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Evidencing and Sharing Value with Decision Making Models in an Industrial Maintenance Network

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ABSTRACT

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Keywords: value, co-creation of value, value sharing, business networks, industrial maintenance networks, maintenance contracts, the value-based life-cycle model, the flexible asset management model

The objective of this thesis is to concretize the potential benefits that the industrial maintenance case network could achieve through using the value-based life-cycle model and the flexible asset management model. It is also inspected what factors prevent value creation and sharing in the maintenance contract practices of the case network.

This thesis is a case study which utilizes modelling. Four scenarios were developed to demonstrate value creation in the future. The data was partly provided by the collaborating company, partly gathered from public financial statement information. The results indicate that value has been created through the past maintenance of the collaborating company's rod mill and that profitability of the collaborating company has been mostly on satisfactory level during the past few years. Potential value might be created by increasing the share of proactive maintenance of the rod mill in the future. Profitability of the network could be improved in the future through flexible asset management operations. The main obstacle for value creation and sharing seems to be the lack of sufficient trust between the network members.

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Tämän diplomityön tavoite on konkretisoida potentiaalisia hyötyjä, joita teollisen kunnossapidon case-verkosto voisi saavuttaa käyttämällä arvopohjaista elinkaarimallia ja joustavan omaisuudenhallinnan mallia. Sen lisäksi selvitetään mahdollisia esteitä arvon luomiselle ja jakamiselle verkoston nykyisissä kunnossapitosopimuskäytännöissä.

Tämä diplomityö on mallinnusta hyödyntävä tapaustutkimus. Arvon luomista tulevaisuudessa demonstroidaan neljän skenaarion avulla. Tarvittavat tiedot saatiin osaksi yhteistyöyritykseltä, osaksi julkisista tilinpäätöstiedoista. Tulosten perusteella näyttäisi siltä, että yhteistyöyrityksen tankomyllyn kunnossapidolla on luotu arvoa menneinä vuosina. Yhteistyöyrityksen kannattavuus puolestaan näyttäisi olleen viime vuosina enimmäkseen tyydyttävällä tasolla. Tulevaisuudessa olisi mahdollista luoda arvoa lisäämällä ennakoivan kunnossapidon määrää, toisaalta verkoston kannattavuutta voitaisiin parantaa joustavan omaisuudenhallinnan avulla. Pääasiallisin este arvon luomiselle ja jakamiselle näyttäisi olevan riittävän luottamuksen puute verkosto-osapuolten välillä.

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Miikka Havukainen

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LIST OF ABBREVIATIONS

FAM	Flexible asset management
LCM	Life-cycle model
MaiSeMa	Maintenance Services Management (research project)
ROI	Return on investment
OBA	Open-book accounting

1 INTRODUCTION

1.1 Background

Industrial maintenance has been increasingly outsourced to external parties (Sinkkonen et al. 2013, p. 330). Weakened financial situation has contributed this development as well as the trend of companies focusing on their core functions in order to achieve cost effectiveness and competitive advantage. Through outsourcing companies try to achieve not just cost savings, but also for example superior quality, resource optimization and increased safety. (Kivimäki et al. 2013, p. 178) Competition is no longer just between companies, but it has started to move into being between business networks (Peppard & Rylander 2006, p. 132, Kulmala 2003, p. 32).

As a result of increased outsourcing and networking, there is an increasing need for tools designed for network-level decision making (Kivimäki et al. 2013, p. 179). The value-based life-cycle model (LCM) and the flexible asset management model (the FAM-model) are examples of such tools. Both of these models are developed in Lappeenranta University of Technology as a part of an ongoing MaiSeMa -project (Maintenance Services Management: Industrial Maintenance Services in a Renewing Business Network: Identify, Model and Manage Value).

In this thesis the value-based LCM and the FAM-model are applied to Company X, the customer company of an industrial maintenance network. The network operates in a mining industry. At the request of the company, the company's real name is not revealed in this thesis. Also input data for the value-based LCM provided by the company as well as monetary amounts in the value-based LCM scenarios are hidden. Only Company X participated in this thesis, therefore the decision making models are applied to a fictional network. The past maintenance data of Company X's manufacturing equipment (rod mill) is reviewed through the value-based LCM and Company X's profitability in recent years is inspected through the FAM-model. After that alternative scenarios to create value jointly in the future and proposals how value created in those scenarios could be shared equitably are presented. In the value-based life-cycle scenarios the network consists of Company X and a fictional service provider, in the FAM-model scenarios there is also a fictional equipment provider included in the network.

1.2 Research objectives and limitations

There are two objectives in this thesis. **The first objective** is to concretize the potential benefits that Company X and the maintenance network can achieve through using the value-based LCM and the FAM-model. **The second objective** is to identify possible obstacles for co-creation and sharing of value in the current maintenance contract practices of the case network.

The objectives are approached through following research questions:

- *How can the existing value and the potential value co-created in the future be evidenced with the models?*
- *How could the co-created value be shared equitably between the network members in order to achieve a win-win situation?*
- *What factors prevent value co-creation and sharing in the current maintenance contract practices of the case network?*

Although only the customer company participated in this thesis, the importance of taking the whole network perspective into account is pointed out. Therefore in addition to customer value, also supplier value, co-creation of value and value sharing practices are inspected in the theoretical part of this thesis. To keep the focus clear, contracts are limited to maintenance contracts.

One of the main results the value-based life-cycle model presents is a proposition for the distribution of value in the network, based on value elements the user has chosen and weighted from the list of different value elements. However, the value element part is not utilized in this thesis and thus is the value distribution part neither. Due to this the value sharing concentrates mainly on monetary value sharing.

1.3 Research methods and data

This thesis is a case study which utilizes modelling. Woodside and Wilson (2003, p. 493) define a case study as a study that focuses on predicting, understanding, describing and/or controlling the individual (e.g. industry, organization or process). The empirical part of this thesis concentrates on an individual equipment and on a few distinct operations, thus making a case study a suitable research method for this thesis.

Empirical data for the models was partly gathered from the financial statements of Company X and partly provided by Company X. An interview of the maintenance contract practices was conducted as a discussion between the author, Company X's two representatives and the author's supervisors. According to Ellram (1996, p. 97) in most situations it is appropriate to utilize both quantitative and qualitative approaches to data analysis. Quantitative results can be expressed in numerical terms, whereas qualitative results are often verbally expressed in order to create an understanding of complex interactions or relationships.

1.4 Structure of the thesis

There are seven chapters in this thesis. The first chapter introduces the contents and the structure of the study. The second chapter sheds light on the previous literature concerning value and value sharing. The third chapter concentrates on industrial maintenance networks and maintenance contracts. The value-based life-cycle model, the flexible asset management model and the case network are presented shortly in chapter four. In chapter five the models are used utilizing the collected data and the maintenance contract interview is conducted. The results are also presented in this chapter. Conclusions and recommendations for future research are presented in chapter six. Chapter seven summarizes the thesis. The structure of the thesis is presented in table 1 below.

Table 1. The structure of the thesis.

Chapter	Title	Contents
Chapter 1	Introduction	Background, research questions, methods and data, structure of the thesis
Chapter 2	Co-creation of value and different methods for value sharing	Definition of value, a view of different value sharing logics
Chapter 3	Industrial maintenance networks and maintenance contracts	Definition of a network, factors needed for a working maintenance contract
Chapter 4	The case network and the presentation of the decision making models	Introduction of the case network and the used models
Chapter 5	Value creation scenarios	Results of the scenarios, interview of the maintenance contracts of the case network
Chapter 6	Conclusions and future research	Conclusions from the thesis, recommendations for future research
Chapter 7	Summary	Summary of the thesis

2 CO-CREATION OF VALUE AND DIFFERENT METHODS FOR VALUE SHARING

2.1 Definition of value in an industrial context

There is no unambiguous definition for value and different definitions of value are often vague (Chicksand et al. 2011, p. 81). Ramsay (2005, p. 550) states, that according to some writers the term value is difficult to define while on the other hand some writers seem to consider it so obvious that they do not explain its meaning at all, even though they use it in their texts. Like Ramsay, also Möller and Törrönen (2003, p. 110) note that defining value is seen as a challenging thing.

Value has been studied both from customer's (e.g. Woodruff 1997) and supplier's (e.g. Möller & Törrönen 2003) perspective. Majority of the research concerning the concept of value has focused on the customer perspective, i.e. *customer value*. This focusing is due to the assumption that supplier's success depends on their ability to create more value to their customers compared to competitors. (Walter et al. 2001, p. 366)

Based on the results of an exploratory study Zeithaml (1988, p. 14) defines customer value approximately as an overall evaluation of the usefulness of a product, which is based on understanding of what is given and what is got. Walter et al. (2001, p. 366) describe customer value as a compromise between sacrifices and benefits. This definition is about the same as Zeithaml's definition. According to Chicksand et al. (2011, p. 82) customer value consists of perceived value and exchange value. Customers determine customer perceived value, while exchange value is what customers are prepared to pay for a service or a product.

Dumond (2000, p. 1062) has formed a following summarization from a set of different definitions of customer value:

- customer value is linked to the use of a product or service, thereby removing it from personal "values"
- customer value is perceived by the customer rather than objectively determined by the seller
- customer value typically involves a trade-off between what the customer receives (e.g. quality, benefits,) and what he or she gives up to acquire and use a product or a service (e.g. price, sacrifices)

According to Möller and Törrönen (2003, p. 110) value is defined by some researchers primarily in monetary terms, while some use definitions that include also nonmonetary sacrifices and benefits, like managerial time spent and social relationships. In fact Simpson et al. (2001, p. 121) emphasize, that when defining customer value, both direct (monetary) and indirect (non-monetary) benefits and sacrifices must be taken into account. Figure 1 represents the formation of customer value in case of an individual customer. On the left side are direct and indirect benefits (e.g. economic benefits and social relationships), on the right side are direct and indirect sacrifices (e.g. price and loss of power).

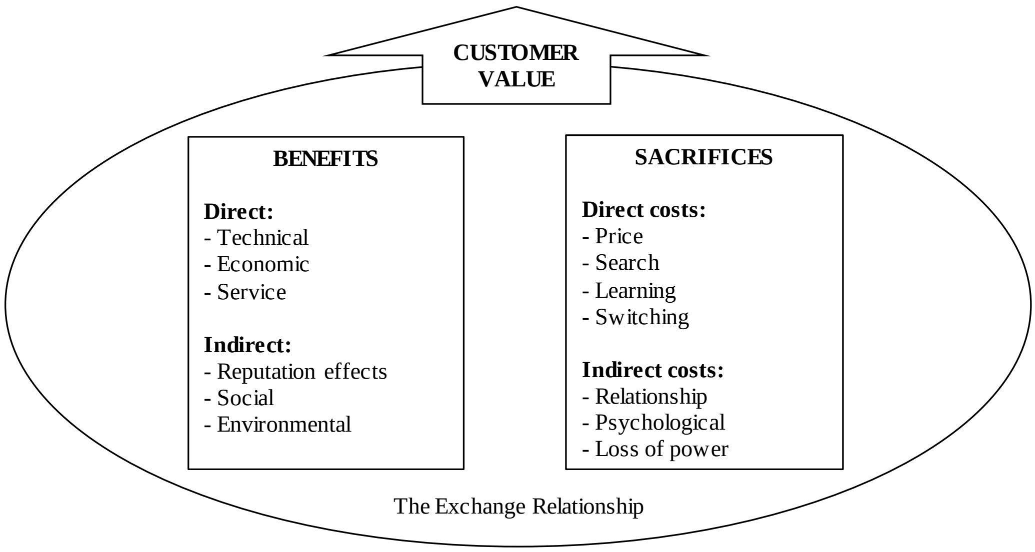


Figure 1. Customer value as a combined effect of benefits and sacrifices (adapted from Chicksand et al. 2011, p. 82).

In an exchange relationship there is always a supplier in addition to a customer and they both benefit from the exchange. Therefore it seems logical to state that value is also enjoyed by the supplier (Ramsay 2005, p. 554). Defining value only from the customer's perspective does not give the whole picture of the exchange relationship and therefore *supplier value* should be understood as well (Chicksand et al. 2011, p. 82).

Defining supplier value can be seen as a "mirror problem" to that of defining customer value. Like customer value, also supplier value can be regarded as a perceived trade-off between direct and indirect benefits gained and sacrifices incurred. A direct benefit for the supplier is e.g. revenues from the customer and indirect benefit is e.g. a possible process and product innovation with the customer. (Möller & Törrönen 2003, p. 110) Chicksand et al. (2011, p. 83) see supplier value as "the net benefits that a supplier receives in exchange for the product or service it produces and supplies to the market", which corresponds to the definition of Möller and Törrönen.

