taylor (2009, 531) identify carrying costs as an expense that is used for keeping goods in stock. Carrying costs differ based on the level of inventory that is kept. In addition, the time period that an item is held in stock can also vary the cost. Carrying costs increase along with the level of the inventory kept in stock for a period of time.

An important factor in inventory carrying cost is the cost of capital. According to Reinikainen, Mäntynen, and Rantala (1997, 112) they typically form major part of the total inventory costs.

Inventory capital cost is calculated by using internal interest rate. Usually the rate varies between 8-12% depending on the organization. Basic formula for calculating capital is as follows:

+	Stock cost
-	Accounts payable
+	Account receivable
=	Capital

FIGURE 5. Capital cost formula, see Sakki (1999, 98)

In addition, Russell and Taylor (2009, 531) recognize the following factors that contribute to carrying costs:

- **Facility:** The cost related to facility consists of the energy that is required for power, heating, cooling, illumination and refrigeration. Facility costs also include rent and/or depreciation, taxes and insurance costs.
- **Material handling:** Equipment that is used in warehousing operations causes costs. This can be for example the rent or depreciation of equipment such as conveyors and different lift trucks, for instance. (Arora & Shinde 2007, 7)
- **Labor:** Costs related to the personnel. Labor expenses such as direct salary costs, healthcare expenses and variable costs.
- **Waste:** Cost related to the loss of stored items. The cause for waste can be for example deterioration, obsolescence, thieving and breakage due to poor handling or packing.

Based on the definition made by Russell and Taylor (2009, 531) inventory carrying costs can be described with two different models. A common approach is to allocate the total of carrying costs aggregating from the individual carrying cost factors mentioned above. The total sum of the costs is divided with the number of stored units during a certain time period like month or year, for instance. With this

approach it can be expressed that carrying costs are e.g. 15 EUR per unit annually. On the other hand, it is also possible to calculate carrying costs as a percentage of a certain item value or from the percentage of the average value of inventory. Based on a general estimation, carrying costs usually vary from 10 to 40% of the value of a produced item.

When a company makes an order for new items and receives them, ordering costs are generated. Usually ordering costs are calculated for the price per order. Typically order size does not affect the order cost. Order costs are proportional to the number of orders placed by purchasers. Basically, all costs that rise along with the placed orders, are considered as ordering costs. (Russell & Taylor 2009, 531).

Ordering costs include the cost of placing an order, transportation, receiving, shelving, picking and possible quality inspections. If a company is dealing with a qualified and reliable supplier, it might not be necessary to make a quality inspection. It is also possible that the supplier delivers items straight to the locations where they are needed. Contrary to the carrying costs, ordering costs can be decreased by increasing the average inventory. (Dilworth 2000, 414).

Shortage costs appear when a company is not able to satisfy customer demand due to an absence of required inventory of items. For this reason shortage costs are also known as stockout costs. In a worst case the shortage may lead to a situation where sales are lost permanently. In such a case the loss of profit is included to the stockout costs. Stockouts may also cause intangible harm in the form of customer dissatisfaction and lost goodwill, which might damage customer relationships and upcoming sales. In addition to the lost revenues due to stockouts, a company may also be required to pay penalties by giving price discounts or rebates to the customer. Internally, stockouts may disable the whole production and cause downtime and waiting time costs. It is more difficult to measure the cost caused by lost sales due to a shortage than to measure ordering or carrying costs. Hence, figures made of shortage costs are often only estimations and guesses. (Russell & Taylor 2009, 531).

Shortage costs are in an inverse proportional relation to carrying costs since stockouts occur when the inventory is lowered in order to cut down carrying costs. When inventory level is increased, shortage costs decrease and carrying costs increase. (Russell & Taylor 2009, 531).

### **3 OUTSOURCING**

The second theory chapter includes a theoretical explanation of outsourcing as a business concept. First, outsourcing as a concept is defined. After the definition, several topics related to outsourcing are discussed. The concept is described from the sourcing organization aspect. The chapter explains what the outsourcing concept means, how it has been evolving, why it is done and what kinds of problems and risks it includes. In addition, different levels of outsourcing and the concept of networking are discussed.

#### **3.1 Concept Definition**

Moving from in-house production to outsourcing has been amongst the strongest and most long-term trends during the last decades. Activities that are traditionally performed with own resources have been moved to external service providers. Organizations have aimed to increase cost efficiency and create flexibility to the structure. (John 1995, 193).

Weele (2009, 162) states that there are four main features of outsourcing that can be recognized. First, in-house activity is moved to be performed by an outsider supplier. Second, in outsourcing, knowledge, resources and even people are transferred outside. Third, in long-term periods outsourcing includes a deeper relationship between organizations. Fourth, during the activity transfer process the customer company is predisposed to new kinds of costs and risks. In 21st century outsourcing has become a standard business practice among small and large organizations regardless of the field of industry.

Reasoning behind the outsourcing phenomenon is fundamentally based on the cost savings. Outsourcing is seen as the best solution if some external party is able to perform a wanted function with a cheaper price. By buying an activity from the outside the companies are able to concentrate on the functions that they do best. (John 1995, 193). Reasons and drivers for outsourcing are discussed more in the part 4.2.1.

Traditionally outsourcing has been used to transfer noncore activities to external suppliers. In manufacturing organizations it has been common to outsource activities such as cleaning, transportation, maintenance and training. Furthermore, in some industries, legal, financial, HR and certain IT services are moved to an external party. Also, accounting systems, distribution and R&D activities have been outsourced in many organizations. (Jackson, Iloranta, & McKenzie 2001, 1; Globberman & Vining 2004, 2).

Typically organizations tend to outsource activities that are not in a strategic position. For such a movement, outsourcing phenomenon is moving more and more closer to the core activities. (Jackson et al. 2001, 1).

Outsourcing has evolved dramatically, more and more activities are transferred to be performed by external parties. Nowadays organizations outsource activities that are considered their main functions and key activities in value chain. Outsourcing is used with such enthusiasm that some companies have transferred activities such as production to a supplier. Companies have also been moving inbound and outbound logistics outside the organization borders. (Globberman & Vining 2004, 2).

Due to strategic implications, outsourcing has got more and more attention in organizations. In many cases the outsourcing decision can contribute to improving the profitability of the company and by that way to increasing the financial strength. (McIvor 2000, 22).

Outsourcing as a business strategy is evolving constantly. Instead of a certain function, organizations are increasingly outsourcing entire business functions. Such

an outsourcing has been conducted for manufacturing and operations. Also, complete distribution, legal functions, call centers and engineering have been outsourced. (Weele 2009, 161).

Many organizations have moved activities to low cost countries (LCC). This phenomenon is referred to as offshoring and in many cases it is used to outsource especially services. According to Brown and Wilson (2005) the utilization of offshoring is increasing and organizations are deciding to move more and more activities to LCC. Typically, the administration costs of outsourcing raise from 5 percent to 12 percent of the total value of a contract. Earlier this percentage has varied from 10 percent to 18 percent varying according to the extent of the project. (Weele 2009, 162; Brown & Wilson 2005, 135).

Outsourcing has different types, where the depth and the complexity of the customer-supplier relationship vary. According to Merl and Husa (2006, 21) outsourcing has four different types: in-house outsourcing, intragroup outsourcing, partial outsourcing/multisourcing and total outsourcing. (Merl & Husa 2006, 21).

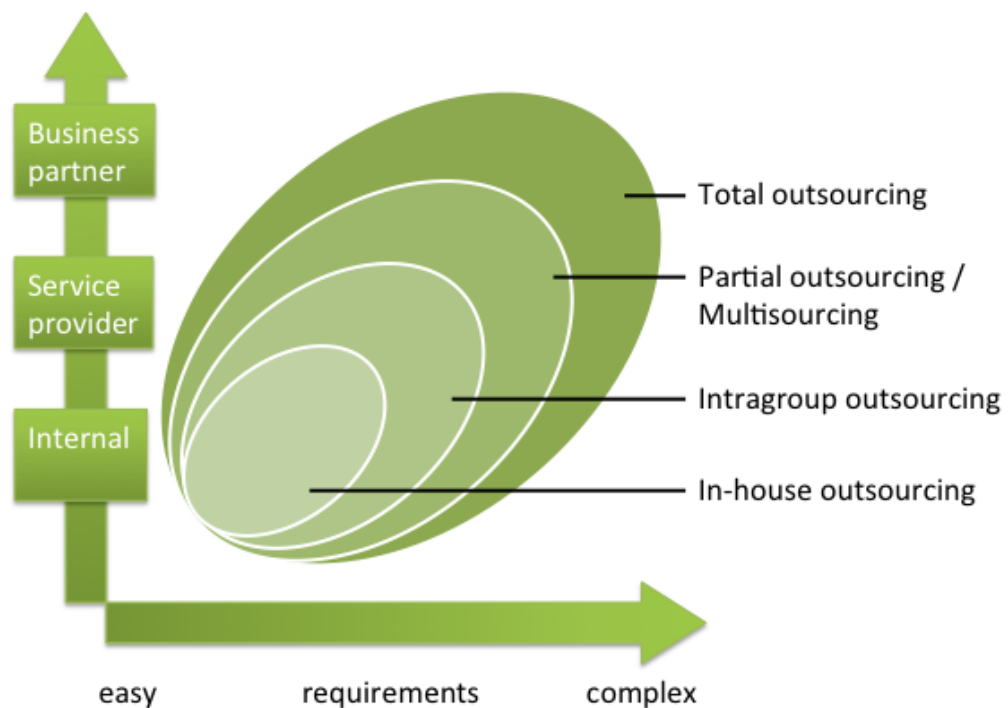


FIGURE 6. Types of outsourcing (Merl & Husa 2006, 21)

Partial outsourcing or multisourcing is a transaction where the integrated activity is only partially moved to an external supplier. The buying organization is still responsible for the control of the activities and functions. In such type of outsourcing, the buyer has more control over the costs and quality. The buyer organization is required to have more knowledge and capacity for coping with outsourcing. (Weele 2009, 162).

Total outsourcing or turnkey outsourcing refers to the outsourcing where the external provider is responsible for the whole activity. In addition to performing the activity the provider is also responsible for the coordination of the executed operations. The buyer does not have an insight into the cost structure and the process. On the other hand the buyer is not required to have the skills and capacity for achieving a certain function. (Op. cit. p. 162).

### **3.2 Problems Related to Outsourcing**

Jackson et al. (2001, 4) describe the six most common flaws that might lead in to problematic and unprofitable outsourcing. The typical flaws are divided into decision-making and implementation phases.

#### **3.2.1 Decision-Making**

If an organization wants to achieve significant cost savings and other benefits, there must be concentration on strategic functions. Many companies fail to receive real benefits by outsourcing only a relatively simple function, such as catering and payroll. Outsourcing of these function might be reasonable, but on the bottom line benefits might be almost negligible. In order to increase output and lower costs, an organization should put emphasize on areas that really affect their business.

In some cases organizations outsource their functions too easily without a proper feasibility study and reasoning. Careless decision-making may lead to over-outsourcing and the company may lose its understanding of its core and noncore activities. The outsourcing decision requires thorough evaluation, since it is possible



that according to study it is more profitable to keep even noncore activities in-house. On the other hand, it may be reasonable to move some of the most critical activities to an external party. Even though the organization wants to outsource its noncore activities, there might not be suitable vendors to perform the function. (Jackson et al. 2001, 4).

Third problem related to the decision-making lies in the poor cost analysis. Organizations may not have proper understanding about the financial influences of outsourcing. Moving activities to an external vendor is considered to be a reasonable solution because the vendor promises to perform the activity by lower cost or with higher efficiency. By looking to the total cost of outsourcing it might reveal that fixed overhead, vendor controlling costs and transition costs make outsourcing much more expensive than expected. According to Garaventa and Tellefsen (2001) organizations get easily seduced by the lower labor cost and forget to take total costs into account. Cost issues related to outsourcing are discussed more in part 4.3. (Jackson et al. 2001, 4; Garaventa and Tellefsen 2001).

### **3.2.2 Implementation**

During the implementation phase a too careless supplier selection appears to be a common problem. The organization may not have expertise to choose appropriate partners. In many cases the customer company becomes over dependent on the vendor, since a throughout evaluation of supplier candidates has not been performed. Proper evaluation should include the assessment of the supplier's competence, experience and cost structure.