2.2 Co-creation of value

Creating customer and supplier value collaboratively in business relationships has been an increasing trend (Walter et al. 2001, p. 366) and therefore value in such relationships has been studied (e.g. Baxter & Matear 2004, Ulaga 2003). According to Lindgreen and Wynstra (2005, p. 739) relationship has value for the customer, because exchanges between customer and supplier become predictable and because in such a relationship new service or product solutions are likely to emerge. Ford and McDowell (1999, pp. 431-432) state, that relationship has value for the customer, because it will reduce the amount of work of the customer's purchasing personnel (in case that the customer concentrates its supplies to a single supplier) and may also reduce quality inspections and therefore bring cost savings. Respectively, relationship has also value for the supplier e.g. in form of reduced negotiation and selling costs and production runs that are more predictable (Möller & Törrönen 2003, p. 110).

Lindgreen and Wynstra (2005, pp. 738-739) recognize two main focus trends in literature concerning relationship value: one that concentrates on *value creation through* relationships or *in* relationships and one that concentrates on the value *of* relationships themselves. The preceding statements of relationship value are associated with the value *of* relationships. Next, *value creation in* relationships will be studied.

Value creation is the essential reason for business relationships to exist (Walter et al. 2001, p. 366). Recent studies highlight that value emerges not only through the use of good or service, but also from the mutual interaction processes between suppliers and customers. At the same time, technological complexity, specialization and knowledge intensiveness are increasing in many industries, making the customer and supplier more dependent on each other's resources and knowledge. Therefore collaboration and extensive interaction between customer and supplier is crucial in value co-creation. (Aarikka-Stenroos & Jaakkola 2012, p. 15)

Lindgreen and Wynstra (2005, p. 738) also propose that because marketing can be seen as a continuation of exchanges between different actors, more value can be created in relational exchanges than in transactional exchanges. That's why it is important for companies to maintain the quality of their business relationships.

According to Grönroos (2011, p. 242) there is a common understanding that the value is created in customer's processes as value-in-use and thus it can be concluded that in a business relationship the customer is the value creator (of value-in-use). Grönroos and Helle (2010, p. 570) clarify the roles of a supplier and a customer in the process of value creation in a business relationship with the help of the following figure 2. It can be seen that the customer creates alone the value-in-use (soft value creation) with resources provided by the supplier or with resources that are otherwise available. This does not require interactions with the supplier. The role of the supplier is to facilitate the value-in-use creation process by providing the customer with value-supporting resources, but it is important to notice that value as value-in-use is *not* created in value facilitation. (Grönroos & Helle 2010, p. 570)

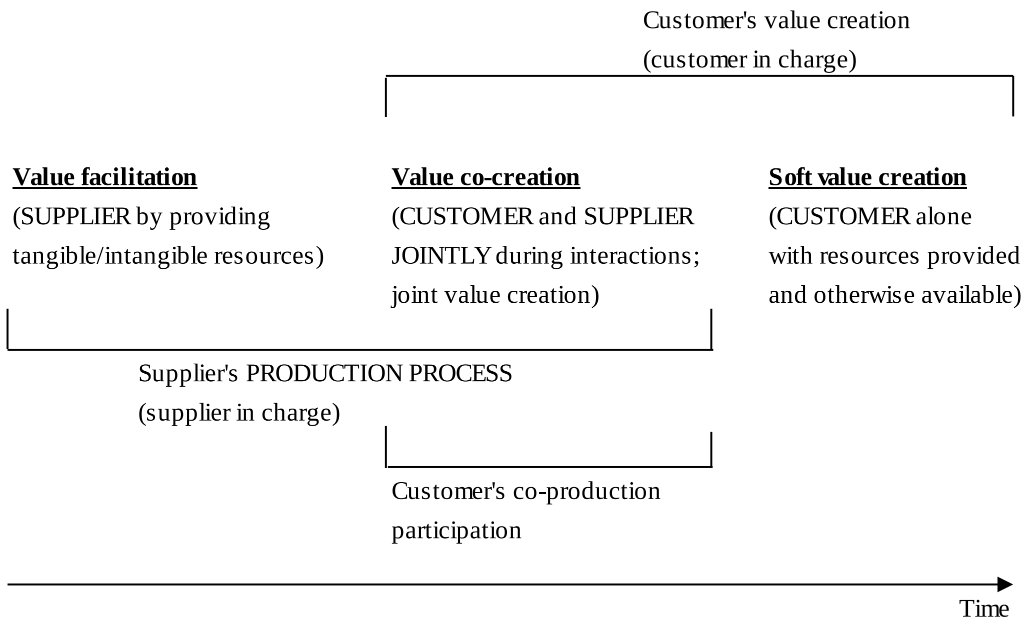


Figure 2. Role of the supplier and the customer in the value-creating process (Grönroos & Helle 2010, p. 570)

In a business relationship there are, however, all kinds of interactions between the customer and the supplier (e.g. negotiations, maintenance of an equipment) and in those situations customer's and supplier's processes run at the same time, causing interactions. When such interactions occur, the supplier may get opportunities to directly influence the value-creating process of the customer, thus becoming co-creator of value with the customer. As it can be seen in figure 2, if value co-creation occurs, the customer participates in the supplier's production process as a co-producer and at the same time the supplier participates in the customer's corresponding process and is thus engaged directly in the value creation process of the customer. (Grönroos & Helle 2010, p. 570)

However, joint value creation (value co-creation) is only possible if interactions between the supplier and the customer occur and if the supplier utilizes the possible opportunities provided by these interactions. Even then the supplier is a *co-creator* of value, not a *value creator*. (Grönroos & Helle 2010, p. 570) In other words according to this way of thinking value is created solely in the customer's processes. The supplier does not create any value, but only aids the customer in its value creation.

Based on the presented ideas of value it can be concluded that when considering value in a collaborative business relationship context, both the customer's and the supplier's perspective should be taken into account as well as the aspects of value co-creation. Customer and supplier value, on the other hand, consist of monetary and non-monetary benefits and sacrifices. Although value and value sharing are mainly considered from the monetary point of view in the empirical part of this thesis as well as in the following chapter 2.3, it is important to keep the non-monetary aspect in mind.

2.3 Value sharing practices

Even if value is jointly created in business relationships, it is not necessarily shared equally between the members. Despite the possible efforts for cooperation, individual companies will try to get as much of that value as possible for themselves. The way in which value is shared depends on many factors, including the following factors that can vary both within and across industries: (Chicksand et al. 2011, p. 86)

- pricing models (the way in which suppliers present their offers)
- purchasing evaluation models (the way in which customers evaluate offers from suppliers)
- the power relationship between the supplier and the customer
- the amount of customer value the supplier is able to present in its sales offering and the amount of supplier value the customer is able to present in its purchasing offering

In a situation where only the other member of the business relationship is dependent on the other, the non-dependent party has likely predominance of the value sharing (this refers to the power relationship between the supplier and the customer). But if power between the supplier and the customer is somewhat equally balanced, the core resources (money, product or service) and the accessory features (e.g. behaviors and commitments) each has to offer become much more important. (Chicksand et al. 2011, p. 93)

Table 2. Features of equal and unequal sharing of value (adapted from Chicksand et al. 2011, p. 89).

Customer-skewed adversarial	**Non-adversarial**	**Supplier-skewed adversarial**
Customer's commercial goals fully achieved	Each party's commercial goals partially achieved	Supplier's commercial goals fully achieved
Supplier invested more in relationship-specific adaptations	Equal distribution of relationship specific adaptations	Customer invested more in relationship-specific adaptations
The customer pays a price which is significantly lower than their utility function (reservation price)	The customer pays a price which is mid-way between its utility function and the supplier's mean cost of production	The customer pays a price which is very close to its utility function
The supplier receives only normal or slightly above normal profit	The supplier receives average profits for the industry sector (comparable companies operating at the same supply chain stage)	The supplier receives sustained above average profits for industry sector
The terms of the contract or agreement favour the customer (i.e. pricing, payment terms, exit clauses etc.)	The terms of the contract or agreement favour neither the customer nor the supplier	The terms of the contract or agreement favour the supplier

Chicksand et al. list characteristics of unequal and equal sharing of value (table 2). The non-adversarial column represents equal sharing of value. It should be noted, that value can be shared equally between the customer and the supplier, even if they are not engaged in an actual cooperative business relationship. On the other hand, a highly collaborative business relationship is not a guarantee for equal sharing of value. (Chicksand et al. 2011, p. 89)

But then, is it always necessary to share value equally? In some cases it may be only appropriate for the other party to get the bigger share of the co-created value. Therefore, instead of sharing the co-created value equally, it is important to share co-created value *equitably* between the members in order to keep the whole relationship competitive (Sinkkonen et al. 2013, Kivimäki et al. 2013).

According to Cox (2004, pp. 413-416) an "ideal" win-win situation, where both the customer and the supplier fully achieve their "ideal" outcomes is not possible in real business relationships, because if the other party achieves the "ideal" outcome, it inevitably means that the other party does not. This is due to fact that the customer's ideal outcome is to achieve constant increase in functionality with constant reduction in total costs of ownership, whereas the supplier's ideal outcome is to achieve constant increase in share of market and customer revenue with constant increase in prices and service or product profitability. Therefore, according to Cox, the possible win-win situations in business relationships are a) customer and supplier both partially win, b) customer wins but supplier only partially wins and c) supplier wins but customer only partially wins.

Grönroos & Helle (2010, pp. 578-584) present a model for measuring and sharing mutually created value in a case where the customer has outsourced or is planning to outsource some of its activities to the service provider. The key points of the model are the measurement of the joint productivity gains (*JPG*) and the sharing of these *JPG*s through price as value to the service provider and to the customer. Joint productivity gains are e.g. reduced work time (its monetary worth) and increased revenues for the customer. The first step is to measure the *JPG*s by equation (1) (Grönroos & Helle 2010, p. 578):

$$JPG = (\Delta EEC - \Delta IEC) - \Delta IES \quad (1)$$

where

JPG	is the joint productivity gain
ΔEEC	is the change in customer revenues
ΔIEC	is the change in customer costs
$(\Delta EEC - \Delta IEC)$	is the change in customer's value-in-use
ΔIES	is the change in provider costs

Simply put, the equation (1) shows the monetary amount of the potential *JPG*s to be shared with the customer and the service provider, when the difference between change in customer revenues and change in customer costs is taken into account together with the change in service provider costs. If *JPG* is greater than zero, it means that the net change in customer revenues and costs exceeds the change in provider costs, which the provider has incurred in the outsourcing process. In other words, joint productivity gains are only created, when *JPG* is greater than zero. If *JPG* is lower than zero, no *JPG*s – and thus no value – is created. (Grönroos & Helle 2010, p. 578)

After the potential *JPG*s have been measured, the next step is to share the joint productivity gains through a pricing mechanism to the customer and to the service provider. This is done with equations (2) and (3). (Grönroos & Helle 2010, p. 579)

$$CVC = JPG * (1 - P) \tag{2}$$

$$PVC = JPG * P \tag{3}$$

where

CVC	is customer's share of the *JPG*s through price in monetary terms
PVC	is provider's share of the *JPG*s through price in monetary terms

P	is provider's share of the *JPG*s in percentages

The last step is to define the relative worth of the proposal, i.e. to define how much value the customer and the service provider could achieve through the outsource process. The relative worth of the proposal to the customer is measured with equation (4). (Grönroos & Helle 2010, p. 580) Value-in-use – as explained in chapter 2.2 – refers to the value created by the customer in its processes.

$$(ValueInUse_B - Price_B) > (ValueInUse_A - Price_A) \tag{4}$$

where

Value-in-use (*B*)	is the value-in-use of the proposal
Price (*B*)	is the price associated with the proposal
Value-in-use (*A*)	is the value-in-use of the existing situation or a competing alternative
Price (*A*)	is the price associated with the existing situation or a competing alternative

If the difference between the value-in-use of the proposal and the price associated with the proposal (the left side of the equation) is higher than the difference between the value-in-use of the existing situation and the price associated with the existing situation (the right side of the equation), it means there is potential (co-created) value for the customer to achieve. The actual amount can be seen when the right side of the equation is subtracted from the left side. (Grönroos & Helle 2010, p. 580)

The relative worth of the proposal to the service provider is measured with equation (5) (Grönroos & Helle 2010, p. 580):

$$RW_p = (\Delta P - \Delta C) \tag{5}$$

where

RW(p)	is the relative worth for the provider
ΔP	is the change in price
ΔC	is the change in provider costs

If the relative worth for the provider is positive, it means that the new proposal allow the service provider to charge a higher price that exceeds the increased provider costs. In other words, the provider has achieved (co-created) value. (Grönroos & Helle 2010, pp. 580-581)

Marttonen et al. (2013a) also propose a concrete logic to share value in flexible asset management contracts. Simply put, flexible asset management contracts are maintenance contracts incorporated with flexible asset management thinking. In flexible asset management contracts e.g. the ownership of the assets and spare parts can be shared between the service provider and the customer. Also the potential importance of the payment term decisions in the contract's profitability is highlighted.

In the flexible asset management model (see chapter 4.3) company's *ROI* is affected by *FA%*, which is the amount of fixed assets in company balance sheet compared with company net sales. If two companies (A and B) decide to share the ownership of fixed assets, they first need to find out how the change in fixed assets affect each one's *ROI*. This can be solved with equation (6). (Marttonen et al. 2013a, p. 656)

$$\Delta ROI_{FA\%} = ROI(FA\%_2) - ROI(FA\%_1) \tag{6}$$

where

$\Delta ROI_{FA\%}$	is the change of the *ROI* caused by an adjustment in the amount of fixed assets

$ROI(FA\%_2)$ is the *ROI* calculated with the adjusted *FA%*

$ROI(FA\%_1)$ is the *ROI* calculated with the initial *FA%*.