In addition, many companies fail to manage their current customer-vendor relationships. Quite often the reason lies in the problems in the day-to-day execution of an activity. Occasionally outsourcing is not successful due to an original contract that does not define clearly the expected results and requirements of a certain activity. It is more typical that the outsourcing turns into an unprofitable solution because there is not a qualified person in charge to manage complicated business relationship.

Management methods and organization structures must be adapted to new processes and relationships that are included when transferring activities to an external party. In the traditional supply relationship management the main goal has been the steering of inputs. In outsourcing the concentration of supply relationship management must be put on process outputs as well. Relying on old habits causes problems in some organizations since they fail to adapt into the new system. An organization might concentrate on the task completion specification instead of relying on the skills and experience of the supplier. (Jackson et al. 2001, 6).

### **3.3 Risks of Outsourcing**

Outsourcing includes risks that the organization should take into account when making decisions on whether to keep an activity in-house or to transfer it to an outsider party. Merl and Husa (2006, 30) state that probably the biggest risks concerning outsourcing is dependency. This refers to the fact that outsourcing is very difficult to reverse. It may be extremely hard to switch the direction when the outsourcing process is running. The host company might get trapped in a dependency where the activity supplier has a monopolistic position.

An organization might be exposed to a risk of losing know-how. The possible supplier might use the transferred knowledge for its own purposes. In the worst-case scenario, the know-how might get into the hands of competitors. (Merl and Husa 2006, 31).

In the long run the total costs of outsourcing might rise to be much higher than estimated. Eventually the costs of outsourcing might exceed the savings that the host company was expecting from outsourcing. It is not rare that in the decision-making phase outsourcing is assessed too optimistically. Costs are easily underestimated and achieved savings are expected to be bigger than in reality. (Pajarinen 2001, 18).

Organizations may get carried away when trying to reach short term cost savings. Decision makers may carelessly outsource functions that are essential what it comes to the competitiveness of the organization. The position in the market decreases and the organization loses its strength. The organization might also lose credibility, which may affect the supplier relationships. Suppliers might lose their interest in continuing relationships. (Pajarinen 2001, 18).

Strategic risks relate to the relationship between the two organizations, the customer and the supplier. Strategic risks are caused by several issues, such as incompatibility between organization strategies. It is crucial that in an outsourcing relationship the strategies of the organization are not in conflict, so that the success of the initiative is not limited. The partnering experience should also be evaluated. Have the parties had success in maintaining outsourcing relationships in advance? Outsourcing requires commitment from both the parties. The level of commitment should be evaluated in order to find out if the management of the organization is devoted to establishing a successful partnership. (Power, Desouza, & Bonifazi 2006, 62).

Operational risks are formed of components such as role definition and process determination. One major concern related to operational risk is organizational culture differences. Integration of different cultures might be a real challenge because of differences in norms and values. Pajarinen (2001) points out that integrating different organization cultures may cause higher costs than expected. In addition, personnel related issues are considered as operational risks. These are issues such as transition, retention and attrition of personnel. (Power et al. 2006, 63; Pajarinen 2001, 18).

In order to minimize risks, it is crucial to perform risk assessment. The purpose of this assessment is to inform decision makers about the dangers behind outsourcing. It is essential to understand risks of outsourcing as a business proposition. At first, possible risks must be outlined. After recognition, the probability of risks must be assessed to be able to estimate what is the likelihood for the risk to occur. The severity of outlined risks must be analyzed in order to find out what the

consequences are if the risk would occur. In other words, what would be the cost that the organization would get back to its feet? (Power et al. 2006, 62).

Risks assessment gives the organization valuable information about the risks concerning outsourcing. The executives are able to decide what and how many risks they are willing to take. (Op. cit. p. 62).

### **3.4 Levels of Outsourcing**

Outsourcing has evolved during the past few decades. Along with development there has been formed different levels of outsourcing that can be recognized. Based on the definition made by Brown and Wilson (2005, 21) it is possible to divide outsourcing into three levels. In this part, these levels; tactical, strategic and transformational, are reviewed and discussed.

#### **3.4.1 Tactical Outsourcing**

Tactical outsourcing is considered as a first-level solution, which is related to a particular problem that is faced within an organization. Typically tactical outsourcing is seen as a solution to remedy internal problems. Organizations have used such type of outsourcing in a situation where the organization does not have the required financial resources to make investments. In addition, reasoning might be based on the lack of managerial competence or talent within an organization. Will to decrease costs is also a typical reason for first level outsourcing.

The purpose of tactical outsourcing is usually to create instant cost savings, reduce the need for upcoming investments, decrease the need for recruiting personnel and liquidate assets into cash infusion.

In the tactical outsourcing it is essential to get the supplier committed. To achieve this the outsourcers must put an effort to the forming of the contract. Typically the main responsibility has been on the purchasing department although it is expected that managers related to the supply chain process understand the requirements that

are set to their managed area. Responsibility of all required departments is needed in order to establish and maintain custom-supplier relationships of tactical outsourcing.

Typically the contract for the outsourced activity has been only a fee for services. The value of the contract equals to the money that is directed to the service provider. In the traditional outsourcing, the use of external suppliers brings value by offering better service for less capital costs and time required from the management. (Brown & Wilson 2005, 21).

### **3.4.2 Strategic Outsourcing**

Outsourcing has evolved to the direction where decision-makers reach to achieve more value from the customer-supplier relationship by varying the goals of outsourcing. Directors and managers have started to think that they could gain a wider control of the activities they are responsible for rather than losing control to an external party. By this way executives have been able to direct their attention to more strategic tasks. Strategic outsourcing gives e.g. a facilities manager a possibility to put effort more on infrastructure issues instead of taking care of recruiting new janitors. In the same way technology management could concentrate on serving internal customer when the operating of data centers is outsourced to a service provider.

Organizations want to achieve more value from outsourcing. For this reason, the application and way of using of outsourcing has been changed into more strategic direction. The involvement of service provider has grown, which has increased the scope of the outsourcing relationship. Strategic outsourcing could be used as a strategic tool since it has increased monetary values, duration of outsourcing relationship and improved the scope of activities. From the managerial aspect the traditional relationship between customer and supplier has evolved to a business partnership.

Strategic outsourcing aims to generate long-term value to the partners instead of offering short-term problem solving. In the strategic model the supplier base is

smaller than in traditional outsourcing. The emphasis is on the best-in-class integrated suppliers instead of using numerous vendors. The relationship between customer and supplier develops to a strategic long-term partnership, which generates value to both parties. (Brown & Wilson 2005, 21).

### **3.4.3 Transformational Outsourcing**

The development of outsourcing has generated a transformational level of outsourcing. Traditional outsourcing requires companies to execute the tasks under certain rules whereas strategic outsourcing is used as tool during the re-defining process of organization. Transformational - third stage - outsourcing aims to be the main element in the organization re-definition process. In the business world of today, organizations must be able to transform their structure and markets in order to re-define the business world. Otherwise the organization is re-defined by the business world. During the struggle with this challenge, executives have found transformational outsourcing to be one of the best tools to make business changes of such a high level.

According to Brown and Wilson (2005) the leading spirit of transformational outsourcing is the utilization of innovations brought from external specialists. In transformational outsourcing the purpose of the supplier is not just to improve the efficiency and business focus of the customer. External service providers are considered to be supporting elements in the business change. (Brown & Wilson 2005, 24)

Differences between traditional outsourcing and transformational outsourcing are compared in the table 1.

TABLE 1. Comparison of traditional and transformational outsourcing (Brown & Wilson 2005, 24)

Transformational Outsourcing	Traditional Outsourcing
Business focus	Operational focus
Centered on creating value	Centered on cutting costs
Assists in managing uncertainty	Assists in establishing controls
Aligns with the business processes that revolutionize in harmonization with your strategic goals	Aligns with basically unchanged business processes
Based on fashioning a network of partnerships in the new connected global economy	Based on external (primarily IT) specialists realizing higher performance for the client than internal non-specialist resources
Business cost and re-engineering facilitate perpetual value creation	Removes noncore functions from the business to provide a one-time discharge of capital

### 3.5 Networking

Company networking is a current topic in many business sectors. As a concept, networking is much wider than traditional vertical outsourcing. Networking can be horizontal movement where an organization can bind relationships with rival organizations.

In addition to the traditional production based co-operation, networking extends to other functions such as R&D, marketing and financing. Based on interviews it seems that networking has a positive influence on business growth and productivity. Organizations that have joined networks have increased their personnel and turnover faster than those who have decided to keep out. (Pajarinen 2001, 55)

Pajarinen (2001) states that main advantages of networking are more efficient utilization of capacity and lower production cost per unit. It is possible to create company networks intently to develop new innovations.

Hakonen (2009, 1) describes organization networks as a value networks where activity providers and buyers create possibilities for finding new innovative groups. Networking does not concentrate only on machines and equipment but also information flows and innovations. End users and suppliers create more and more productive networks. This has been made possible by the rapidly growing globalization that enables organizations located far away from each other to form co-operative relationships. (Hakonen 2009, 1).



### 3.6 Outsourcing Process

In the final part of the outsourcing theory framework the outsourcing process is explained. There are many different approaches how to describe the outsourcing process. For example Weele (2009) describes the outsourcing process as a 3-phase process consisting of strategic, transition and operating phases. Also Kiiskinen, Linkoaho, and Santala (2005) illustrate the process as a process formed of three main phases: outsourcing decision phase, supplier selection phase and transition phase. (Weele 2009, 167; Kiiskinen, Linkoaho & Santala 2005, 100).

Lever (1997) has divided the outsourcing process into four main phases: discovery phase, negotiation phase, transition phase and assessment phase. Jalanka, Salmenkari, and Winqvist (2003) categorize the process into six steps: establishment of the project, preparation, bidding, contract negotiation, implementation & starting and management. (Lever 1997, 38; Jalanka, Salmenkari & Winqvist 2003, 14).

According to Brown and Wilson (2005) the outsourcing process phases are Strategy phase, Scope phase, Negotiation phase, Implementation phase, Management phase, Completion or termination phase. Greaver (1999) uses a seven-phase categorization for the generic outsourcing process which includes the following steps: Planning initiatives, Exploring strategic implication, Analyzing costs/performance, Selecting providers, Negotiating terms, Transitioning resources and Managing relationships. (Brown & Wilson 2005, 21; Greaver 1999, 17).

When these main phases are divided into smaller steps basically the same steps can be discovered in every theoretical source. The way of dividing the process into bigger themes varies according to the author. In this thesis the generic outsourcing process described based on the model created by Brown and Wilson (2005).



FIGURE 7. Outsourcing process (Brown and Wilson 2005, 25)

- 1. Strategy phase** At the first stage the objectives and scope of outsourcing are defined. Feasibility study is performed in order to make a decision on, whether to continue with the process or not. In addition, resources such as time and budget for the outsourcing process are planned.
- 2. Scope phase** During the second stage, a baseline is established. The required service levels of suppliers are specified and the relationships between the outsourced and in-house function are clarified. Requests for proposal are sent to supplier candidates. Finally, a supplier is selected based on the responses received from the candidates.
- 3. Negotiation phase** After the supplier is selected, the contract is prepared and agreements are negotiated. Parties sign the contract after the sufficient agreement is gained.
- 4. Implementation phase** At the fourth level the chosen activity is transferred from in-house to the selected supplier. The actual outsourcing project is launched.
- 5. Management phase** The relationship between the sourcing company and supplier is managed throughout this phase. This involves companies to negotiate and

implement possible changes that may occur during the relationship. It also includes performance monitoring and cost administration. Management is a vital function to ensure that the outsourcing of an activity fulfills expectations set.

**6. Completion or termination phase** In the final phase of the process continuation of the existing outsourcing relationship is evaluated. It is possible to continue with the existing contract or end the relationship and look for other suppliers when the outsourcing process starts from the beginning. The third option is to insource the activity back to the organization premises. (Brown & Wilson 2005, 25)

## **4 MAKE-OR-BUY DECISION**

This chapter explains the make-or-buy decision from the point of view of different theoretical sources. The purpose of the chapter is to explain what things should be considered when the management is deciding whether to perform a certain operation in-house or buy it from the outside. In addition, drivers and a generic model for decision-making are discussed.

### **4.1 Definition**

A make-or-buy decision is one of the most critical decisions made by the management of an organization. During the life of the organization, it adds and leaves services or products from its range of offering. Along with these decisions, make or buy decision must be included. According to Humphreys, McIvor and Huang (2002) surveys have revealed that executives agree that the make-or-buy decision should be included in the business strategy of the organization. (Johnson, Leenders & Flynn 2011, 120; Humphreys, McIvor & Huang (2002, 567).

Decision must be made with every input that the organization is using in its operations. With each of these inputs there is typically a possibility to produce it by own resources or purchase it from supplier. (Fill & Visser 2000, 43).

The make-or-buy decision affects radically the whole character of the organization. Competitiveness and productivity are strongly influenced by the decision made. Over the years, the aspect to this topic has drastically changed due to globalization, which has increased the competition. There is a huge pressure on cost reduction and downsizing. Organizations have to concentrate on their core activities in order to survive on the markets. (Johnson et al. 2011, 120).

In different field of industries, in-house production has been a typical choice especially for large organizations. These organizations have had a large variety of different manufacturing, assembly and preassembly facilities. The purchasing department has been mainly concentrating on buying raw materials. During the past few years the markets have moved into a direction where organizations need to increase flexibility, closeness to customers, productivity and competitiveness. These requirements have forced companies to focus on the things they do best. Nowadays it is unusual if one single organization is able to compete in every sector of manufacturing and providing services. (Johnson et al. 2011, 120).

## **4.2 Drivers**

This part includes discussion about the reasons and drivers that guide organizations to make decisions concerning the make-or-buy decision. First the main reasons to keep the activities inside the organization borders are reviewed. After that there is an analysis made on, why organizations make decisions to transfer activities to external parties.

### **4.2.1 Produce In-house**

There exist numerous reasons that make companies to keep certain operations in their own facilities instead of buying them from the outside. Reasons might be political, competitive, social or environmental. These reasons might prevent the company from buying from the outside although it might be preferable. Some countries do not allow companies to move a certain amount of material processing outside of national borders. In some cases a company might keep the process in-

house in order to decrease unemployment in the local area. Cost might not be the dominant driver for decision making in each of these cases. (Johnson et al. 2011, 123).

Furthermore, Johnson et al. (2011) defines additional reasons that might lead organizations to keep certain operations in-house.

1. Sourcing company is not attractive from the supplier perspective due to too small product quantities.
2. A certain product is so special or it requires so exact quality features that the possible supplier cannot be found.
3. Company might react better to the demand by controlling the supply.
4. Company is not willing to share technological secrets
5. Lower cost is reached by keeping operation in-house
6. Idle equipment and/or labor is utilized
7. Sole-source situation is tried to avoid. Using a single supplier might cause supply disruption and lead into higher prices. (Waters-Fuller 1995.)
8. Suitable supplier is not available at a reasonable distance.
9. Major customer requires the company to make.
10. To minimize risk.

(Johnson, et al. 2011, 123; Waters-Fuller, 1995).

#### **4.2.2 Buy from the Outside**

There exist many different reasons for buying an activity from an external supplier. The categorization and definition of the reasons vary according to approach of the author. Organizations outsource activities in order to achieve cost reduction and strategic shift. Also, market forces and technical considerations make decision makers to consider outsourcing. (Fill & Visser 2000, 44).

Competitive pressures are relieved by the use of outsourcing. Organizations are forced to minimize profit margins and to decrease resources that are bound to facilities. By using outsourcing, organizations can raise the level of quality and productivity. Companies also get access to external resources and form strategic relationships with other companies. In addition, along with outsourced activities, administrative problems of an organization can be decreased when certain functions

are moved outside. Typical drivers for outsourcing are listed and discussed below. (Op. cit. p. 44).

**Quality** Buying an activity might be done in order to increase quality. Organization can be in a situation where it does not have enough capacity to fulfill quality demands. Outsourcing can be lead by increased demand of quality. Problems might also lie in the lack of qualified staff. By outsourcing an organization is able to get access to more qualified resources. (Op. cit. p. 44).

**Costs** By outsourcing companies can prevent and control costs of operations. This is essential especially when a company is using cost leadership business strategy. Competitive position can be improved by using outsourcing as a way to decrease costs. (Op. cit. p. 44).

**Finance** Limited investment budgets might force companies to consider to buy from outside. It is more efficient to invest the funds in activities that are in the most important role in the company. According to Greaver (1999, 4), an organization may generate cash by moving assets to the external party. (Fill & Visser 2000, 44; Greaver 1999, 4).

**Core-Business** Organizations have their main activities that bring the majority of the profits. These activities can be defined as a core-business of an organization. Other activities are seen as supportive activities, which do not play so significant role. According to Fill and Visser (2000, 44), other than core-business activities should outsourced. Jackson et al. (2001, 2) state that by focusing into core activities, internal resources can be moved away from non-core functions. Greaver (1999, 4) sees core-business thinking as a way to improve effectiveness by focusing on the activities that the organization can do best.

In addition, core-business concentration has also seen as a way to increase efficiency and productivity. Companies that specialize on some specific area may attract highly qualified personnel. (Aubert, Rivard & Patry 1996, 52).

**Technology** The buyer organization might be able to take advantage of the technological resources possessed by suppliers. Some suppliers may have more skills and knowledge to perform certain activities due to specialization. Access to higher-level technology may lead to increased operation reliability and performance. In addition, the total cost structure may be brought to a higher level in the long run utilization of technology resources. (Jackson et al.2001, 2).

**Market Discipline** Bidding of certain activities helps organizations to get a picture of the total cost structure. Organization may gain transparency and accountability to the functions. (Jackson et al. 2001, 2).

**Flexibility** In fluctuating market buying an activity may increase capability to respond demand changes. By outsourcing, organization may archive costs savings, since it does not have to invest on new labor and facilities when growth in demand occurs. (Jackson et al. 2001, 2).

Although reasoning behind the outsourcing decision is based on cost issues, there might still be a non-monetary reason for moving an activity to an external supplier. The reason for buying can be competitive, political, social or environmental. In some cases the organization has no option to choose whether to produce in-house or to buy. Based on the government's requirement an organization might be required to spend a pre-determined percentage of its spend to marginal suppliers. (Johnson et al.2011, 132).

Environmental properties might require companies to buy an activity from a supplier that has a more suitable location for a certain process. For instance, some processes might consume big amounts of water, which is not available at the location of the customer company. According to an article of Raunio (2006) this phenomenon is recognized in the production of aluminum. Due to a rise of energy cost, European companies move production from Europe to Arabic countries where energy costs are significantly lower. (Johnson et al. 2011, 132; Raunio 2006).

Based on Corbett (2004, 11) benefits of outsourcing are illustrated in hierarchical order in Figure 8. It is notable that cost reduction is the most obvious reason to outsource. The core business focus along with the variable cost structure and access to skills are also significant drivers for moving activities outside. Growing revenues, quality improvements, capital conserving and innovations play only a minority role when decision-makers consider outsourcing.

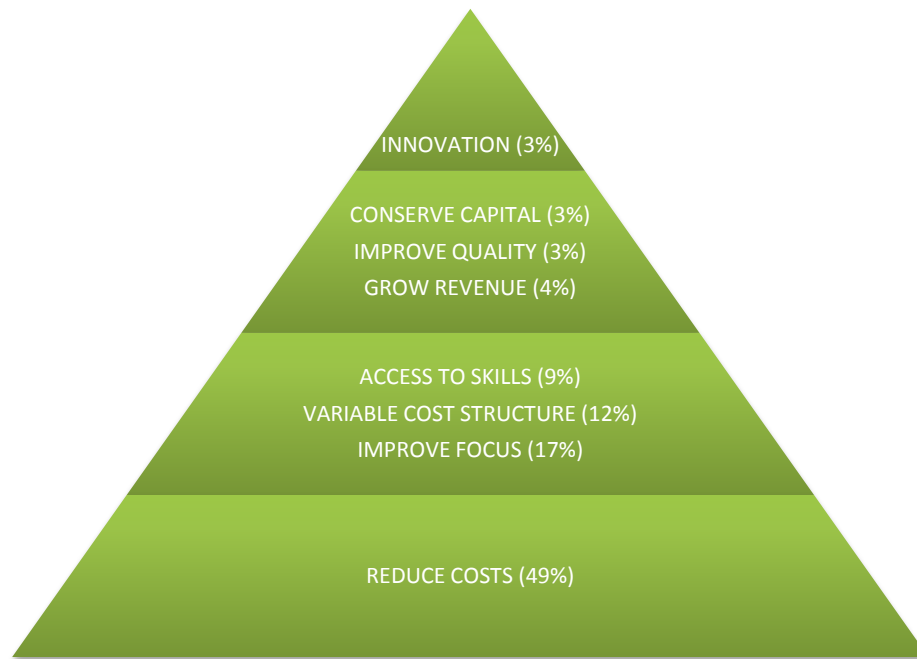


FIGURE 8. Benefits of outsourcing (Corbett 2004, 11)

### 4.3 Cost of Outsourcing

Outsourcing includes different cost factors that should be considered when planning an outsourcing initiative. In this study, costs are divided into direct costs, governance costs and transaction costs.

#### 4.3.1 Direct Costs

Money that is paid for performing and implementing the outsourced activities is considered direct costs. According to Power et al. (2006, 58), direct costs are tangible and easily measurable. Direct costs include the cost of resources that are consumed



when performing the desired activity. Ashley (2008, 41) emphasizes that it is essential to understand the direct cost in order to be able to prepare budgeted and business case for the activity that is planned to be outsourced.

#### **4.3.2 Governance Costs**

In addition to the direct production or purchasing costs, outsourcing involves governance costs, which can be divided into two different categories. During the decision-making the management should consider bargaining and opportunism costs that contribute to increasing the aggregate cost of outsourcing.

Bargaining cost consists of four different kinds of costs. The first cost type involves costs that are formed during the negotiations concerning details of the contract. The second type is costs of post-contract negotiations concerning changes due to unexpected shifts in circumstances. The third cost type consists of monitoring costs that are caused by the supervision of the performance of the supplier. The fourth type relates to cost of disagreement, which appears when neither the supplier nor the customer is willing to use the resolution mechanism agreed in the contract. This could be the contract-breaking mechanism where the agreement for co-operation expires. (Globerman & Vining 2004, 11).

It is more common that the bargaining costs are higher in the customer-supplier relationship than inside the organization. Results are based on the fact that there are more issues to bargain over with an external party. In addition, there is no need for price negotiations and a formal contract within the organization. This is considered to be one of the advantages of internalizing or insourcing, although wages, bonuses or internal transfer costs may contribute to bargaining costs significantly. (Knez & Simester 2000, 1).

Based on the description made by Globerman and Vining (2004, 11) bargaining costs are directly or indirectly related to the communication between customer company and external party. The development of communication technology has been a factor to lower bargaining costs. Deregulation and communication development have been

one of the reasons to encourage an organization towards international outsourcing. Knez and Simester (2000, 1) state that bargaining consists of cost of negotiation, documentation and execution of an agreement.

Opportunistic behavior among the parties may cause additional opportunism costs. Such behavior appears in a situation where either a supplier or a customer tries to benefit from the relationship by varying the agreed terms. These kind of acts made in bad faith usually appear in the outsourcing context more than between departments of organization. The reason for this lies on the distribution of profit, which is in a more significant role in the customer-supplier context. (Globerman & Vining 2004, 11).

Usually opportunism appears after the implementation when the outsourcing process is already running. Nevertheless, in some cases it still possible to recognize behavior with opportunistic characteristics already in the contract negotiation phase. (op. cit. p. 11).

On a theoretical level it is possible to make a division between bargaining costs and opportunism costs. In practice, a clear distinction might be more difficult to perform. Opportunistic vendors tend to reason their behavior by referring to unexpected changes in conditions such as demand fluctuations. In many cases the customer organization is not able to see whether the reasoning is true or not. In offshoring the distinction, it is even more difficult to try to find the reason and a way to repair disagreements. In the international field, language borders and cultural differences might complicate the communication and understanding between organizations. (op. cit. p. 11).

Organization should aim for a situation where the sum of production, bargaining and opportunism costs would be minimized. In the decision-making, the strategic management could make a comparison between the sum of the outsourcing costs and the cost of performing activity in-house. (op. cit. p. 11).