Let's assume that company A takes fixed assets from company B's balance sheet into its own balance sheet. Due to this company A's profitability decreases but company B's profitability increases. Presumably, company A wants a compensation for its decreased profitability. The price of this "asset ownership service" should be set somewhere between the profits of company B and the losses of company A in order for both companies to benefit from the arrangement. A suitable price can be determined with equation (7). It is possible that profits decrease for both companies or the increased profits of company B are lower than the decreased profits of company A. In these cases there is no agreeable price, which means that there is no value to be shared either. It is also possible that shifting assets from company B to company A increases profitability for both companies. In such a case the service price can be used to share the profits between company A and B, using a logic accepted by both companies. (Marttonen et al. 2013a, p. 656-657)

$$-\Delta ROI_A * (D_A + E_A) < p < \Delta ROI_B * (D_B + E_B) \tag{7}$$

where

p	is the price charged by company A from company B for taking the ownership of the asset
$\Delta ROI(A)$	is the decrease of the *ROI* caused by the increased fixed assets in company A
$\Delta ROI(B)$	is the increase of the *ROI* caused by the decreased fixed assets in company B
$D(A)$	is the amount of long-term debt in company A
$D(B)$	is the amount of long term debt in company B
$E(A)$	is the amount of equity in company A
$E(B)$	is the amount of equity in company B

Besides the ownership of fixed assets, also the ownership of spare part stock and payment terms are taken into account in flexible asset management contracts. They both can be handled together, because they both have an impact on the cycle time of operational working capital (see equation (10) in chapter 4.3). As was the case with fixed assets, also before value sharing of payment term alterations and spare part stock ownership can be determined, the impact of these actions on companies' *ROI* must be defined first. This is done with equation (8). (Marttonen et al. 2013a, p. 657)

$$\Delta ROI_{CCC} = ROI(CCC_2) - ROI(CCC_1) \tag{8}$$

where

ΔROI_{CCC}	is the change of the *ROI* caused by an adjustment in the cycle time of operational working capital
$ROI(CCC_2)$	is the *ROI* calculated with the adjusted CCC
$ROI(CCC_1)$	is the *ROI* calculated with the initial CCC

After the impact on *ROI* is defined, the process and the logic of sharing value are similar to the process and logic described for fixed asset ownership procedures. Therefore equation (7) can be used also in pricing payment term alterations and spare part stock ownership. (Marttonen et al. 2013a, p. 657)

3 INDUSTRIAL MAINTENANCE NETWORKS AND MAINTENANCE CONTRACTS

3.1 Definition of business networks

Companies' tendency to concentrate on their core competencies has led to outsourcing of activities that have traditionally carried out internally. This, in turn, has led to the formation of business relationships and networks. (Möller & Törrönen 2003, p. 109). Thus, competition is no longer just between individual companies, but has started to move into being between business networks (Peppard & Rylander 2006, pp. 132, Sinkkonen et al. 2013, pp. 332, Kulmala 2003, pp. 32). According to Ulaga (2003, p. 677) business networks offer notable opportunities for companies to achieve excellent results and gain competitive advantages.

According to Henneberg et al. (2010, p. 355) business networks are "complex, systemic webs of interdependent exchange relationships" consisting of complicated exchange structures and interactions as well as multifarious actors. However, it can be questioned whether all organizations of a business network are really dependent on each other in reality. For example a big industrial customer is unlikely to be very dependent on a small service provider, but the service provider may, instead, be strongly dependent on the customer. Hohenthal et al. (2014, p. 11) state that business networks consist of at least two different business relationships interconnected in a way that business in other relationship is dependent on other relationship's business. Business relationships can also be connected indirectly to other relationships that have some effect on them.

According to Hohenthal et al. (2014, p. 11) it can thus be assumed, that there are no intentionally created boundaries in business networks, but the boundaries are in fact defined by views of observers and network members. They also state, that network is widely seen in studies as a place where firms can gain experience and learn new. In addition to business relationships with suppliers, customers and other actors the knowledge is created in social relationships between the people who do the business. Network is a larger system of both directly and indirectly connected relationships and it works as a system that shares information between network members.

The view of business networks as channels for information sharing is also shared by Håkansson and Ford (2002, p. 133). They describe network as a structure consisting of nodes that are connected to each other by certain threads. Business units (service and manufacturing companies) are the nodes and the relationships between these companies, in turn, are the threads. The threads and the nodes are "heavy" with knowledge, resources and understanding in multiple different forms. This "heaviness" is the result of complex investments, interactions and adaptations that have occurred over time within the companies and between them. There are not just individual, separate transactions between companies, but instead each company is linked to many other companies in many different ways through its relationships.

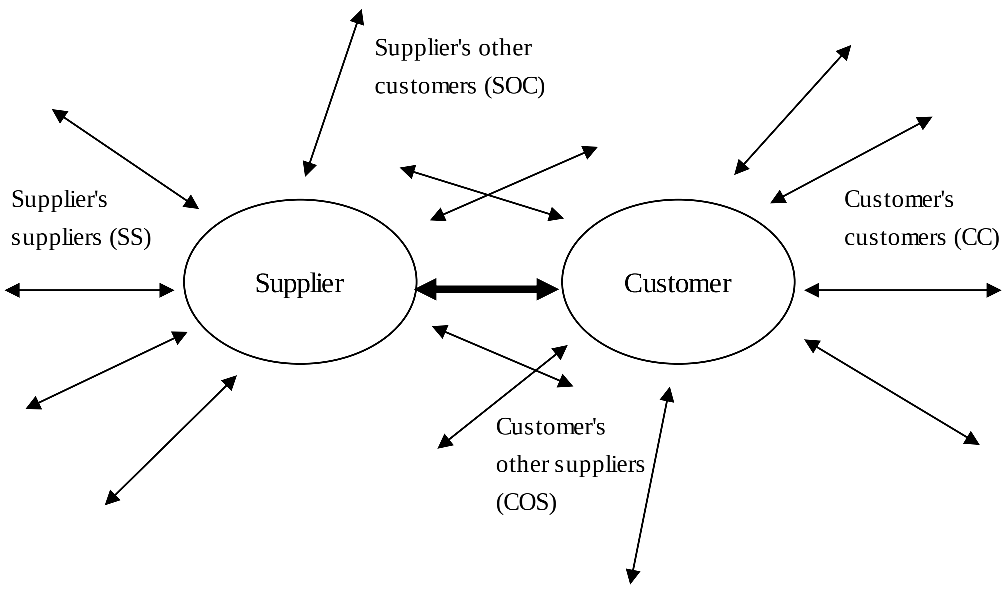


Figure 3. A focal business relationship and how it is related to the business network (Blankenburg-Holm et al. 1999, p. 474).

Blankenburg-Holm et al. (1999, pp. 473-474), in turn, define a business network as two or more business relationships that are connected, which is somewhat similar to the presented definition of Hohenthal et al (2014). Blankenburg-Holm et al. demonstrate the relation of business relationships and business networks as presented in figure 3 above. The thick arrow illustrates the focal business relationship between the supplier and the customer. But as it can be seen, the customer's customer relationships (CC), the customer's other supplier relationships (COS), the supplier's supplier relationships (SS) and the supplier's other customer relationships (SOC) may all be connected to the focal business relationship.

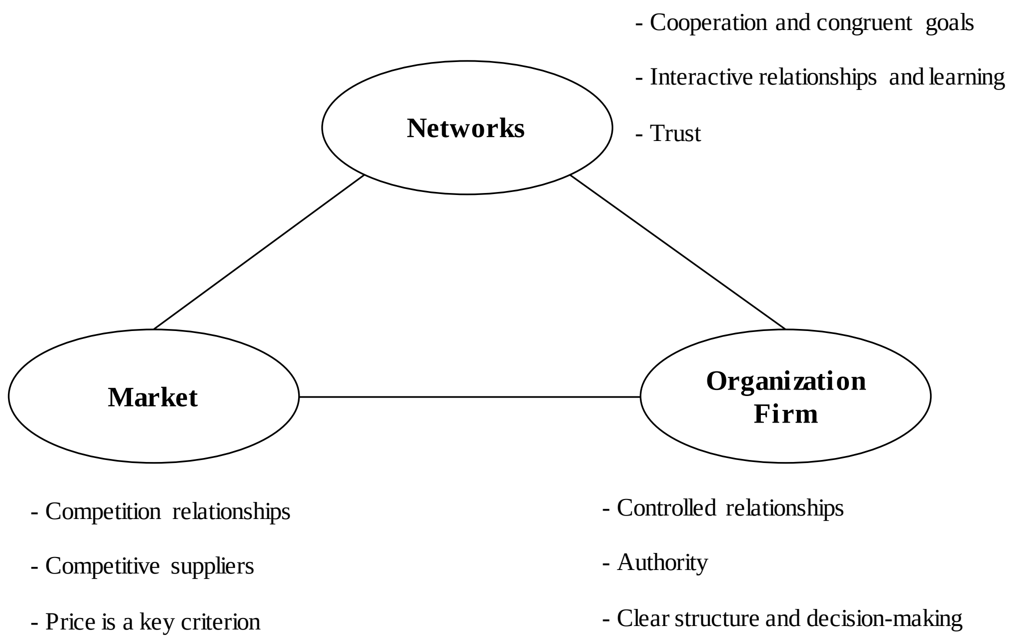


Figure 4. Networks, hierarchies and markets as forms of organization (adapted from Valkokari et al. 2009, p. 12).

Valkokari et al. (2009, p. 12) illustrate the positioning of networks between the two basic forms of organization as shown in figure 4. Next to or below the bubbles are listed some characteristics of each form of organization, e.g. in networks trust between the partners has an important role. In order to understand the opportunities of networks, managers have to also recognize the alternative ways to operate. Network is one option, but there are challenges when operating in a one. Like the basic forms of organization, networks are also affected by market mechanism (e.g. competing suppliers and competitive relationships), because although working in cooperation, the network members are still individual companies that are primarily running their own interests.

Möller et al. (2004, pp. 8-9) state, that definitions of net and network are not unambiguous and therefore different terms are used to describe the same thing and respectively, the same term is used to describe different things. For example terms *value networks* and *strategic networks* are used. In fact, Möller et al. (2004, p. 10) separate terms *net* and *network* in a way, that *net* is seen as a network-organization formed by specific croup of companies and other organizations and is built consciously and purposefully. Net has an objective(s) which control the actions and development of the net, but every network member has still one's own goals as well. *Network*, on the other hand, is seen as a basically boundless, business crossing "network tissue" which consists of relationships between companies and other organizations.

3.2 Rise of industrial maintenance networks

Industrial maintenance has been increasingly outsourced to external parties (Sinkkonen et al. 2013, p. 330). This has led to the formation of industrial maintenance networks between the customer, the equipment provider or the service provider. According to the presented definitions of net and network by Möller et al. (2004), this kind of industrial maintenance network wouldn't be in fact a network but a net. On the other hand, although the basically boundless nature of networks is also shared by other presented definitions, this definition by Möller et al. (2004) can be seen to refer to a wider context, basically to the whole modern market. Therefore, to keep the focus clear, the term net is not used in this thesis.

In the wake of maintenance outsourcing also the number of inter-organizational cooperation and cooperative industrial maintenance networks has increased. Through outsourcing companies try to achieve e.g. cost savings, superior quality, resource optimization and increased safety. (Kivimäki et al. 2013, pp. 178-179). Other reasons for maintenance outsourcing and maintenance collaboration are e.g. the need to share risks, knowledge and resources as well as the need to achieve flexibility and efficiency in production (Ahonen et al. 2010, p. 563).

Different reasons for outsourcing in general are listed in figure 5. As can be seen, the differences between US and European based organizations are relatively small. The two most important factors are cost control and aim to achieve best practice. Organizations often outsource activities, which have varying work patterns when it comes to performance and burden. Maintenance can be considered to be this kind of activity. (Fernández & Márquez 2012, p. 166) The reasons in figure 5 are approximately the same as are the major reasons for maintenance outsourcing listed by van der Meer-Kooistra and Vosselman (2000, p. 63).