### 4.3.3 Transaction Costs

Communication with the supplier, price and term negotiations, agreeing and contract signing are issues that form the transaction costs of outsourcing. In other words the transactions costs consist of the time and effort that is used during the outsourcing process. (Ashley 2008, 42)

Ashley (2008, 42) categorizes transaction cost into two groups: the cost of procurement and the cost of implementation. The costs of procurement include expenses that are used in the supplier selection phase. These kinds of expenses are for example time and effort required for the request for proposal (RFP) creations and sending. Also, visits to the possible supplier candidates cause costs of travelling and entertainment. Time and effort might also put on the traveling when visiting current customers and references of the supplier candidates.

Implementation transaction costs include factors such as asset and employee transition costs, which occur when an activity is moved outside. Asset transition may require paying off amortization or depreciation that has not been realized totally. Employee transition costs may include paying of severance, pension, retention bonuses or other compensational expenses. (op. cit. p. 44)

### 4.3.4 Cost Comparison

The real benefit that is achieved by outsourcing depends on many different factors. In the Figure 9, the cost distribution between outsourcing and in-house production is compared. Based on an analysis made by Jackson et al. (2001) 28 percent of the in-house costs are fixed costs that cannot be reduced by outsourcing. Transition costs also cause significant spend, which decrease the financial benefit gained from the outsourcing. The attraction towards outsourcing usually decreases after the fixed and transition costs have been included. After considering these costs, the apparent benefit gained is only 7 percent. (Jackson et al. 2001, 5)

When looking at the Figure 9 below, it is noticeable that production level improvements contribute to make outsourcing more beneficial and attractive. Executives tend to believe that higher motivation and productivity is achieved by using specialized external service provider. With higher output and less downtime of the supplier, 15 percent improvement in production level is usually achieved. After combining all the costs and benefits together, the total benefit of outsourcing reached is 22 percent.

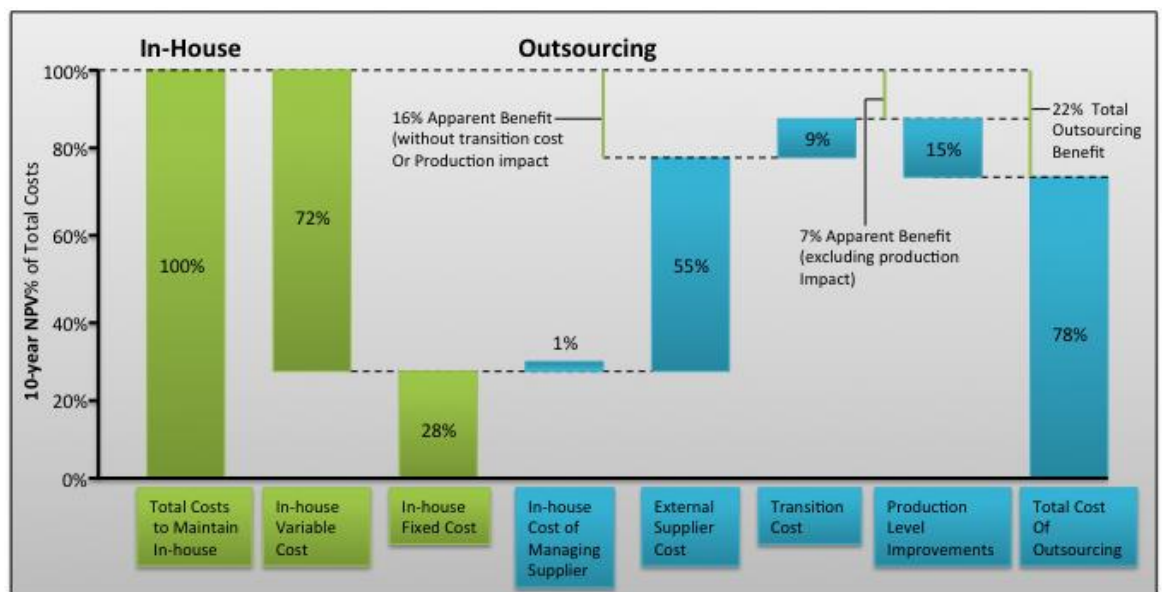


FIGURE 9. Cost comparison of in-house and outsourcing (Jackson et al. 2001, 5)

#### 4.4 Model for Make-or-Buy Analysis

The make-or-buy analysis defined in this thesis is based on the model developed by Humphreys et al. (2002, 572). The model includes a five-step analysis that addresses issues that should be taken into account when studying organization profiles and the technical capability of supplier candidates. In addition, the model makes a comparison between the supplier and the customer companies possible. This method is a generic model to help organizations to make justified decisions.

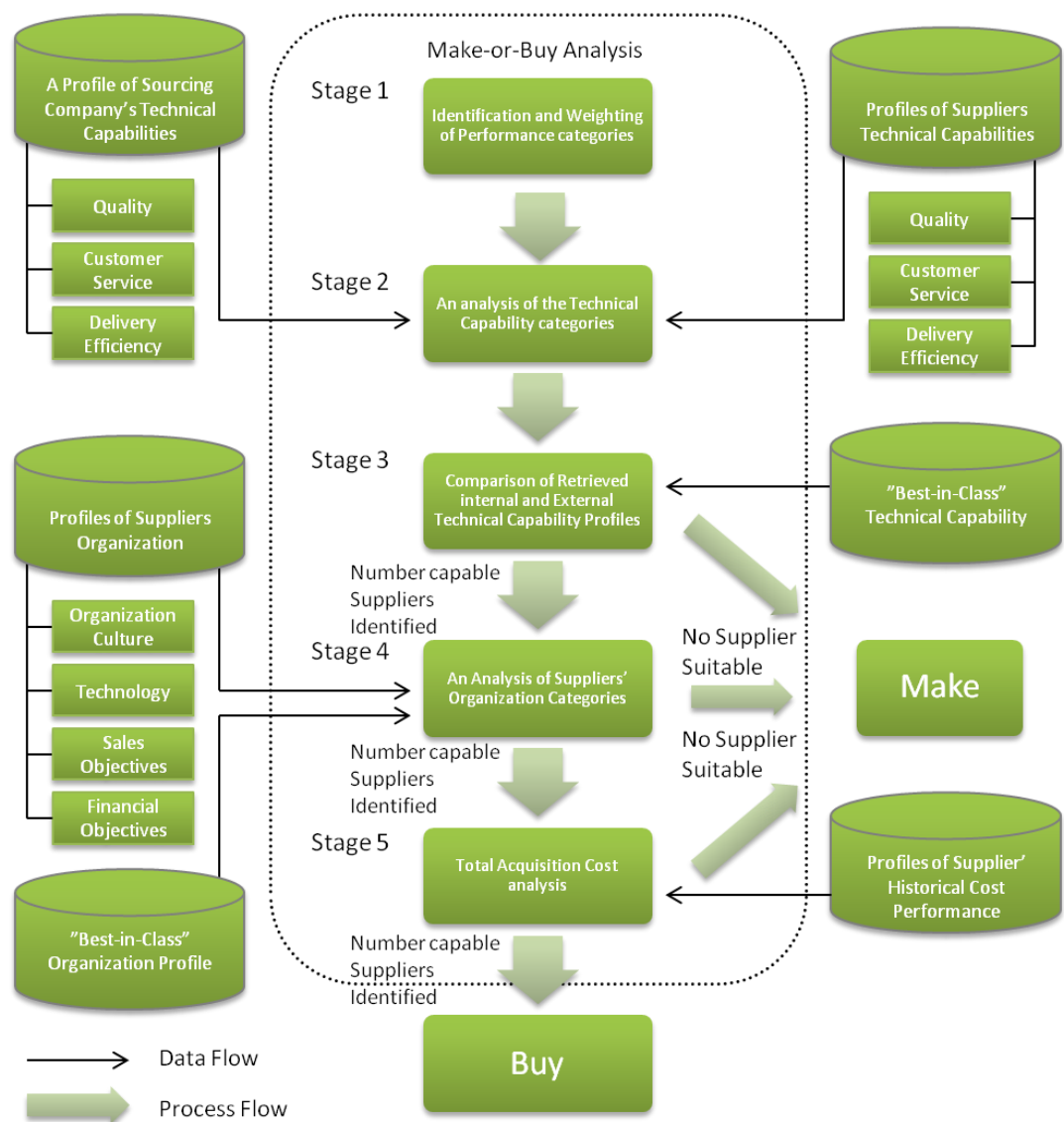


FIGURE 10. Make-or-Buy analysis (Humphreys et al. 2002, 572)

### **Stage 1 – Identification of performance categories**

At the first stage of the analysis identification of the key performance categories is done. These categories are required to determine, design and produce a certain product or service.

- Quality: Amount of waste, warranty claims, production downtime and scrap percentage
- Customer Service: Response time and percentage for customer enquiries, inspection rate percentage
- Delivery efficiency: supply accuracy, cost of transport, percentage of delivery complaints against purchase orders, unit cost, order-to-delivery time.

The identification of key performance categories is done in order to analyze if the possible supplier organization is compatible with the host organization. The profile of supplier organization is composed from the following categories:

- Organization culture: management attitude and compatibility, strategic compatibility, structure and personnel of an organization, reliability
- Technology: capabilities of design and manufacturing, level of R&D
- Sales objectives: market share, geographical spread, performance of sales
- Financial objectives: efficiency, liquidity, profitability and health of finance.

Each of the categories is numbered with the importance rate, which determines the position of a certain category in the analysis. (Humphreys et al. 2002, 574)

### **Stage 2 – Analysis of the technical capability categories**

The purpose of the second stage is to assess a supplier's performance and capability to provide a certain item or service. With the help of this assessment the host company is able to put suppliers in a ranked order according to their technical competence. Supplier candidates are evaluated with scores by assessing each of earlier mentioned categories.

### **Stage 3 – Comparison of internal and external technical capability profiles**

At the third level internal and external capabilities are benchmarked with best-in-class results. Internal and external performance is compared to the best suppliers globally. By this method the level of performance can be identified.

After the analysis the suppliers with the lowest ranking from the technical capability analysis are filtered out. The host company can define the certain ranking that must be achieved. Suppliers above the threshold level are considered worthy candidates. Rankings resulting from benchmarking for both internal and external parties are compared. If there are identified suppliers that are technically competent, the host company should proceed to a further analysis. If there are no competent suppliers available, the host company should consider the make-decision. (op. cit. p. 578).

### **Stage 4 – Analysis of suppliers' organizations**

This stage includes the assessment of the supplier's organization profile, which has been identified at the stage 2. The previously identified organization culture, technology, achievement of sales objectives and financial objectives are directed through in-depth analysis. These identified factors are in a key role when the company is about to form strategic business relationship with a supplier.

There are numerous factors in the supplier' organization profile that are difficult to define. Factors such as strategic compatibility, financial health and management compatibility affect the business relationship both long-term and short-term. It is important to understand that these less quantifiable factors are in as important role as the ones that are usually assessed in the supplier selection phase. When the host company forms strategic partnerships, it is crucial to consider all of these factors. (op. cit. p. 578).

### **Stage 5 – Total acquisition cost analysis**

At the final stage of the analysis the total cost of acquisition is studied. Total acquisition cost includes all the possible and actual costs related to the acquisition process. In addition to the actual purchasing price, all acquisition costs along the supply chain of the object are considered. This includes all costs from the design phase to the phase where the final product or service is delivered to the end customer.

The make-or-buy analysis made by the host company is completed after the total acquisition costs are calculated for both the internal and possible external parties. The make-decision should be made if the suppliers identified in the earlier stages have higher total acquisition costs. On the contrary, if the total acquisition costs appear to be lower at the external supplier, the buy decision should be made and the host company would continue to the supplier selection phase. (op. cit. p. 581).



## **5 CURRENT STATE OF THE DRIVELINE ASSEMBLY**

The purpose of the current state definition was to identify how the supply of driveline units was managed and what resources are required to perform the assembly. The current state definition is divided into two main sections: Initial Level Analysis and Assembly Cost Structure Definition.

The initial level analysis included supply description, assembly process definition and materials management definition. The supply description included identification of supply of the main components. The assembly process definition was made in order to clarify, what different phases the assembly of driveline units includes. This information was used when the cost structure of in-house assembly was identified. The assembly process definition was also utilized in the market analysis to assist the supplier candidates to give quotation for the assembly work.

The materials management related to the driveline assembly was studied in order to identify how the item handling and the material flow of the driveline components are controlled in the ERP and the PDM systems at MCO.

The assembly cost structure definition included identification of different cost factors of the driveline assembly. A cost structure model was created which can be applied also for other pre-assemblies. The percentage distribution of cost factors is discussed in the cost distribution section.

### **5.1 Initial Level Analysis**

At the moment the assembly of drivelines is done at the production facilities located in Finland. There are 15 different basic level driveline combinations that are in active use. Main components are the engine, the transmission and the radiator. The most valuable part of the driveline is the engine + transmission –combination. The engine and the transmission components form approximately 85% the total value of the driveline BOM.

Complete driveline consists of approximately 200 different components. The number of components depends on the specification of the driveline. In addition to the main parts, the driveline assembly contains different kinds of hoses, switches, connectors and electric wires. Driveline unit is illustrated in the figure below.

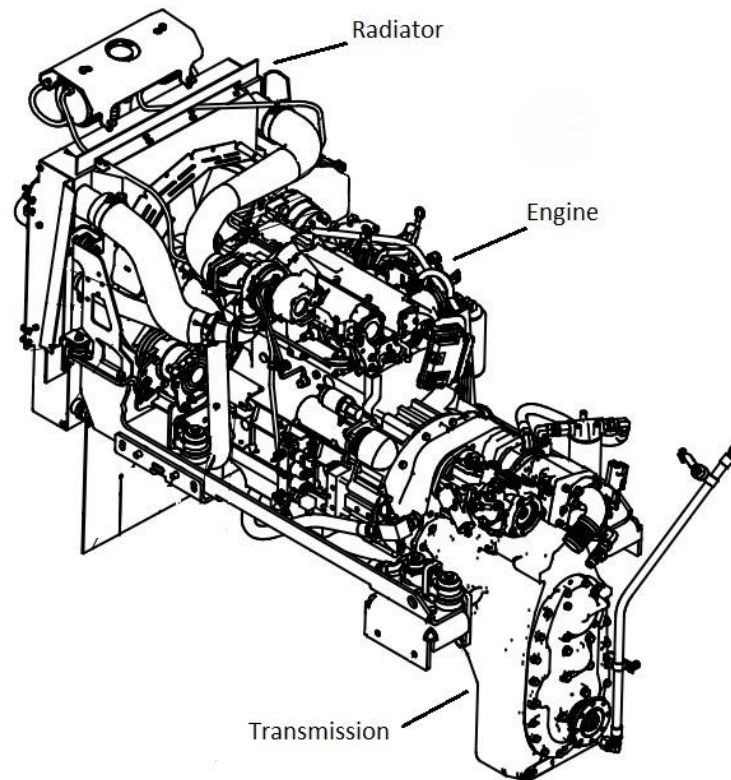


FIGURE 11. Driveline unit

MCO has also a partner in Finland who performs the assembly of vehicles. This external service provider is performing the assembly of several smaller and simpler vehicles, where the level of variance is smaller and the amount of installed accessories is at a minimum level. The assembly service includes also assembly of drivelines. MCO has a highly experienced mechanic who is constantly present at the assembly place of the service provider.

The current service provider is only responsible for the assembly work. MCO is responsible for the supply of the components, which are delivered to MCO and then forwarded to premises of assembly service provider.

### 5.1.1 Supply Description

The whole BOM is purchased as separate items from suppliers to the manufacturing company. It was found out that the number of suppliers per driveline combination is as follows:

- Driveline 1: 18 suppliers
- Driveline 2: 15 suppliers
- Driveline 3: 21 suppliers

The number of suppliers was identified from the materials list that was run from ERP to Excel by using a programmed query. The list showed materials that are required in a certain driveline assembly. Each component on the list includes supplier number, which was sorted out to get the total number of suppliers per materials list.

MCO uses engines of two different international brands. Usage volume is expressed by percentage of the total number of engines used in 2011. Engines are purchased from domestic dealers.

TABLE 2. Engine types of Engine manufacturer 1

Engine Manufacturer 1	Power	Percentage of total usage of engines
Engine 1.1	66 kW	16,52%
Engine 1.2	120 kW	15,92%
Engine 1.3	112 kW	7,21%
Engine 1.4	112 kW	9,01%
Engine 1.5	96 kW	11,41%
Engine 1.6	74,9 kW	4,50%
Engine 1.7	165 kW	0,90%
Engine 1.8	119,6	0,30%
Engine 1.9	86,5 kW	0,30%
Engine 1.10	95 kW	0,30%
Engine 1.11	95 kW	0,30%

TABLE 3. Engine types of Engine manufacturer 2

<b>Engine Manufacturer 2</b>	<b>Power</b>	<b>Percentage of total usage of engines</b>
<b>Engine 2.1</b>	110 kW	18,02%
<b>Engine 2.2</b>	170 kW	6,91 %
<b>Engine 2.3</b>	90 kW	7,51%
<b>Engine 2.4</b>	175 kW	0,90 %

One single manufacturer supplies the transmission units. MCO has 10 different types of transmission in active use. Transmission units are purchased from the dealer. The usage of the transmission units is expressed in the Table 4.

TABLE 4. Distribution of transmission units

<b>Transmission</b>	<b>Percentage of total usage of transmission units</b>
<b>Transmission 1</b>	39,35%
<b>Transmission 2</b>	17,74%
<b>Transmission 3</b>	6,77%
<b>Transmission 4</b>	9,35%
<b>Transmission 5</b>	7,74%
<b>Transmission 6</b>	6,13%
<b>Transmission 7</b>	3,87%
<b>Transmission 8</b>	5,81%
<b>Transmission 9</b>	2,90%
<b>Transmission 10</b>	0,32%

Radiator units have one supplier. Units are purchased straight from the OEM manufacturer. In 2011 MCO used four different models of radiator units. Driveline combinations observed in this study compose from following engine and transmission units:

- Driveline combination 1 – Engine 1.2 + Transmission 1
- Driveline combination 2 – Engine 1.5 + Transmission 2
- Driveline combination 3 – Engine 2.1 + Transmission 1

### 5.1.2 Assembly Process Definition

The driveline assembly is done in the pre-assembly hall of MCO. The assembly work is conducted by three mechanics at a specific assembly area. Three driveline assemblies are done simultaneously in a way that each mechanic is working with his own driveline unit. At the moment, MCO does not have any defined assembly procedure. There is no best practice or determined model that is followed in the driveline assembly. Each mechanic has his own working methods.

In addition to the different assembly methods, the assembly procedure depends on the optional accessories that can be chosen by the customer.

There is a variance in the assembly process depending on the mechanic. Despite the individual methods, there can be recognized three main phases that are gone through in every assembly process.

The assembly of the driveline unit can be divided into three main phases:

1. Equipment of main components
2. Combining of main components
3. Connecting main components into a functioning system

In the first phase the main components; the engine, transmission and radiator, are equipped. The engine is lifted to the assembly jig for installation. In this phase components for the optional air conditioning system of the cabin can be installed.

After the engine installation, it is possible to continue either with installation of the radiator or the transmission.

In the transmission installation, there are basically two working methods. The transmission unit can be equipped separately, when it is attached to the transportation support rack. The equipment can also be done after the transmission unit has been connected to the engine. In the transmission equipment phase, the hydraulic pump is installed.

At this point of the assembly process the engine and the transmission are equipped and they are connected together. In the next phase the radiator is installed to the driveline. This phase may include also the installation of the cell for air conditioning if the customer has selected the A/C option.

In the final phase of the process the driveline assembly is connected into system. This includes the hose and the electric winding installation.

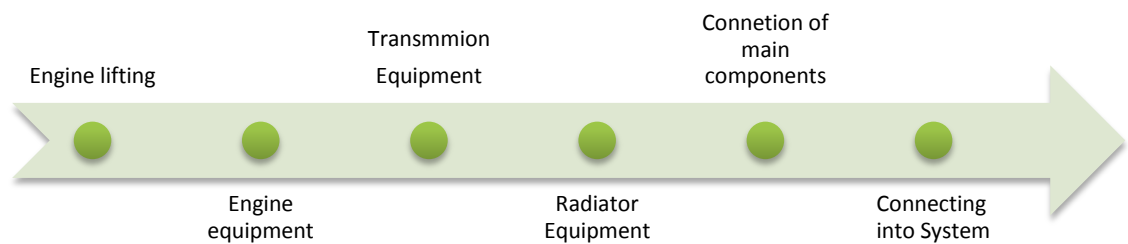


FIGURE 12. Assembly process of the driveline unit

Assembly is done on a special jig, which has wheels and adjustable attaching clamps for different driveline types. Currently MCO has three new jigs with lifting capability, which are in primary use. There are also two old jigs with a more simple structure, which are used if needed. These jigs are used during the assembly process and the transportation. The complete driveline is moved on the jig to the final assembly cell where it is lifted and installed to the vehicle.

### 5.1.3 Materials Management Definition

Materials management starts from the production planning which is done in the PDM (Product Data Management) system. MCO has 3 different item types in its PDM system: purchasable items, manufactured items and phantom items. Purchasable items are goods that are ordered from suppliers whereas manufactured items are made at own premises. Phantom items are goods that are not purchased and are not manufactured to the stock. Such items are left out from the manufacturing order and they do not appear in the materials list or in MRP.

Items appear in the ERP systems after the item status is accepted from “In design” - status to “In production” –status. The item type is determined in the item management section of the ERP. In practice the planner determines, whether the item is purchased or made in MCO premises.

MCO uses a mass customization principle for the structure forming, which is based on certain interfaces. This is a feature-based customization where the features of the products are determined by choices made by the end customer. The type of the driveline configuration is determined by the type of vehicle and the optional accessories that are selected.

Due to this kind of operations method, each driveline unit is assembled for a certain vehicle that is ordered by the customer. There are no driveline units assembled to the stock.

PDM system contains different modules that form the final product. When the customer selects a basic level vehicle, a certain type of driveline unit for it is pre-determined. Different optional accessories such as air conditioning are located in separate modules. Some of the optional features affect also to the assembly of driveline unit. Cabin air conditioning option requires installation of cell to the radiator unit, for instance. Air conditioning is shown as an individual module in the PDM, therefore it is not included in the basic driveline structure.

The materials structures are formed in a way that all the accessory options are located in a separate module. Accessory modules include all the components that are required for the certain option. There is no specific module such as “air conditioning components for driveline assembly”. All the air conditioning related components are listed in one module structure.

## **5.2 Assembly Cost Structure Definition**

The purpose of this analysis is to find out what kind of costs does the assembly work cause to MCO. What kinds of resources are required and what is the cost of making the assembly work at MCO? The cost structure of the driveline consists of manufacturing and warehousing costs. Manufacturing costs include all the resources that the assembly requires. These are the cost of personnel, materials, equipment and facilities. Warehousing costs include capital, personnel, facility and equipment costs. Values used in the definition were collected by acquiring data from the ERP. In addition, the data was collected by interviewing specialists and by making visual observations at the assembly and the warehouse facilities.

Acquired data was collected and combined into Excel documents. All the calculations were done by using the formulation tools available in Excel. Costs were calculated in the form of cost per assembled driveline unit. By this way it was calculated how much resources is required to produce one driveline unit.

### **5.2.1 Cost Factors**

#### **Material costs**

The cost of the components used in the driveline units was found out by making a temporary manufacturing order in the ERP system. By using a programmed query, the materials list was brought from the ERP to Microsoft Excel for observation. From the table could be seen a list of components that are used in the specific driveline assembly. The price of each component was calculated to be the average purchasing price. The average purchasing price is the landed cost, which includes the price of the product, and the cost of transportation.

#### **Assembly personnel costs**

The assembly work requires a certain amount of manpower, which forms the personnel costs. Manufacturing labor costs consist of direct labor per hour costs and



variable costs per hour. MCO has defined an hour charge for manufacturing labor. This sum was used when calculating the labor costs of the driveline assembly. The structure of the labor cost is listed below:

- Actual direct labor cost (basic salary, overtime not included)
- Salary of a year of service
- Over year accumulated salary of sickness, reduction of working hours, immovable feasts compensation
- Overtime salary
- Bonus
- Variable cost

Assembly labor costs were calculated from the working hours of the driveline assembly. The manufacturing department has recorded separately the time of assembly for each pre-assembly. The timekeeping system functions in a way that when a mechanic starts the assembly work, he signs into the work task. When the assembly work is finished, the mechanic signs out from the work task. The recording system has been in use only from autumn 2011 so there is no great historical data available.