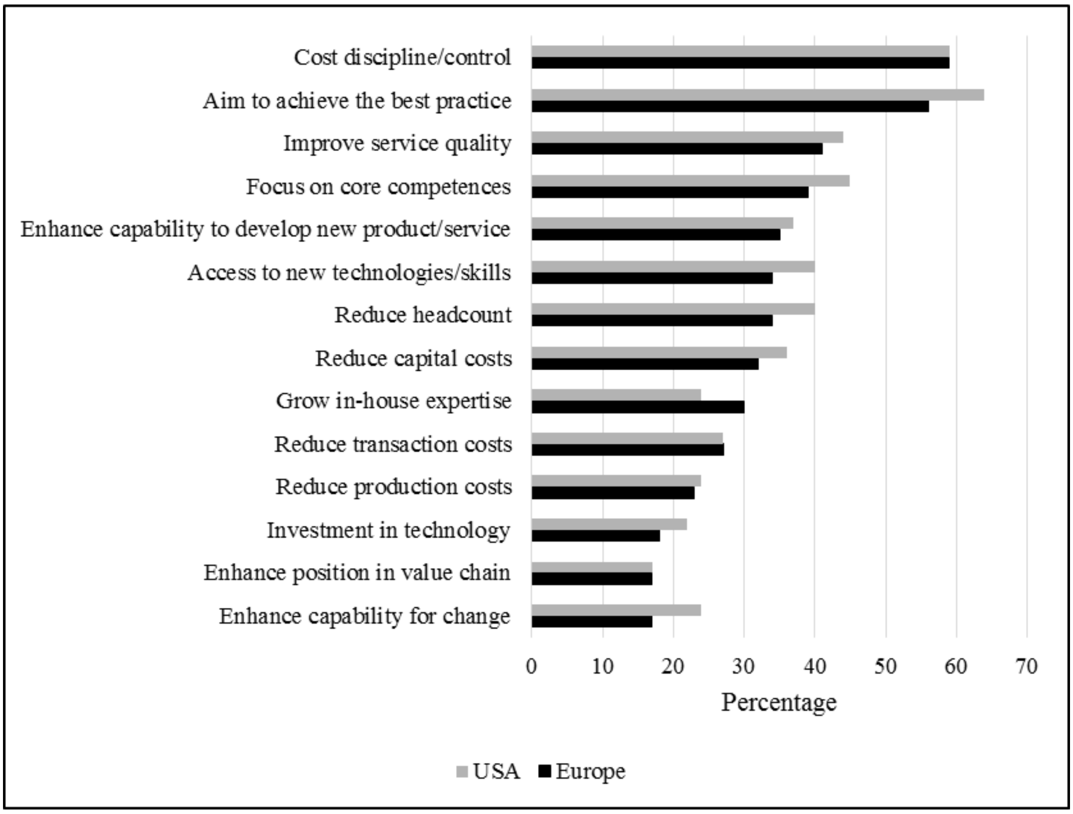


Figure 5. Reasons for outsourcing in European and US based organizations (adapted from Fernández & Márquez 2012, p. 166).

Fernández and Márquez (2012, pp. 167-168) have also listed advantages and disadvantages of outsourcing. Potential advantages are e.g. 1) cost reduction, 2) costs restructuration (changing fixed costs by variable costs in terms of provided services), 3) improving company focus, 4) access to outside expert knowledge and 5) moving resources for other purposes. Potential risks and disadvantages are e.g. 1) loss of skills or knowledge through transfer to the supplier, where they are more difficult to improve and retain (this happens regularly), 2) dependence on the supplier may cause adverse consequences for the customer 3) unfulfilled or questionable expectations and 4) loss of staff motivation (the customer's employees feel their jobs are valueless).

Members of a maintenance network may have many different reasons for being a member of the network in question. Some of these reasons may never be shared with other network members, even if the network has commonly acknowledged objectives. This type of secrecy is a common thing in business, but it may also result in a fear of opportunistic behavior. The risk of opportunistic behavior may be reduced by clearly pointing out the negative effects opportunism has on collaboration as well as clarifying the advantages of efficient collaboration. The management of a healthy maintenance network should not be based on a vast variety of formal rules and complicated contracts, but instead occurring problems should be solved flexibly and in genuine cooperation. (Ahonen et al. 2010, p. 579) However, as mentioned in chapter 2.3, each member of the network usually tries to maximize its own profits. Therefore the trust-based problem solving would probably be very difficult to implement in practice.

According to Levery (1998, p. 39) the business relationship between the customer and the maintenance service provider must be built on mutual understanding and trust. Instead of multiple specifications, the customer and the service provider should define how they cooperate in order to gain mutual benefits and thus create a win-win situation. If responsibility cannot be clearly assigned to either of the members, it should be shared together. To be able to achieve such a cooperative and trust-based business relationship, it is very important that the relationship is built to be a long-term.

3.3 Maintenance contracts

The importance of maintenance and other support services among industrial sector is increasing due to more and more complex and advanced industrial equipment. Customers are entering into service contracts either with independent service providers or with the original equipment provider. In the latter case the equipment provider provides also the maintenance service. Negotiation is an essential part of contracting and if service contracts are negotiated carelessly, it may result in low equipment performance and conflicts. (Kumar et al. 2004, p. 400)

According to Wang (2010, pp. 239-240) maintenance service contracts are multifaceted and they involve several conflicting aspects from both the customer and the service provider. Financial flexibility of the customer can be increased through the service contract, for example if the service provider offers to take over the customer's technical systems or ties the price of the service to the customer's output. On the other hand, offering maintenance services to the customer should bring profits to the service provider. Therefore taking over some parts of the customer's business risks and encumbrances the service provider may appeal more attractive to the customer and hence may get higher profits. As mentioned earlier, the management of a healthy network should be based on a genuine desire to solve things in cooperation. But as Wang presents, in reality the management seems to be based mainly on contracts.

There is no exact type of maintenance contract for outsourced maintenance, but the contents of the contract will depend on the offered services and the payment terms. The price of each individual work can be based, for example, on a catalog price or on a fixed price per service which will be paid in a predetermined time. A maintenance contract should include the following sections: heading, contract objective, useful definitions, scope of the works and technical, commercial, organizational and legal considerations. (Fernández & Márquez 2012, p. 169)

Also van der Meer-Kooistra & Vosselman (2000, pp. 56-57) state that comprehensive contracts cannot be made in situations “characterized by uncertainty and strong dependencies between the parties owing to specific investments.” Outsourced maintenance can be seen as such a situation. They also state that agreements in contracts made in mentioned situations need to be checked over passage of time. When negotiating the contract, trust plays an important role, because contract parties will assume that the needed revisions will be made with mutual satisfaction in mind.

The importance of improving the competitiveness of the whole industrial maintenance network should be kept in mind also when negotiating maintenance contracts. According to Kumar et al. (2004, p. 401) it is essential to analyze and define – in cooperation with the customer – what kind of services the customer and the equipment needs. The objective of a negotiation is to find a solution that satisfies all members and to reach mutual interest.

Kumar et al. (2004, pp. 408-412) conducted a survey to find out what factors are needed in order to negotiate a successful agreement and to reach a win-win situation. Based on the survey, a following list of key contents of a service contract was formed:

- price
- product reliability
- payment terms
- goals and scope of work
- operational requirements
- spare parts management
- overhaul and maintenance mission
- training and documentation
- types of services (e.g. planned and unplanned maintenance)

The survey also indicates, that the most common factors influencing the negotiation process are (Kumar et al. 2004, p. 409):

- customer’s organizational cultures and competence services
- government rules/regulations
- geographical locations
- customer’s own capabilities
- service provider’s own capabilities
- availability of competitors
- operational requirements
- product history and reputation
- customer corporate strategy regarding purchasing of services or maintenance policies
- types of services needed to prevent system downtime

Based on the survey it seems that the service delivery contract should be negotiated before the service is sold/bought in order to prevent misunderstandings between contract partners. And because the performance of the product and the service is the basis for a relationship between contracting parties, a system to measure whether or not the service has fulfilled its targets should be agreed upon. (Kumar et al. 2004, p. 411)

All in all, to ensure a long-term business relationship and to achieve the best agreement that satisfies both parties, all mentioned factors need to be considered and handled. Both parties should also keep in mind that there can be undesirable inputs that influence a negotiation process. Such inputs are e.g. unclear (or even wrong) information about what services are to be delivered and how they are to be delivered. These may cause conflicts and service delivery failures. Also if critical information is hidden from the other party, it may result in a non-optimal delivery of a service. Therefore transparency plays an important role. One relevant point is also the fact that during the negotiation process, it is impossible to know for sure what will happen in the future. That is why parties need to be ready to renegotiate if the original contract is no more feasible. (Kumar et al. 2004, pp. 410-411)

Tantardini et al. (2014, pp. 241-257) propose that because provider flexibility is highly appreciated by the customer, contracting partners should enclose costs of maintenance rescheduling in the maintenance contracts. E.g. if the customer's production level suddenly increases, it may require rescheduling of production machine's maintenance in order to reduce the risk of stock out. Measuring these costs can be used by the service provider as a monetary quantification of the flexibility it provides to the customer and thus be a basis for pricing the provided flexibility. Although it is obvious that the service provider aims for profits with offered flexibility, showing rescheduling costs to the customer clarifies the fact that an extra-flexibility is actually provided.

Before moving to the presentation of the case network and the used decision making models, a short review of *open-book accounting* is in order. Inter-firm accounting techniques like open-book accounting (or shortly OBA) are described as important ways to effectively manage costs in customer-supplier business relationships, to improve the quality of such relationships, to maintain control of outsourced activities and to increase efficiency of a supply network (Windolph & Möller 2012, pp. 47).

Collaborative networks provide potential opportunities for cost reduction, but this requires transparent cost structures and that network members are willing to share their cost data with each other. Sharing confidential information requires trust, and it is often mentioned as a prerequisite for open-book accounting. On the other hand, if the disclosed cost data is not misused OBA may actually contribute to building trust between network members. Therefore mutual trust can have a positive influence on business networks and rather than being a prerequisite for OBA, it may in fact be a result of open-book accounting. But although it is usually taken for granted that OBA has positive effects for all network members, empirical studies suggest that customers appear to benefit more from open-book accounting than suppliers. Revealing cost data may cause pressure on suppliers to reduce prices and it may also result as an unfair share in cost savings. (Kajüter & Kulmala 2005, pp. 180-183)

Successful OBA is most likely achieved in long-term hierarchical networks that manufacture functional products, consist of network relationships based on trust and provide a good infrastructure for OBA. Both social and technical requirements should be considered simultaneously in order to achieve a working OBA. Technical requirements mean that the existence of a proper cost accounting system should be ensured and support for data collection or improvement should be provided. Social requirements refer to mechanisms that decrease supplier's worries about the potential misuse of revealed cost data. (Kajüter & Kulmala 2005, pp. 202)

Cost data disclosure can be either unilateral (one-way) or bidirectional. In a unilateral cost data disclosure usually only the supplier reveals its cost data. Although unilateral cost data disclosure has been criticized by researchers due to potential chance for misuse of the shared cost information, this seems to be the dominant policy in practice. (Windolph & Möller 2012, pp. 48)

4 THE CASE NETWORK AND THE PRESENTATION OF THE DECISION MAKING MODELS

4.1 Introduction of the case network

Participating companies of the MaiSeMa-project operate in energy industry and in mining industry. The participating company in this thesis is Company X, which operates in mining industry. Company X represents the customer company of an industrial maintenance network, but because only Company X participated in this thesis the value-based LCM and the FAM-model are applied to a fictional network. The equipment which maintenance data is inspected in this thesis via the value-based life-cycle model is a rod mill of Company X. Rod mill’s relation to the mining process is shown in figure 6. Rod mill is part of Company X’s grinding and flotation process.

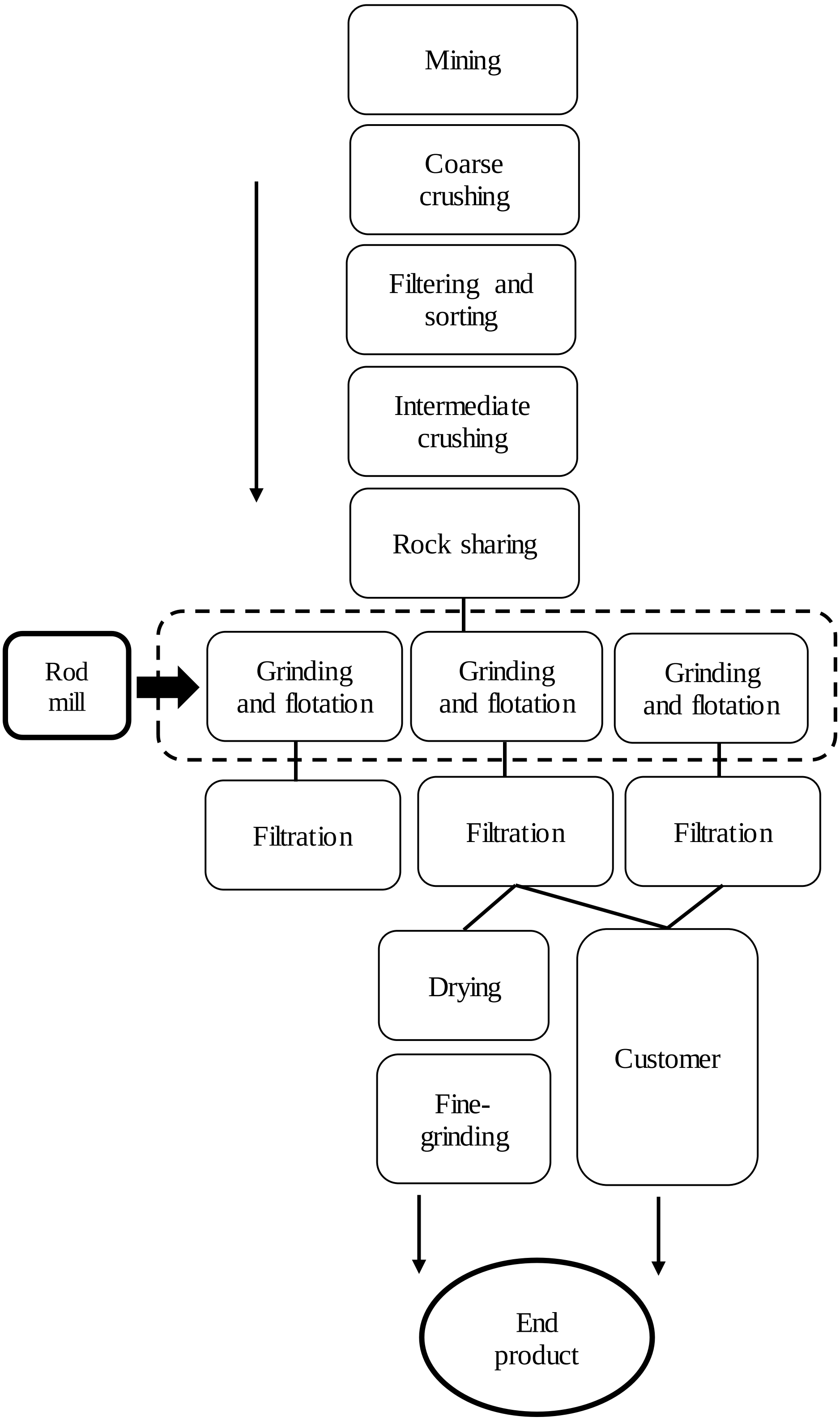


Figure 6. Position of the rod mill in the mining process (adapted from Kivimäki et al. 2013, pp. 184).