The collecting of the assembly time data turned out to be a bit problematic since MCO has not put much effort to the monitoring of the recording. In many cases recording has not been done at all. Based on the interviews, it also appeared that the utilization of timekeeping is not very accurate. Heterogeneous results might be caused by the poor timekeeping. In some cases, the throughput time of the assembly has been measured for two driveline assemblies instead of one. These kinds of errors distort the gathered data because in the statistics a long throughput time appears as a peak.

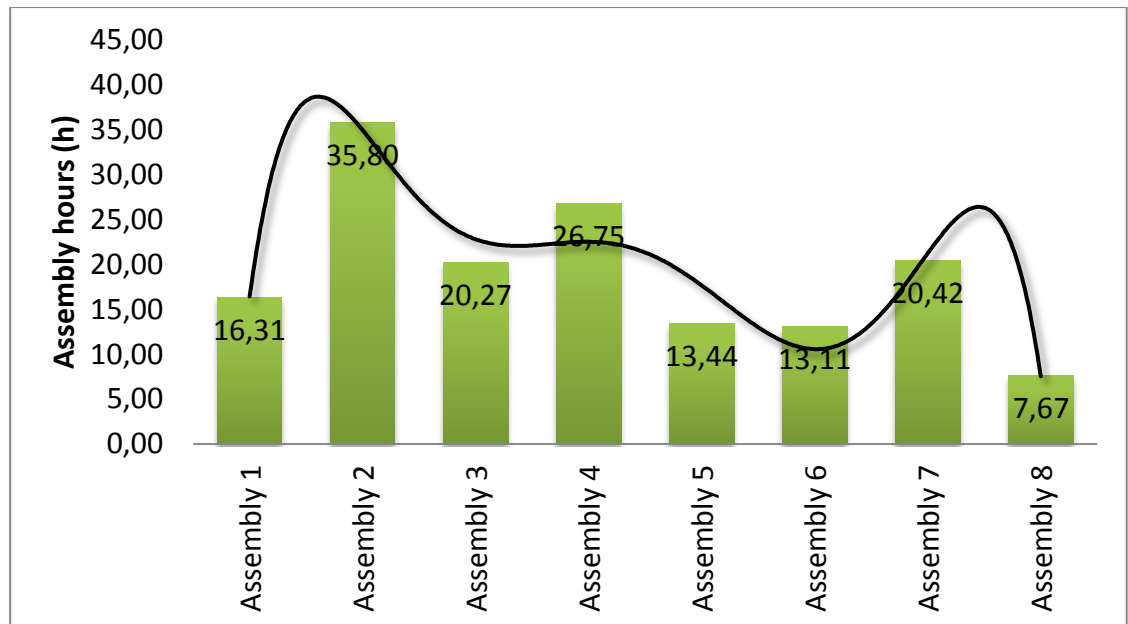


FIGURE 13. Assembly hours of Driveline 2

A long throughput time might be caused also by a waiting time. If the required component is not available, the assembly work is disturbed. These kinds of errors also contribute to increasing the assembly time. It is not possible to determine whether the peaks in the assembly time log are caused by the recording errors or problems in the component supply. For this reason, the recorded time was not used in the manufacturing costs calculations.

Eventually the working costs were calculated by using the average assembly time of 15 hours. The assembly time was based on the interviews. The assembly labor cost per driveline unit was calculated by multiplying the labor cost per hour with the average assembly time. The manufacturing labor costs are calculated in Appendix 1 by using the following formula:

$$\text{Assembly labor cost} = \text{Assembly labor cost (EUR/hour)} \times \text{Average assembly time(hours)}$$

### **Assembly facility costs**

The facility costs of the assembly place were calculated by including the costs of heating and lighting. At the moment the driveline assembly is running in one shift, which means eight hours per day. The assembly work is done in the pre-assembly hall where also the assembly of cabins and booms is performed. Although the driveline assembly is done only in one shift, the lighting costs are calculated for two shifts. This is done based on the fact that lights of the driveline assembly are switched on for 16 hours per day because of the other pre-assemblies that are performed in two shifts.

The driveline assembly place utilizes two units of 58-watt fluorescent lights and five units of 250-watt light bulbs. The cost of the electricity was given from the facility management. The cost included the electricity tax and the transferring cost. Since the electricity cost varies according the stock price, there was used the average cost for electricity. Lighting cost of the assembly place is calculated in Appendix 4 by using the following formula:

***Annual cost of lighting equipment*** = *Light item price x Light lifetime + Cost of electricity x Power consumption x Annual usage*

***Lighting cost of assembly place*** = *Number of fluorescent lights x Annual cost + Number of light bulbs x Annual cost*

Driveline assembly place requires a floor area of 122 m<sup>2</sup>. The height of the pre-assembly hall is 5,3 meters. From the total floor area approximately 40% is required for the temporary warehousing of components. The heating costs of the assembly place per driveline unit were calculated from the total cost of the annual heating oil usage.

***Cost of heating for driveline assembly cell*** = *Total volume of MCO facilities / Volume of driveline assembly place x Cost of heating year 2011*

***Heating cost per driveline unit*** = *Cost of heating for driveline assembly / Volume of driveline units year 2011*

### **Assembly Equipment Costs**

The equipment costs of the assembly place were calculated by estimating the power consumption of the hoist crane. The components – the engine, transmission and radiator – are lifted during the assembly process by using a typical hoist crane with the maximum load of 5 tons with power of 3kW.

A crane is utilized normally three times during the assembly process of a driveline unit. First, when the engine is lifted to the assembly jig. Second, when the transmission is lifted and attached to the engine. Third, when the radiator is lifted and attached to the engine. Based on the observation at the assembly place, the crane is operated maximum for 2 minutes in each phase. Hence, it is estimated that the time needed for the lifting per each driveline assembly is 6 minutes.

The power consumption is calculated with the power of 1,5kW since the full lifting capacity of the hoist crane is not used in the driveline assembly.

***Electricity cost per driveline unit*** = *Power consumption x Usage time per driveline unit x Cost of electricity*

Equipment costs of the assembly place are calculated in the Appendix 3.

## Warehousing costs

Components that are used in the driveline assembly cause warehouse costs.

Components are purchased from the suppliers and delivered into the receiving area of MCO. Components are moved into the stock to wait for the assembly.

Warehousing costs consist of inventory capital, personnel, facility and equipment.

The capital is measured by using an interest rate of 10%. This rate illustrates how much money is lost by keeping the inventory. Warehousing costs are calculated with numbers in Appendix 2. Capital cost was calculated by using the following formula:

$$\textbf{Working capital} = \text{Total stock value} - \text{Accounts payable} + \text{Accounts receivable}$$

$$\textbf{Capital cost} = \text{Interest rate } 10\% \times \text{Working capital}$$

$$\textbf{Capital cost of driveline} = \text{Capital cost} \times \text{Percentage of driveline of total stock cost}$$

$$\textbf{Capital cost per driveline unit} = \text{Capital cost of driveline} / \text{Annual volume of driveline units}$$

Stock value of driveline components was calculated by sorting the stock places from the Excel sheet containing the total contents of the warehouse. By using a programmed query, it was possible to print out a document that contains all the stored materials with the item values and the shelf locations. Along with the stock value, also the total number of shelf slots was calculated. By using sort function also shelf slots reserved by driveline components were calculated. Values of accounts payable and accounts receivable were received from the financial department of MCO.

Based on the Excel sheet it was found out that approximately 7% of the warehouse space is used for driveline components. When looking at the inventory value, the driveline components covered approximately 19% of the total inventory value. The warehouse data used in this study was gathered in the beginning of March 2012.

### **Warehouse personnel costs**

It is estimated that the warehousing of components used in the driveline assembly requires approximately the work contribution of one warehouse worker. Based on this assumption, the operational warehousing costs are calculated by dividing the salary costs of one warehouse worker by the number of drivelines produced at MCO annually. Salary costs were received from the HR department. The cost excluded annual bonuses, which normally vary between 0% - 8% of the total salary based on the product output.

### **Warehouse equipment costs**

It was assumed that the warehousing of components used for driveline assembly requires one additional forklift truck. MCO utilizes counterbalance forklift trucks that are rent from external service provider. The annual rental cost a the forklift was divided by the total number of drivelines produced 2011 in order to calculate the cost per assembled driveline unit.

### **Warehouse facility costs**

Warehousing facility cost was calculated from the cost of heating and the cost of lighting. The warehouse is illuminated by 39 units of 58-watt fluorescent lights and 60 units of 250-watt light bulbs.

The lighting costs were based on a calculation, which included the unit cost of lighting equipment and the annual cost of illuminating the facility. It was estimated that lighting is utilized 20 days per month and 16 hours per day. The lighting cost calculation can be seen in the Appendix 4.

***Annual cost of lighting equipment*** = *Item price x lifetime + cost of electricity x power consumption x annual usage*

***Total lighting cost of warehouse*** = *Number of fluorescent lights x annual cost + Number of light bulbs x annual cost*

***Warehouse lighting costs for drivelines*** = Total lighting cost of warehouse / Total number of storage places x Storage places required for Driveline assembly

The warehouse heating costs per driveline unit was calculated from the total cost of the annual heating oil usage. By using the drawings of the factory layout, it was calculated that the indoor floor area of the warehouse facilities is approximately 3000 square meters. With the height of 5,3 meters it was calculated that the volume of the warehouse space is approximately 16000 cubic meters.

The heating costs of the warehouse were calculated from the total heating costs of MCO. The cost per one driveline unit was calculated with the percentage of the stock space required for the driveline assembly. Calculations can be seen in the Appendix 3.

***Cost of heating for warehouse*** = Total volume of MCO facilities / volume of indoor warehouse space x Cost of heating year 2011

***Warehouse heating cost per driveline unit*** = Cost of heating for warehouse x Percentage of stock place required for driveline assembly / volume of driveline units in 2011

### 5.2.2 Cost Distribution

Values of different cost factors were combined into one table that is enclosed in the appendix 5. Percentage distribution of cost factors is illustrated in the pie chart of figure 14 that displays the contribution of each value to a total.

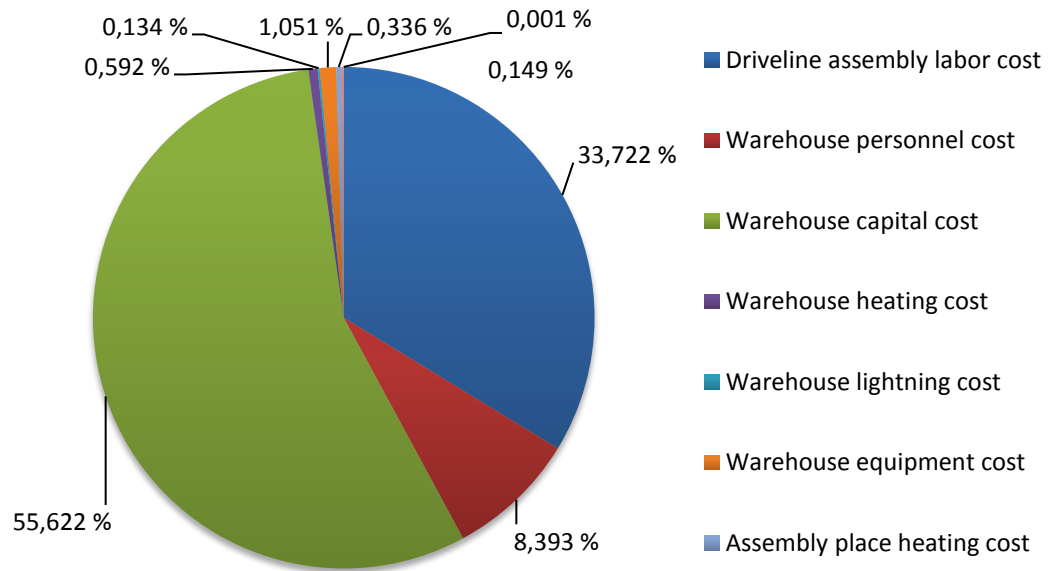


FIGURE 14. Distribution of assembly cost factors

As seen from the chart, majority of the assembly costs are formed by the capital cost and the assembly labor cost. The facility and equipment costs play relatively small role, when it comes to the contribution of costs. The big portion of the warehouse capital costs is caused by the high stock value of components used in the driveline assembly.