4.2 The value-based life-cycle model

The value-based life cycle model was created in Lappeenranta University of Technology by Kivimäki et al. (2013). The model was further upgraded to version 2.0 by Ylä-Kujala (2014) as a part of his master's thesis. Version 2.0 is utilized also in this thesis.

The model can be used in monitoring the life-cycle costs and profits of past maintenance. It can also be used to design how value can be created through future maintenance and how this created value can be shared equitably between the network members. In addition to these the model can be used to support maintenance contract negotiations. The value-based life-cycle model takes not just the customer company, but also the other members of the maintenance network into account. The model is designed to be used at item-level and it can be utilized separately in each company or as a mutual tool on the business network level. (Kivimäki et al 2013, pp. 178-184) The structure of the model is presented in figure 7.

As a main result the model shows cumulative present value of maintenance net profits (monetary value) and benefit-cost ratio. If cumulative present value of maintenance net profits is positive, cumulative present value of profits is greater than cumulative present value of costs. However, it should be noted that even if cumulative present value of maintenance net profits is negative in a certain year, it does not necessarily mean that *annual costs* are greater than *annual profits* in that year.

Benefit-cost ratio is calculated as cumulative present value of profits divided by cumulative present value of costs. If benefit-cost ratio is over 1, cumulative profits are greater than cumulative costs. The model provides also other results, e.g. the amount of lost profits of customer caused by maintenance stoppages and capacity underutilization. The customer sheet of the model is presented in appendix 1.

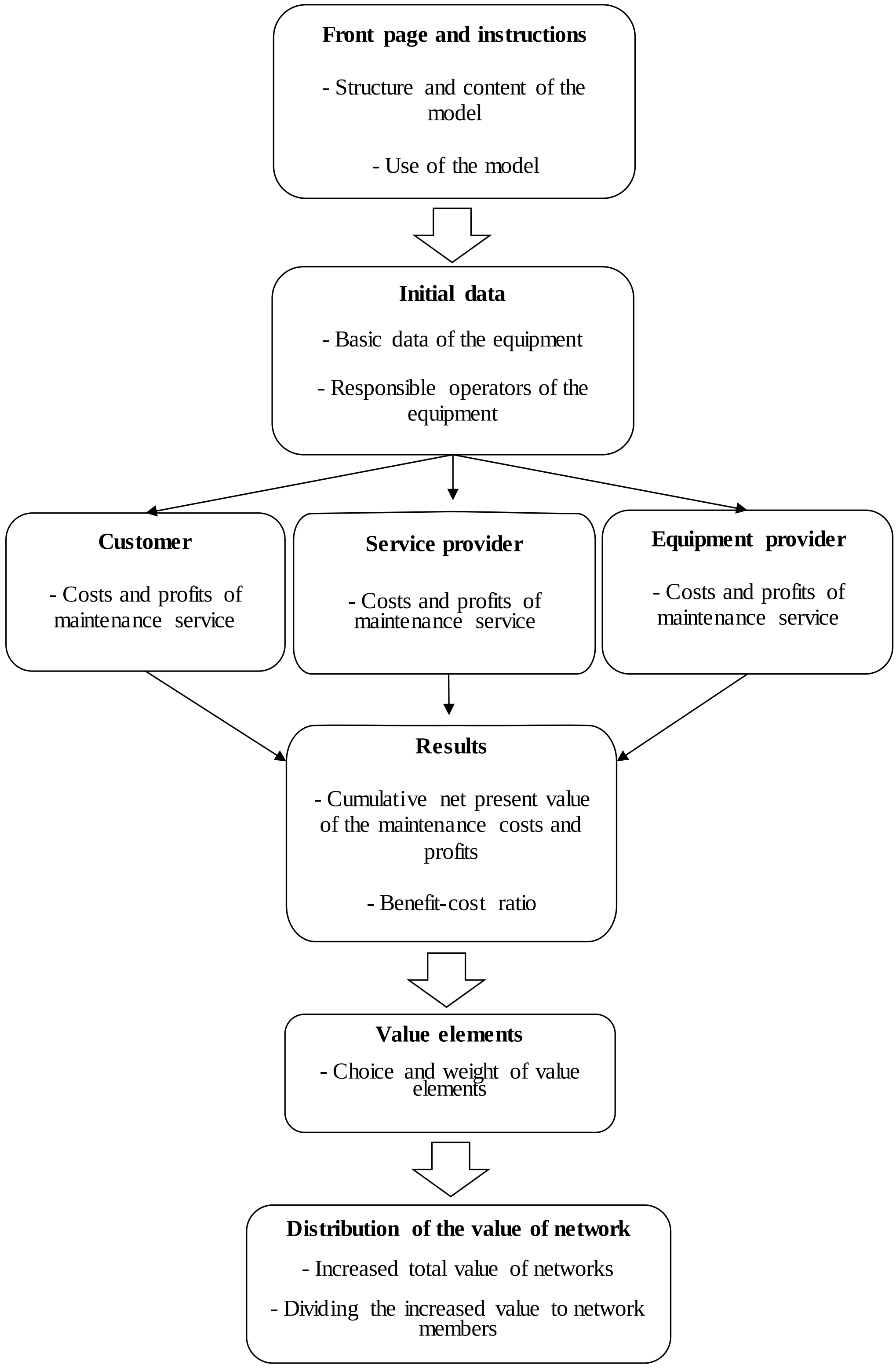


Figure 7. The structure and the contents of the value-based life-cycle model (adapted from Kivimäki et al. 2013, pp. 185).

4.3 The FAM-model

The FAM-model (the flexible asset management model) is also developed in Lappeenranta University of Technology by Marttonen et al. (see e.g. Marttonen et al. 2013a, Marttonen et al. 2012). The FAM-model can be used to control the terms of contracts from the profitability perspective either on a customer or a supplier level. Through the FAM-model it is possible to observe the impact of working capital management on relative profitability. (Marttonen et al. 2013b, p. 430) One reason for the emergence of industrial maintenance networks is to reach flexibility. It is possible for companies to improve profitability through flexible asset management, in which the fixed assets and operational working capital should be managed simultaneously. (Marttonen et al. 2012 & 2013a). The FAM-model is presented in equation (9) (Marttonen et al. 2013a, p. 653).

$$ROI = \frac{EBITDA\% - \left(FA\% * \frac{1}{B-1}\right)}{\frac{CCC}{365} + \frac{r}{365} + FA\%} = \frac{i_D * D + i_E * E}{D + E} \tag{9}$$

where

ROI	is the company's return on investment
EBITDA%	is the proportion of the profit margin to the net sales
FA%	is the proportion of the fixed assets to the net sales
B	is the average depreciation time in years
CCC	is the cycle time of operational working capital in days
r	is the residual which consists of other current assets and other current liabilities
i_D	is the interest rate of company debt financing
i_E	is the company return on equity
D	is the amount of long-term debt in the company balance sheet
E	is the amount of equity in the company balance sheet

The cash conversion cycle (or the cycle time of operational working capital) is presented in equation (10) (Marttonen et al. 2013b, p. 433):

$$CCC = DIO + DSO - DPO \tag{10}$$

where

DIO	is the cycle time of inventories
DSO	is the cycle time of accounts receivable
DPO	is the cycle time of accounts payable

5 VALUE CREATION SCENARIOS

5.1 Review of the past maintenance data of the rod mill

Before the scenarios were developed, previous maintenance data of the rod mill was inspected. Maintenance cost information, interest rates of costs and profits, annual maintenance hours, theoretical maximum operating time, utilization rates of the rod mill, shares of maintenance of maximum operating time and the proportions of proactive and corrective maintenance needed for the LCM were provided by Company X, but some information had to be estimated by the author.

Table 3. Estimates by the author.

Factor	Estimation
Selling price of calcite	120 €/tn
Profit margin ratio	30%
Unit production costs	92 €/tn

The most relevant estimates made by the author are in table 3. The estimates for selling price of calcite, profit margin ratio and unit production costs are as they are because with somewhat lower numerical values the model gave negative results. The factors in table 3 are considered to remain same in the history review as well as in both two LCM scenarios.

Because the numerical values of selling price and profit margin ratio have an influence on the cumulative present value of maintenance net profits, a sensitivity analysis was made regarding the selling price of calcite and profit margin ratio. The effect of selling price on cumulative present value of maintenance net profits is presented in figure 8 below. If profit margin ratio is kept as 30%, the minimum selling price of calcite seems to be somewhere between 100 and 105 €/tn.

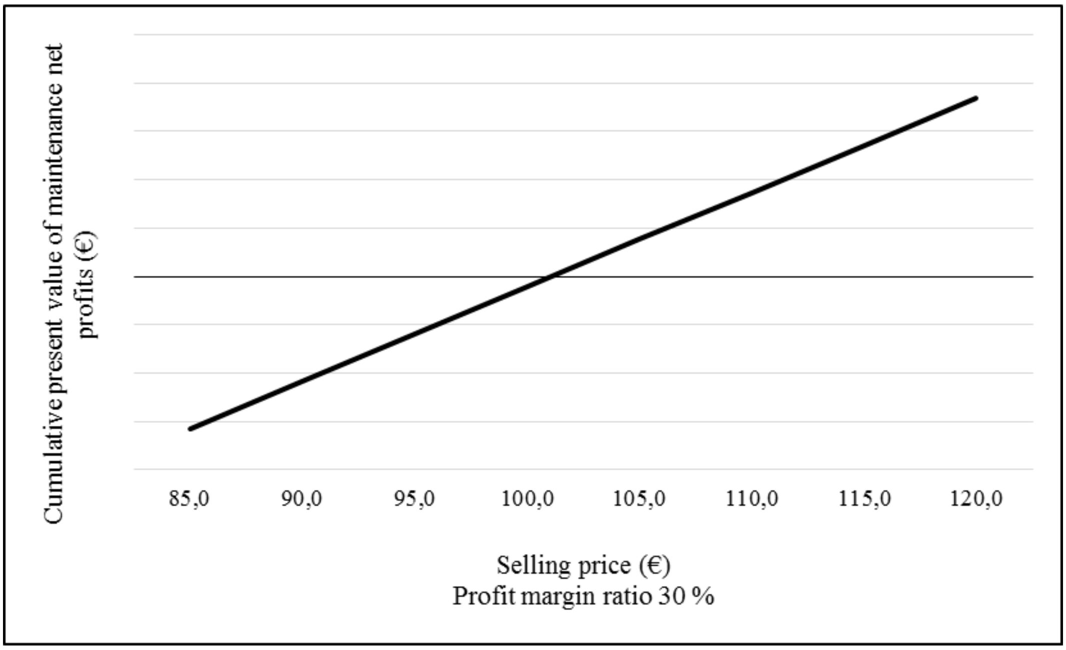


Figure 8. The effect of selling price of calcite on cumulative present value of maintenance net profits.

The effect of profit margin ratio on cumulative value of maintenance net profits is presented in figure 9. If selling price is kept as 120 €/tn, minimum profit margin ratio should be somewhere between 24 and 26%.

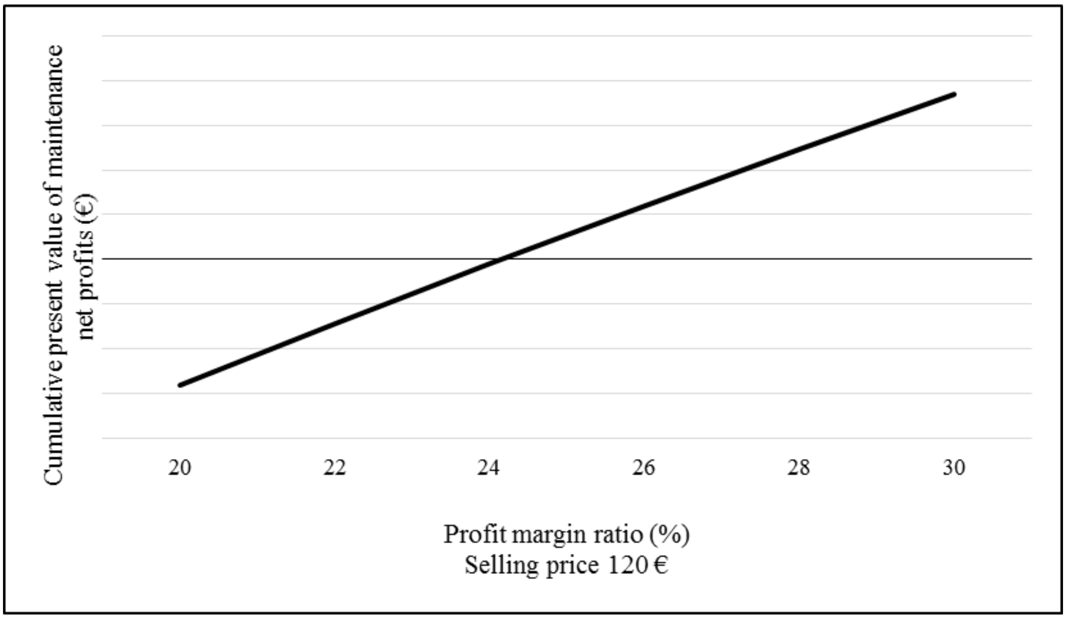


Figure 9. The effect of profit margin ratio on cumulative present value of maintenance net profits.

The customer sheet of the model (without any data) is presented in appendix 1. Only the first history year is presented in the appendix, but in the model there are more years on display. The cost and other information provided by Company X as well as the estimates by the author are entered in the yellow-colored cells. It should be noted that only labor-, material- and outsourcing costs were utilized in this thesis, because these were the maintenance costs Company X provided. Past maintenance of the rod mill inspected with the model covers years 2008-2013, planned maintenance period (i.e. when scenarios take place) is from 2014 to 2018.

Maintenance cost data from years 2008-2013 is shown in figure 10. Year 2009 is not included, because according to Company X year 2009 was exceptional e.g. due to layoffs and could therefore distort the results too much. Two types of bigger maintenance operations are made to the rod mill approximately in every five years, in period 2008-2013 those years were 2008 and 2010, which explain the higher total costs. In 2012 there were some problems in changing the motor, causing the higher total costs compared to years 2011 and 2013.

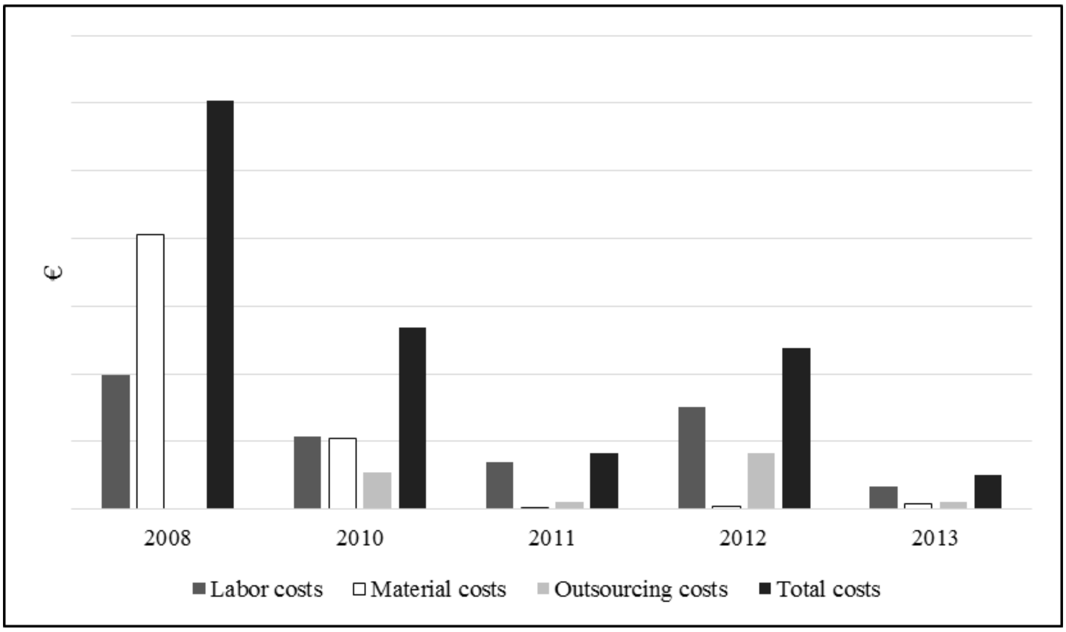


Figure 10. History cost data of the rod mill's maintenance.

In the history period most of the maintenance has been corrective. According to Kivimäki et al. (2013, p. 186) proactive maintenance is often cheaper than corrective maintenance. Increasing the share of proactive maintenance in the future might result in decreased total maintenance costs.

Figure 11 shows, that the cumulative present value of maintenance net profits is positive in the period 2008-2013. In other words, maintenance profits have exceeded the costs and thus value has been created through maintenance operations.

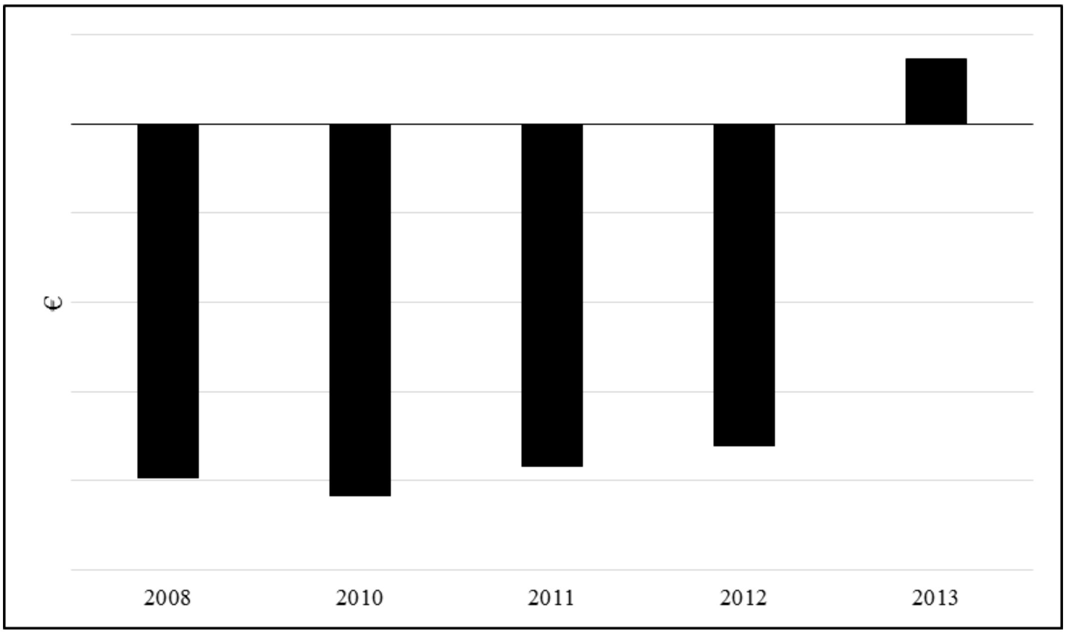


Figure 11. Cumulative present value of maintenance net profits.

As can be seen though, the cumulative present value of maintenance net profits is clearly negative until year 2013, i.e. cumulative present value of costs has been greater than cumulative present value of profits. Positive value in 2013 is probably caused by higher utilization rate of the rod mill in that year (meaning more profits) and notably lower share of maintenance of maximum operating time compared to other years of the period. The fact that the maintenance costs in 2008 were notably higher than in other years may have had a quite a significant effect on cumulative present value of maintenance net profits.

The following scenarios are based on information from the history period (2008-2013). As mentioned, two types of more extensive maintenance operations are made to the rod mill approximately in every five years. In the history period these operations occurred in 2008 (type 1) and in 2010 (type 2). They are assumed to take place again in 2014 (type 1) and in 2015 (type 2). Therefore information from 2008 is used as reference data for year 2014, whereas data from 2010 is used as reference data for 2015. The relations between different years is shown in table 4. Years 2016-2018 are considered as so called "normal years", when no especially expensive maintenance occurs. The corresponding years in the past are 2011-2013.

Table 4. Relations between scenario and history years.

Level of maintenance	**Type 1**	**Type 2**	**Normal years**		
Scenario year	**2014**	**2015**	**2016**	**2017**	**2018**
Corresponding history year	**2008**	**2010**	**2011**	**2012**	**2013**

5.2 The value-based LCM scenario 1

In previous years most of the maintenance has been corrective. In this scenario Company X and the service provider decide to increase the share of proactive maintenance by 20 percentage points. According to Kivimäki et al. (2013, p. 182) proactive maintenance plays an important role in the mining industry, because if critical equipment fail the whole process may stop working in a very short time. Based on the already mentioned fact that proactive maintenance is usually cheaper than corrective, it is estimated that increasing the share of proactive maintenance will decrease the total maintenance costs by 10% annually. The service provider is able to execute the proactive operations at lower price, because proactive maintenance allows the service provider to plan its actions more accurately, which leads to increased efficiency. Year 2012 was exceptionally expensive for a “normal year”, therefore the average total costs of 2011 and 2013 are used as basis for year 2017. Key information for the scenario is gathered in table 5 below.

Table 5. Key data for the value-based LCM scenario 1.

Level of maintenance	Type 1	Type 2	Normal years		
Year	2014	2015	2016	2017	2018
Total costs	90 % of total costs of 2008	90 % of total costs of 2010	90 % of total costs of 2011	90 % of average total costs of 2011 and 2013	90 % of total costs of 2013
Utilization rate			94 %	94 %	94 %
The share of maintenance of max. operating time			3 %	3 %	3 %
The share of proactive maintenance	+ 20 pp	+ 20 pp	+ 20 pp	+ 20 pp	+ 20 pp

Due to increased proactive maintenance, the probability of unexpected maintenance operations is estimated to decrease. Because of that, annual utilization rate is estimated to be 94% in years 2016-2018 and the share of maintenance of maximum operating time is set to 3% per year in those years. This estimation is based on the history data of the rod mill provided by Company X. Utilization rates and the shares of maintenance of maximum operating time in 2014 and 2015 are considered to remain unchanged due to larger maintenance operations occurring in those years, therefore information is hidden.

Cumulative present value of maintenance net profits in scenario 1 is presented in figure 12. The results from the history period have been included in the figure for comparison. Cumulative present value of maintenance net profits is negative in 2014-2017, but as can be seen, in 2018 it is above zero, meaning that value is created during the inspection period.

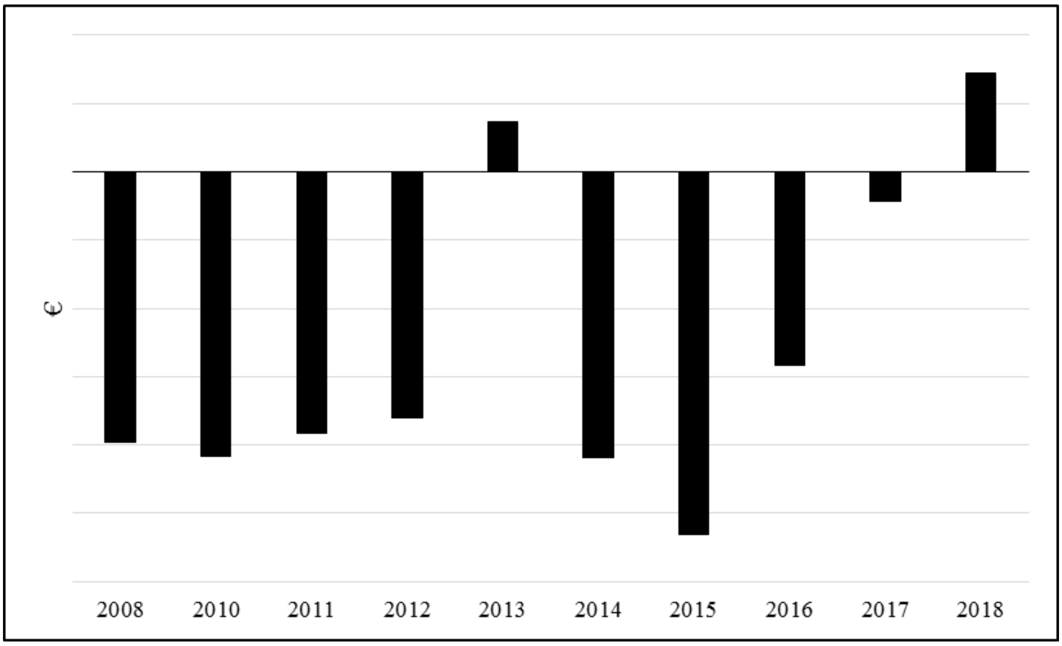


Figure 12. Cumulative present value of maintenance net profits in scenario 1.