## 6 FEASIBILITY STUDY

After the current state definition the feasibility study was performed. The purpose was to identify the capabilities of external resources and to clarify if there were limitations that complicate the outsourcing. The risk assessment was done in order



to find out possible risks related to the outsourcing proposal. Benefits of both making and buying of assembly were analyzed.

## **6.1 Market Analysis**

The market analysis was conducted in order to clarify the possibilities of buying the assembly service of the driveline. The aim was to find out, if there was a supplier that would be capable to perform the assembly work. The purpose was also to clarify, what would be the cost for the assembly work performed by an external supplier.

The cost of outsourced assembly was observed by sending a request for quotations to four different suppliers. The candidates selected to the enquiry were already in the supplier base of the Manufacturing Company. The letter was sent to the suppliers who deliver the main components of the driveline.

- Supplier 1 – Dealer for the transmission units
- Supplier 2 – Dealer for the radiator units
- Supplier 3 – Dealer for the Engine Manufacturer 1
- Supplier 4 – Dealer for the Engine Manufacturer 2

The purpose of the RFQ was to find out if there were potential suppliers available. The main idea was to find out what are the process costs at the possible supplier. Suppliers 1,2 and 4 had already shown general interest in the project. There was no knowledge about the interest of Supplier 3 in advance.

The letter included RFQ for three driveline combinations that were observed in this study. The suppliers were required to give an explicit quotation for the price per assembly hours and an estimation of the time required for the assembly.

Although the RFQ concerned only three driveline combinations, the supplier candidates were informed about the whole picture of the driveline assembly. It was stated that in the ideal customer-supplier relationship along the assembly work the supplier would also be responsible for the purchasing activities for all required SKUs.

The request for quotation was sent via email to supplier candidates in March 2012. At the beginning, the deadline for quotations was set to three weeks. Due to the amount of questions and request for information the deadline was extended to 5 weeks. The supplier candidates were given answers via email. The annual volume, the quality assurance, the assembly process and technical issues were main topics for the questions.

Supplier candidate 1 asked for an opportunity to observe the assembly process at the premises of MCO. Visit was arranged in a way that two representatives of the supplier candidate 1 came to follow the assembly for a one shift. At the assembly place there was going on an assembly of three driveline units. All of the assemblies were going in different phases, which gave visitors an opportunity to get proper understanding about the overall assembly process during one day.

It was notable that the supplier candidate 3 did not show any kind of interest in the project although the company is doing remarkable business with MCO. Management and Board of Directors of supplier candidate 2 assessed the RFQ. The supplier 2 informed that assembly service including purchasing, inventory control and logistics was too complex and too far away from the company strategy. Therefore the supplier 2 did not submit the quotation.

## **6.2 Comparison**

The cost comparison of different supply solutions was made after the quotations were received from the supplier candidates. The comparison was made by comparing the costs of assembly work of the supplier candidates to the cost of assembly performed at MCO. Eventually supplier candidates 1 and 4 submitted the quotation for the assembly. These quotations were evaluated in the comparison part.

The quotations excluded the costs for materials, purchasing, warehousing, transportation and packing materials. Also the investments required for tools, transportation jigs and the cost for assembly workshop were not included in the

quotation price. Cost comparison with price information can be seen in the Appendix 6.

Quotation submitted by the supplier candidate 1 included cost of assembly work. The supplier also gave price estimation that included the costs of necessary equipment, production area and updating of internal routines.

The estimated time used for assembly was 16 hours. The supplier informed that the assembly of driveline units would require large investments. Due to the investment requirements the supplier was not able to deliver annual demand of units at the beginning. It was estimated that at first the supplier is able to deliver 80 units assembled by one mechanic. The given number was approximately 27% of the total demand of MCO in year 2011.

The supplier 1 required that during the first 12 months of operation MCO would be taking responsibility of the procurement process. The company proposed that after one year the cooperation would be evaluated.

The quotation of the supplier candidate 4 included price per man-hour and an estimation of the average assembly time required per unit. The figure given for the labor also included all side costs for labor. Given estimation of the average assembly time was 16 hours.

Average assembly hours are compared in the table 5. It can be seen that either of the suppliers are not able to perform the assembly faster.

TABLE 5. Comparison of average assembly hours

Average time required for assembly	
MCO	15 hours
Supplier 1	16 hours
Supplier 4	16 hours

The comparison revealed that the assembly hour price of the supplier candidate 1 was 126% higher than the assembly labor cost of MCO. The assembly hour price with the supplier candidate 4 was 38% higher. When looking at the assembly price per driveline, the difference increases up to 141% due to a longer assembly time. With the supplier candidate 4 the figure was 47% higher compared to the cost at MCO. Percentage differences in assembly labor costs are illustrated in the Figures 15 and Figure 16.

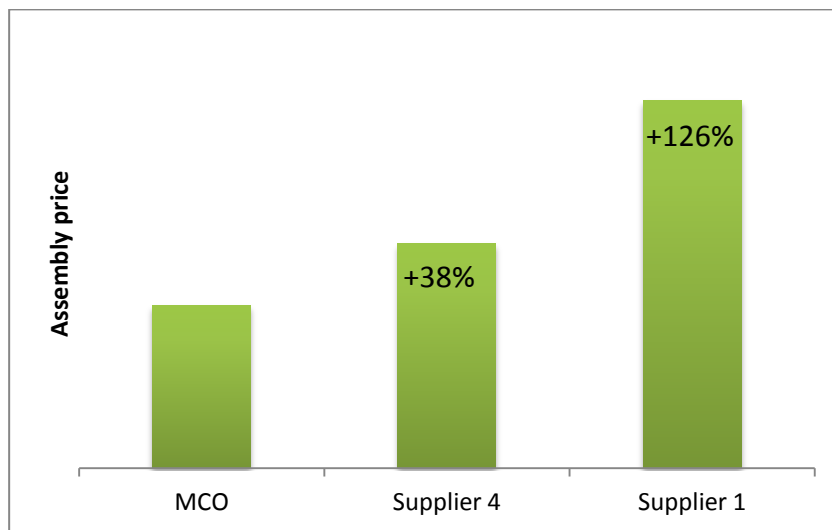


FIGURE 15. Assembly hour cost

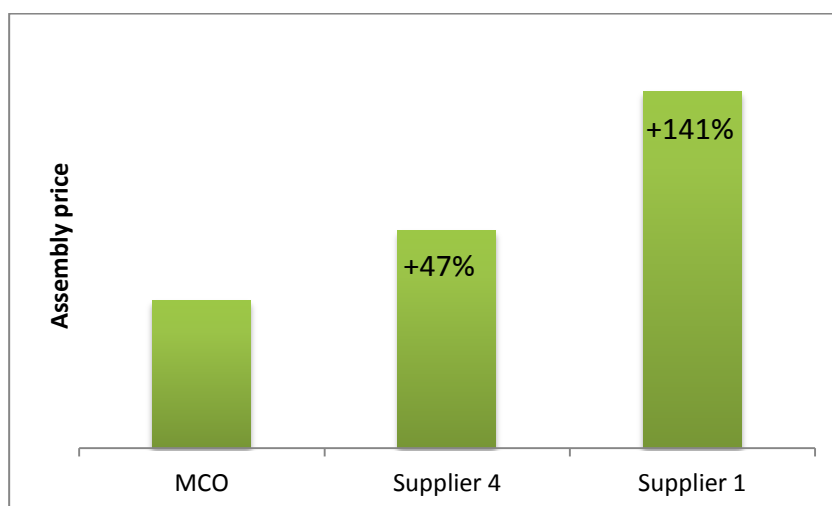


FIGURE 16. Assembly cost per driveline

The assembly cost comparison of the driveline assembly is illustrated in the table below. The assembly labor costs per driveline unit are compared to the total cost of assembly work done at MCO. Because the RFQ excluded other than assembly process costs, there is made a rough estimation of other costs that are added to the assembly labor costs. The assembly cost comparison is illustrated in the Figure 17.

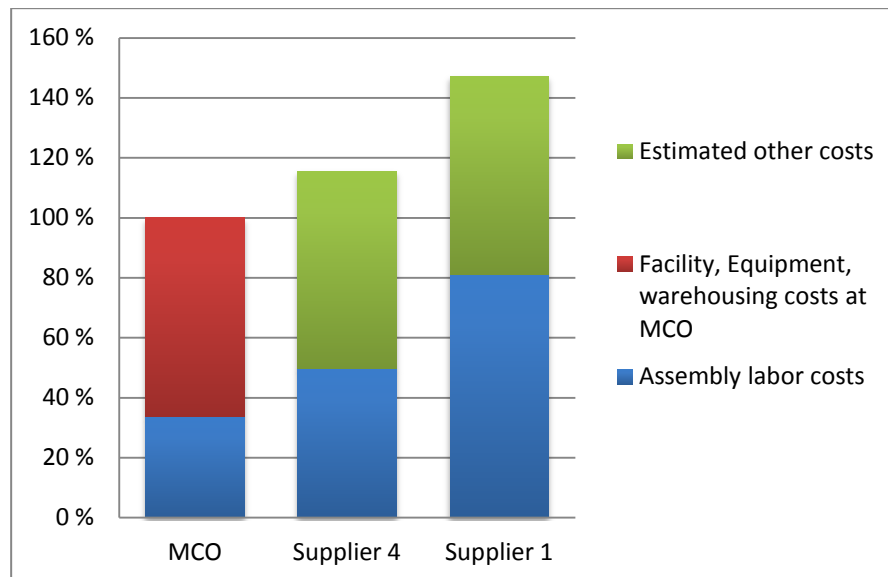


FIGURE 17. Cost comparison of the driveline assembly

## 6.3 Risks Assessment

The purpose of the risks assessment was to identify what kind of risks should be considered if MCO moves forward in the outsourcing process.

### 6.3.1 Changes in demand

During a long delivery time it is possible that the specification of the product changes on short notice. If the supplier does not have enough flexibility in its delivery capabilities, this would lead to a situation where MCO receives complete driveline unit that is not compatible for the final assembly. In such situation, the driveline unit must be modified to the correct form at MCO, which requires that MCO still has to have an assemble place to conduct assembly work. It would also require that there exists stock of components to perform corrective assembly.

Other option is that the driveline unit is put to stock to wait for a next demand.

Waiting time can be relatively long in case of rarely used driveline combination. In practice MCO would need to keep highly valuable driveline units in stock and hope that there occurs demand for the specific combination. This would partially eliminate the benefit of decreased stock that is achieved with outsourcing.

Due to sudden changes in specification, the supplier must be able to deliver complete units with short delivery time. This obviously requires that the supplier has to have remarkable amount of buffer stock so that it is able to react quickly to the changes in demand.

In some case the supplier might deliver a driveline unit that has correct engine but the transmission is not what the customer eventually requires. In such a case the driveline unit would be left in the stock to wait for use. Otherwise the unit must be disassembled and fixed.

It is also important to take significant business growth into account. Operations of the MCO are expected to grow 30 percent annually. The capacity of the supplier must be considered. Even though the supplier is able to deliver drivelines according to current demand it must be ensured that it is capable to cope with the business growth. Since the increase of sales at MCO is directly related to the number of driveline units required, it is crucial that the supplier is able to deliver higher amount of units in the future.

### **6.3.2 Material Structure Errors**

Based on the interviews at the assembly place, it was noticed that there occur errors in the material structures. Mechanics informed about a case, where according to documentation there should have been made an installation of cabin air conditioning to the driveline unit. Before assembly mechanic had noticed that the end product is an open cabin vehicle, which does not include window glasses.

Such errors aggregate when operations are moved outside. The external service provider does not have high level of experience and tacit knowledge, which would decrease the probability of mistakes to occur. It is estimated that the service provider would not question the documentation so easily.

### **6.3.3 Quality**

The driveline unit can be referred as a heart of the vehicle. If the driveline unit fails during its operation, the customer cannot operate the vehicle. Due to the crucial role of the driveline, the quality of the assembly work must be taken into account when considering the outsourcing possibility.