The cumulative costs of the history period and the cumulative costs of scenario 1 are presented in figure 13. It can be seen that due to increased share of proactive maintenance, maintenance costs in scenario 1 are considerably lower than in the history period.

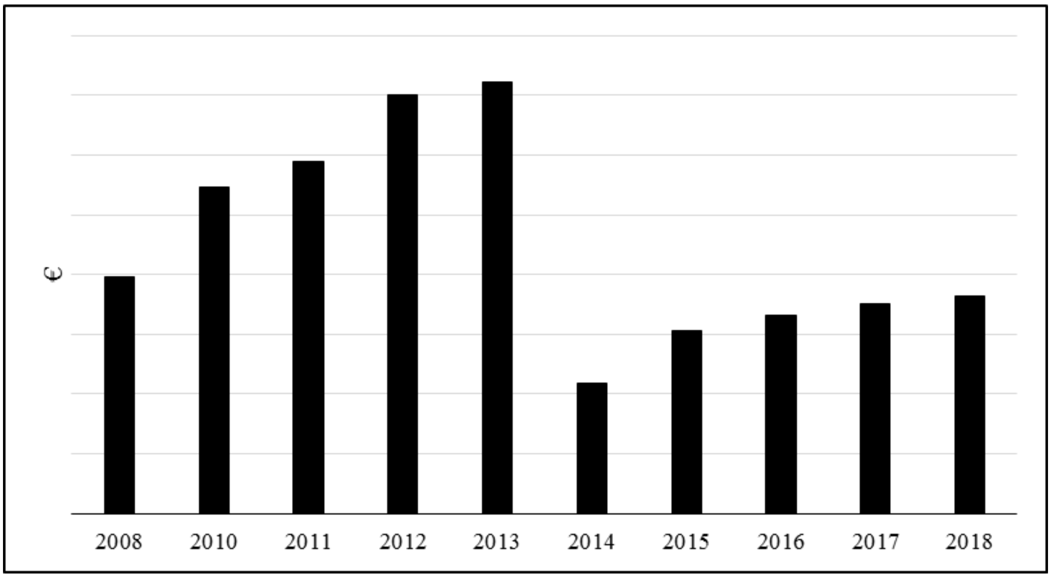


Figure 13. Cumulative present value of maintenance costs in scenario 1.

5.3 The value-based LCM scenario 2

Scenario 2 in numbers is presented in table 6. In this scenario Company X removes one rod mill from production due to overcapacity. The spare rod mill could be used e.g. if unexpected stoppages occur.

Table 6. Key data for the value-based LCM scenario 2.

Level of maintenance	Type 1	Type 2	Normal years		
Year	2014	2015	2016	2017	2018
Total costs	90 % of total costs of 2008	90 % of total costs of 2010	90 % of total costs of 2011	90 % of average total costs of 2011 and 2013	90 % of total costs of 2013
Utilization rate			96 %	96 %	96 %
The share of maintenance of max. operating time			2 %	2 %	2 %
The share of proactive maintenance	+ 20 pp	+ 20 pp	+ 20 pp	+ 20 pp	+ 20 pp

Because one rod mill is removed from production, the utilization rates of the remaining rod mills are estimated to increase to 96% in years 2016-2018 and the shares of maintenance of maximum operating time are estimated to be 2% in those years. Years 2014 and 2015 are handled in the same way as in scenario 1. The share of proactive maintenance is assumed to be like in scenario 1 and respectively, the total maintenance costs are estimated to decrease by 10% in each year. As explained earlier, using the average total costs of 2011 and 2013 for year 2017 is due to the fact that 2012 was exceptionally expensive.

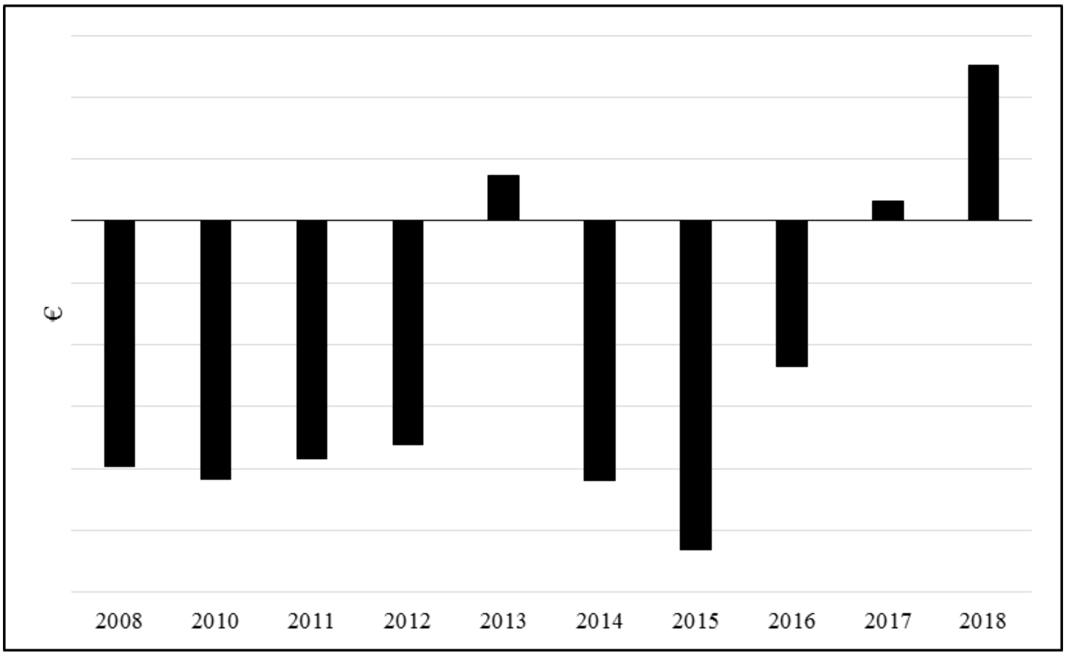


Figure 14. Cumulative present value of maintenance net profits in scenario 2.

Cumulative present value of maintenance net profits in scenario 2 is shown in figure 14. Results of scenario 2 are quite similar to those of scenario 1, which is natural because differences in key data of scenarios are only minor. However, in scenario 2 the cumulative present value of maintenance net profits is positive already in 2017 and the total value created in scenario 2 is over 3 times the value created in scenario 1. This is caused by higher utilization rates in years 2016-2018. Cumulative present values of maintenance costs are the same as in scenario 1 (presented in figure 13).

5.4 History review through the FAM-model

Before the scenarios were developed, a review was made based on Company X's financial statement information from the years 2008-2012. Changes in Company X's return on investment are presented in figure 15. As can be seen, *ROI* has been below 10 % in the inspection period. According to indicative values of *ROI* Company X's return on investment has been on satisfactory level between years 2008 and 2010, but only adequate in 2011. It should be noted that *ROI* is calculated using the operating income; in 2012 Company X's operating income was negative, which explains the negative *ROI* of the same year. However, income of the financial year was still positive in 2012. *ROI*s in figure 15 are calculated by using the equation (9) presented in chapter 4.3.

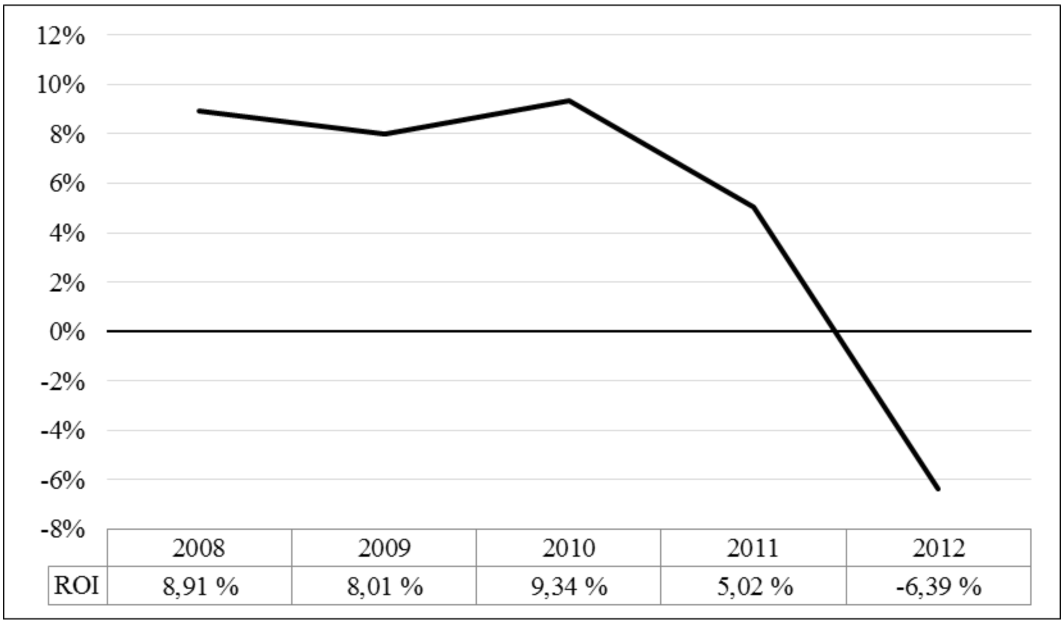
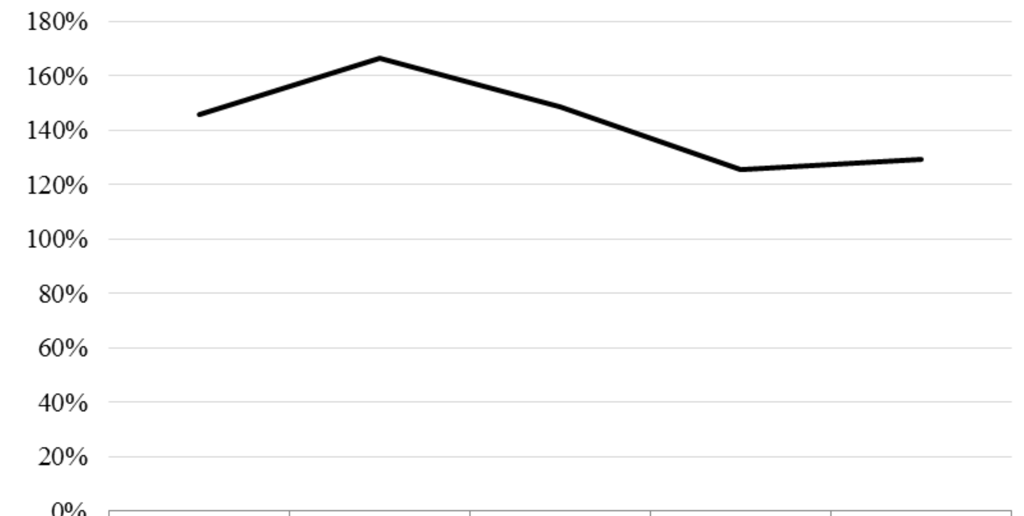


Figure 15. Company X's *ROI* from 2008 to 2012.

Indicative values of the return on investment are as follows (Balance consulting 2014):

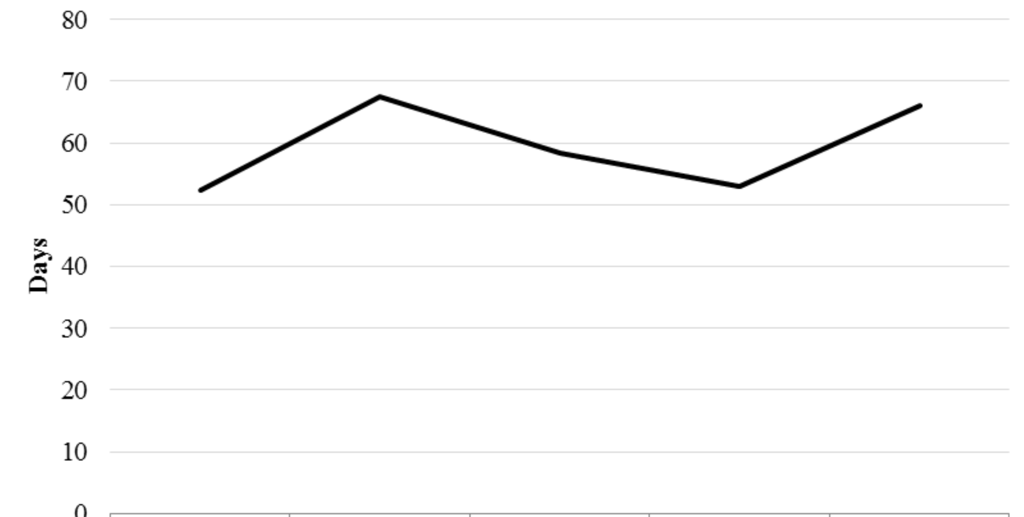
- Excellent over 15 %
- Good 10-15 %
- Satisfactory 6-10 %
- Adequate 3-6 %
- Poor below 3 %

The most important reason for the quite low level of *ROI* is probably the high amount of fixed assets on Company X's balance sheet, which causes the high fixed asset percentage (figure 16). *FA %* has a direct and a rather significant effect on company's return on investment, which can be seen from the equation (9).