At the moment there is not a defined quality assurance system that would be used in the driveline assembly. Functionality and correctness of the driveline unit assembly is tested after the final assembly when the unit has been installed to the vehicle. There is not any testing equipment used to ensure proper assembly before the final installation. Currently the quality of the assembly is ensured by the mechanics. Assembly work is done carefully and the correctness is observed visually. There is higher risk for errors to occur, when the assembly work is done by an external supplier with less experience.

## **6.4 Problems and Challenges**

The definition of problems and challenges in the outsourcing of driveline assembly was done based on the interviews and observations at the assembly place. During the study there was identified four main topics that make the outsourcing more difficult; timing and space, inadequate documentation, materials management and number of type variants.

### **6.4.1 Timing and Space**

A complete driveline unit should be delivered to the final assembly with exact timing so that MCO could decrease its stock value. This requires that the assembly is done strictly according to the production schedule. At the moment the production of MCO is not fully compatible for such delivery system. Due to several issues the production has problems in keeping to the schedule. It is common that the planned production schedule is not met due to delays in assembly. Such delays are caused e.g. by stockouts of the required components.

It is also typical that the production planning changes the production order of the vehicles. Big customers might put pressure on the delivery time, which might force MCO to deliver some vehicles in shorter time. In order to realize this, the production schedule must be restructured.

Delays and changes in production lead to a situation where the delivered complete driveline units start to pile up to the warehouse. Delivered drivelines require indoor stock space, which is already starting to run out. Stock space is added if the whole driveline assembly would be done outside the company. This benefit would be decreased if the new free stock space would be filled with driveline units that wait for the final assembly. The storing of complete driveline units requires use of transportation cradle. Due to the big size and the need for cradle, units cannot be stored in a regular pallet shelf. In addition, the complete driveline units would increase the value of stock significantly.



#### **6.4.2 Inadequate Documentation**

The level of documentation can be seen as a challenge of outsourcing. There is a lot of essential information missing in the assembly documents. This is tacit or practical knowledge that cannot be seen in the documentation. This problem is faced especially with the old designs. The situation is better with the new models.

Over the years mechanics have gained experience and information of the assembly process that is not visible in the documentation. For example, some tightness rates of bolts are based on a mutual knowledge. Processes done with a so-called gut feeling are difficult to transfer to an external party. People have got used to performing tasks by memory, therefore pressure has not been put on the design department about the level of documentation. There might be wrong and inadequate information in the documentation, mechanics have accepted it and thought: "This document is poor, but I know how to install the component." It would require improvement work of the documentation and a lot of consultancy should be given to the supplier in order to make the outsourcing possible.

#### **6.4.3 Materials Management**

At the moment MCO does not have proper tools for materials management that would support the outsourcing of driveline assembly. In order to purchase complete driveline units from the supplier, MCO must be able to inform the supplier that it needs to deliver a basic driveline unit with certain additional accessories. In practice MCO purchasing needs to create a purchase order that combines all the necessary items (basic driveline, A/C cells, hydraulic pumps etc.) into one order. The sent order informs the supplier what engine + transmission combination is used and what optional components are installed.

With the current system structure used at MCO, it is not possible to create individual purchase orders with a specific item number, which would include the required components for the driveline unit.

One solution is to arrange different modules into one single driveline set where the assembly phase is added to each of the modules, such as the driveline, exhaust system, heat isolation and inlet air system piping. By this method a set of items is created that is purchased instead of making an individual purchase order of every item separately. The set of items appears in the MRP as one single item.

There are yet some problems included in the set forming. For example driveline units with air conditioning option are problematic since the air conditioning module includes all the components that are required in the vehicle, not just the driveline unit. When the A/C option is added to the driveline set, also components that are not attached to the driveline unit are included in the set. By this way, the purchasable driveline set would include e.g. cabin related air conditioning components.

It is possible that the driveline supplier would deliver also these not-driveline-related components along with the driveline unit. This would yet require that the cabin assembly is scheduled according to the driveline unit deliveries. If the driveline units are delivered late, the cabin assembly will stop.

Set forming is a structure-based definition, which is valid only for a specific vehicle. This means that the set forming must be done separately for every driveline unit ordered. In addition, it must be done in the PDM system before accepting the unit into the “In production” –state. This would cause additional work in the production planning and require changes in the process.

#### **6.4.4 Number of Type Variants**

As mentioned earlier, MCO has currently 15 different driveline variants in use. In addition to this the optional accessories increase the number of different kind of unit entities. With the current materials management systems controlling of such number of variants is very challenging.

## **6.5 Benefits of In-house Assembly**

The current operations model offers flexibility to the production. Due to a high level of stock MCO is capable to react relatively fast to changes in customers' requirements. MCO faces situations where customers decide to change the specification of the vehicle at short notice.

The pre-assembly is done in the same building with the final assembly. Close distance brings flexibility when there occurs need for fixing errors or making changes to the assembly.

## **6.6 Benefits of Outsourced Assembly**

The outsourcing of the driveline assembly would free space that could be used for other applications. The assembly space could be used for other pre-assemblies that are done at MCO. Whether the pre-assembly space of cabins or booms could be expanded by taking the new free space into use. Reserved warehouse space could be transformed to a pre-assembly space or it could be utilized for warehousing of other items.

The space that is reserved for the driveline assembly is not suitable for the final assembly of the vehicles. Due to its height of 5,3 meters, the pre-assembly hall is too low for performing the final assembly.

The production throughput time is decreased if MCO receives complete driveline units. At the moment the average time used for driveline assembly is 15 hours. By purchasing complete driveline units from an external supplier, there would be no need for the inventory of driveline components. This would decrease the stock value of MCO by approximately 19%. In addition, approximately 7% of free warehouse space could be created.

## 7 RESULTS

In order to get real benefit out of the outsourcing, MCO must move the whole pre-assembly of the driveline units to the external supplier. The assembly cost structure definition showed that the majority of the costs are caused by the components that are kept in the stock. Partial outsourcing of the assembly does not remove the need for the inventory of expensive engines and transmission units. Based on the study, the only possibility to get significant stock savings is to reduce the driveline components from the stock by performing the assembly outside the company.

The assembly of the drivelines is manual work where possibilities to use automation is minimal. Large number of different variations makes the use of automation even more difficult, even impossible. In the comparison of the assembly costs it was notable that neither the supplier candidate 1 nor 4 are able to perform the assembly work in shorter time. This gives an impression that the supplier candidates do not have the methods to perform the assembly work with higher efficiency.

Due to the nature of the assembly, it is difficult to conduct the assembly work with a significantly higher efficiency. Based on the comparison, efficiency of the driveline assembly is at a competitive level at MCO compared to the supplier candidates. The average assembly time at MCO is 15 hours whereas supplier candidates 1 and 4 estimated that the assembly process requires an average 16 hours. According to the results, it is not possible to get financial benefit with the outsourced assembly when looking at the assembly process costs.

Due to the properties of the per-assembly hall it is not possible to increase the number of final assembly cells in the current facilities. The current driveline assembly cell is feasible for other pre-assemblies or warehousing space. Problem is that these kinds of layout changes do not increase the number of end products that are dispatched to the final customer.

In order to make the outsourcing of driveline assembly reasonable, MCO should have smaller number of different variations, which would make materials management easier. This would require a massive re-structuring in design department. On the other hand, MCO would lose partially its strategic strength by decreasing the variety of products. With a smaller product variety customer might be forced to make compromises in product specification. At the moment customers' requirements are fulfilled with remarkably high level.

Market analysis excluded the cost of facility, equipment and warehousing. Based on the cost structure definition, assembly process costs cover 33 % of the total assembly cost. Because there is required flexibility in the delivery of the drivelines, it is indispensable for the possible supplier to maintain relatively big buffer stock of the components. It is estimated that the compensation of facility, equipment and warehousing costs would increase the total price of the assembly significantly.

There would be a need for the special transportation jigs if the complete driveline units would be delivered to the final assembly of MCO from the external supplier. Transportation jigs would require significant investments because the driveline unit cannot be transported on a regular pallet due to its big size and prominent shape.

Outsourcing of the driveline assembly requires long transition phase due to the complexity of assembly and great number of different unit variants. Transition would require a lot of time and effort from the sourcing company and the supplier. There should be a significant financial benefit achieved in order to make such a heavy transition worth of executing.

The current materials management system creates significant limitations for the outsourcing proposal. Due to the materials structures, ordering of complete drivelines is not possible to make logically. Major changes and development should be done in the materials management in order to make the outsourcing possible. Based on the reasoning stated in this study, outsourcing of the driveline assembly is not reasonable and recommendable at the moment.

## 8 CONCLUSION

The objective of the study was to clarify the possibilities to improve the productivity of pre-assembly by purchasing complete units instead of separate components that are put together in the premises of the assigner company. The study was performed to the assembly of driveline units.

By purchasing complete units from an external party, the throughput time of the production would be decreased. In addition, the value of inventory would be decreased by one fifth.

In this thesis it was found out that the operations model and the materials management of MCO do not support ordering of complete driveline units. Based on the study there are no suppliers available to perform the assembly work with higher efficiency. According to the study it is not possible to improve the productivity of pre-assembly by increasing delivery contents, when it comes to assembly of driveline units. Hence, the outsourcing proposal was not recommended.

The market analysis performed during the study gave valuable information about the supplier candidates. If MCO decides to move towards outsourcing at some point in the future, there is already information achieved about the interests and capabilities of the suppliers. Based on the quotations it was notable that supplier candidates 1, 2 and 4 showed their interest in the project whereas supplier candidate 3 did not respond to the RFQ at all.

Further cost comparison should be done in order to get more accurate results about the profitability of the outsourcing. As the study was limited to the process cost comparison, the cost compensation of additional cost factors is not included in the comparison. If the outsourcing proposal is taken in to a further consideration, more in-depth cost calculations and the RFQ should be made. The logistics cost factors warehousing, purchasing and transportation systems should be taken in to account in the cost figures.

Several figures used in the study were estimates. In the assembly cost structure definition cost factors such as the warehouse and the assembly cell facility cost are not measured results because they are calculated from the statistical data. In addition, quotations received from the suppliers are rough estimates. If MCO moves forwards with the outsourcing proposal, it is estimated that the quotation prices will vary. Due to the early phase of the project, supplier candidates were not required to give in-depth quotations. Submitting of more accurate and detailed quotation would require much longer period of time. In addition, supplier 1 based the quotation on 80 units, which is only a part of the total volume of units. In long run the unit cost would be lower when the total volume increases. The quotation price was still used in the comparison, because it was estimated that the price difference would not affect to the final result.

Even though the cost calculations included estimates, they are not affecting the reliability of the results. Along with the monetary figures, the outcome of the study was based on the intangible factors such as operations model and limitations caused by the current the materials management system and production.

The assembly cost structure model created in this study can be used also in other feasibility studies. By changing figures and parameters, the same cost model can be applied for other pre-assemblies as well. In the future it might be useful to investigate the possibilities to use an external assembly service provider for other pre-assemblies, since it is essential to find out solutions to decrease stock values and to create more free space.

In the future MCO should study the possibilities of the partial outsourcing of the assembly work. It should be studied if it was reasonable to purchase for example assembled engine + transmission pairs and do the rest of the assembly work at MCO.

Due to the internal limitations, MCO should put more focus on its own operations management before taking steps towards outsourcing. Internal operations should be improved to a level, where the different departments function more systematically. The short notice demand changes should be removed by keeping the freezing point

of the production stable. The sales department should offer delivery times that are realistic from the engineering department point of view in order to reduce the amount of late BOM changes. Of course this is not a simple task to do, since the delivery time is one of the factors that affect the competitiveness of the company.

The modular structure of the products should be developed in a form, which would take purchasing capabilities into account. At the moment it is not possible to make purchase order of the complete driveline unit with the correct contents.

Along with the driveline assembly, the development in operations management would open up new possibilities also with the other pre-assemblies. MCO has increased its business at incredibly high rate over the past few years. In order to sustain such a growth, the improvement process of operations should be constant. More and more networking and partnership solutions could be adapted to improve the productivity when the manageability of the internal operations is improved.

At the moment the outsourcing of driveline assembly is not a solution that would create benefit. MCO has issues to improve that are not fixed by moving the function outside the company. Currently the outsourcing of driveline assembly would only move problems from one assembly hall to another, which is not a solution that would be profitable and functional. If the company has not a full control over its internal operations, it is likely that better results cannot be achieved with external resources.



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