	2008	2009	2010	2011	2012
FA %	146 %	167 %	148 %	126 %	129 %

Figure 16. Company X's *FA %* from 2008 to 2012.



	2008	2009	2010	2011	2012
CCC	52	67	58	53	66

Figure 17. Cycle time of operational working capital between 2008 and 2012.

Company X's cycle time of operational working capital is presented in figure 17. The rise between 2008 and 2009 is presumably affected by lower net sales of 2009, which is likely caused by layoffs of that year. *CCC* is calculated by equation (10) presented in chapter 4.3.

5.5 The FAM-model scenario 1

Let us inspect the fictional industrial maintenance network, consisting of Company X (the customer), the equipment provider and the maintenance company. The network has decided to adopt flexible asset management practices in order to improve the competitiveness of the whole network. For this to happen, the equipment provider's *ROI* is decided to raise to 20 % and the maintenance company's *ROI* to 15 %. Because the equipment provider's and the maintenance company's information are purely fictional, it is simply assumed that these levels of *ROI* can be achieved if Company X takes fixed assets worth of 5 000 000 € from the equipment provider's and 1 000 000 € from the maintenance company's balance sheet on its own balance sheet. The initial situation is described in table 7. Because in 2012 Company X's operating income was negative the financial statement information of year 2011 is used as initial data for Company X. The initial data for the equipment provider and the maintenance company are estimated by the author. *FA %* and *ROI* of the network are simply averages of *ROI* and *FA %* of the three network members. At the request of Company X net sales and fixed assets are hidden.

Table 7. Initial data for the FAM-model scenario 1.

	Company X	Equipment provider	Maintenance company	Network
Net sales		50 000 000 €	15 000 000 €	
FA		15 000 000 €	3 000 000 €	
FA %	125,6 %	30,0 %	20,0 %	58,5 %
ROI	5,02 %	5,00 %	3,00 %	4,34 %

The results are shown in table 8. Although Company X took 6 000 000 € of fixed assets on its balance sheet, Company X's *ROI* has decreased less than 0,3 percentage points, while equipment provider's *ROI* has increased by 15 pp and maintenance company's by 12 pp. And, more importantly, the *ROI* of the network has increased, as was the purpose of this arrangement. Δ*ROI*s in table 8 are calculated using the same logic as in equation (6) presented in chapter 2.3.

Table 8. Changes in return on investment and *FA %*.

	Company X	Equipment provider	Maintenance company	Network
Current FA%	125,6 %	30,0 %	20,0 %	58,5 %
FA% after FAM	129,4 %	20,0 %	13,3 %	54,2 %
Δ FA%	**3,79 %**	**-10,00 %**	**-6,67 %**	**-4,29 %**
Current ROI	5,02 %	5,00 %	3,00 %	4,34 %
ROI after FAM	4,75 %	20,00 %	15,00 %	13,25 %
Δ ROI	**-0,27 %**	**15,00 %**	**12,00 %**	**8,91 %**

Due to Company X's heavy balance sheet, the amounts of fixed assets that change the situation of the equipment provider and the maintenance company considerably, have only a minor effect on Company X's *FA %* and *ROI*. For comparison, if *Company X's* return on investment is wanted to increase by 1 pp, fixed assets worth of approximately 19 million euros would be required to be transferred to the equipment provider's and the maintenance company's balance sheets (other factors kept constant). This, in turn, would decrease *ROI* of the both companies significantly. And while Company X's *ROI* would increase only 1 pp, the sacrifices are hardly acceptable.

5.6 The FAM-model scenario 2

This time, the goal is to shorten the cycle times of operational working capital of the equipment provider and the maintenance company, in order to improve the competitiveness of the network. The *CCC* of the equipment provider is wanted to decrease to 40 days and the *CCC* of the maintenance company to 30 days. This is done by reducing the inventories and accounts receivable of these companies. Net sales and accounts payable are kept unchanged. The initial data is presented in table 9. Like in scenario 1, Company X's data is from year 2011 and the equipment provider's and the maintenance company's information is estimated by the author. *DIO, DSO, DPO* and *CCC* of the network are simply the sums of the network member's *DIO, DSO, DPO* and *CCC*.

Table 9. The initial situation and data for the FAM-model scenario 2.

	Company X	**Equipment provider**	**Maintenance company**	**Network**
Net sales		50 000 000 €	15 000 000 €	
Inventories		6 000 000 €	1 800 000 €	
Accounts receivable		5 000 000 €	1 000 000 €	
Accounts payable		2 000 000 €	900 000 €	
DIO (days)	53	44	44	141
DSO (days)	38	37	24	99
DPO (days)	38	15	22	75
CCC (days)	53	66	46	165

Influences on *CCC*s are presented in figure 18. *DPO*'s are kept unchanged (because accounts payable are kept constant). As can be noticed, Company X's *CCC* has risen by 10 days, but the equipment provider's *CCC* has shortened by 26 days and the maintenance company's by 16 days. The *CCC* of the network has shortened by 32 days, meaning that flexible asset management operations were successful.

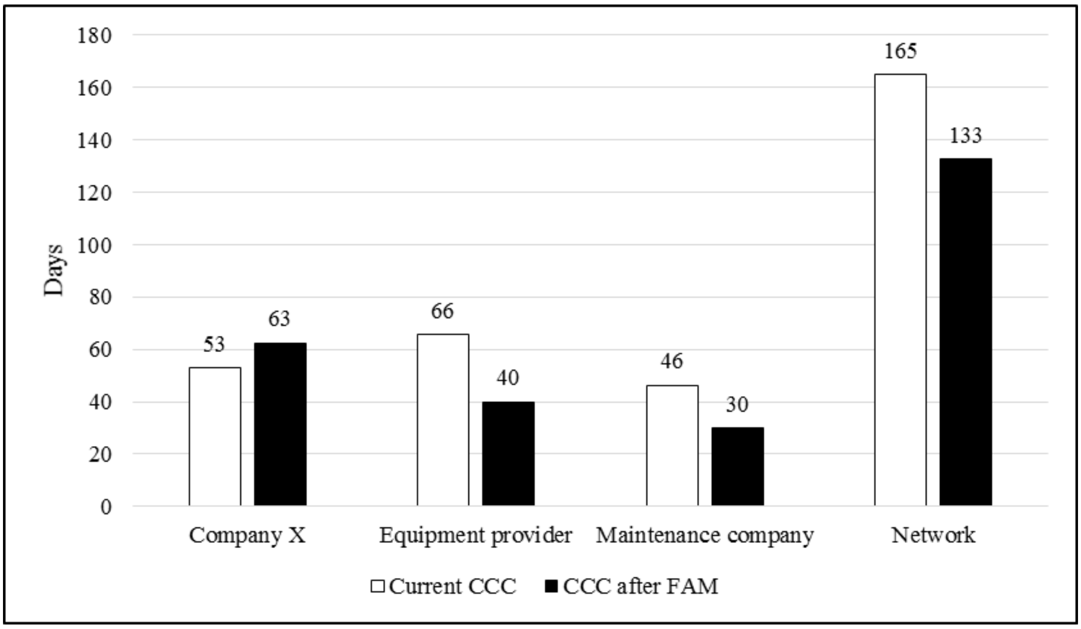


Figure 18. Effects of the FAM operations on the cycle time of operational working capital.

Although Company X's cycle time of operational working capital increases by 10 days, its effect on Company X's *ROI* is only marginal. If the new *CCC* is 63 days and other factors of the equation (9) are kept unchanged, Company X's new *ROI* would be only 0,1 percentage points smaller compared with initial situation.

As shown in scenarios 1 and 2, transferring fixed assets and inventories from the one company to the other may have a positive effect on *ROI* and *CCC* of the network. Companies with high amount of fixed assets or inventories are likely less affected by a minor increase in these factors, compared with smaller companies. However, transferring does not change the total amount of fixed assets or inventories in the network. But centralizing e.g. inventories to a one operator, it is possible to achieve economies of scale, because this way only one network member need to have warehouses, stock workers etc. And when more units are handled in the same warehouse, storage costs per unit are likely to decrease.

5.7 Sharing the co-created value

As discussed in chapter 2.3, the co-created value is not necessarily shared equally or equitably between the network members. Because one research question of this thesis is to find out how the co-created value could be shared equitably between the members of the network, it is assumed that in all scenarios Company X and the network actively seek ways to improve profitability and competitiveness of the whole network. This applies also to the sharing of the co-created value.

In the value-based LCM scenarios the proposed changes in maintenance practices have a potential to create value for Company X. The service provider is not involved in this thesis, therefore it was not possible to inspect how the made changes affect to the service provider in reality. It is simply assumed that this arrangement has potential value also to the service provider; otherwise it would not have agreed to the proposed terms.

Company X could e.g. provide some bonuses to the service provider, if the set utilization rates are achieved or even exceeded. Co-created value in the value-based LCM scenarios could also be shared e.g. using the equations (1)-(5) presented in chapter 2.3.

In the FAM-model scenarios the flexible asset management operations seem to have positive results from the point of view of the equipment provider, the maintenance company and the network as a whole. However, these positive results would not be possible without Company X showing flexibility at expense of its profitability. And although the profitability of the network as a whole may have improved, Company X is now clearly the only member who has not benefit from the arrangements. Therefore, in order to reach a win-win situation, the suitable compensation should be paid to Company X for the risks it takes and for the negative effects these operations have on its profitability.

One way could be that the equipment provider and the service provider offer their services to Company X at a discount for their improved *ROI*s, resulting in lowered outsourcing costs of Company X. This, in turn, could lead to Company X's *ROI* to increase. Still assuming that all network members act for the common good, the discount should be such that the *ROI* of Company X wouldn't decrease due to FAM operations, but not so high either that it neutralizes the achieved benefits of the equipment provider and the maintenance company. Based on this, the following equations (11) and (12) are presented using the logic of equations (6), (7) and (8) by Marttonen et al. (presented in chapter 2.3) as a basis:

$$\Delta ROI_{DISCOUNT,A} > \Delta ROI_{SCENARIO,A} \quad (11)$$

$$\Delta ROI_{DISCOUNT,B} < \Delta ROI_{SCENARIO,B} \quad (12)$$

where

ΔROI (DISCOUNT, A)	is the INCREASE in Company X's *ROI* caused by the discount (lowered costs)
ΔROI (SCENARIO, A)	is the DECREASE in Company X's *ROI* in scenario 1 or 2
ΔROI (DISCOUNT, B)	is the DECREASE in service provider's or equipment provider's *ROI* caused by the discount (lost profits)
ΔROI (SCENARIO, B)	is the INCREASE in service provider's or equipment provider's *ROI* in scenario 1 or 2

The discount itself, therefore, should be such that the both equations are valid. The compensation for Company X could also be defined directly through price, when the price of the flexible asset operations in both scenarios could be find out e.g. using equations (6), (7) and (8).

5.8 Review of the current maintenance contract practices of the case network

While the results of the scenarios were presented to the two representatives of Company X, it was also discussed whether or not it is currently possible to execute the ideas proposed in scenarios. This issue was approached through two questions:

1) Do the current maintenance contracts enable the arrangements described in scenarios and is it possible to share the co-created value as proposed?
2) If the current maintenance contracts do not enable the arrangements or the proposed ways to share the co-created value, what factors are seen as the main obstacles?

The main points of the discussion are gathered below. According to the representatives:

- The exchange of information between the contracting partners is not prevented by contracts, but in practice e.g. cost data is not revealed.
- Providing bonuses to the service provider is seen complicated, because measures can be falsified (e.g. if bonuses are based on utilization rates).
- Instead of bonuses, binding the price of a service to the level of production is desirable for Company X, but service providers are reluctant to agree to this because of risks involved. If the same provider operates in multiple plants, it could work better.
- Renegotiating is possible.
- Types of services (e.g. planned/unplanned maintenance) are defined at least on some level.
- A mutual performance measurement system is under development as a part of the MaiSeMa-project. However, a performance measurement system involves a risk that some measures are improved at the expense of the other measures.

According to the representatives, the main obstacles for the arrangements and value sharing proposed in the scenarios are the following:

- The risk for the service/equipment provider is too high.
- To make it possible to create and share the value as proposed in scenarios is a big process.
- Responsibilities are difficult to define.

When comparing the views of the representatives with different factors needed for a successful maintenance network or a maintenance contract presented in chapters 3.2 and 3.3, it seems that some factors are already taken into account in the current maintenance contracts of the case network. For example types of services are defined and a measurement system is under development. On the other hand, e.g. information exchange does not appear to be very open.

As discussed in open-book accounting theory, in order to reach a working OBA both the social and technical requirements should be considered simultaneously. In this case it seems that the technical details of the contracts are not the main obstacle for improvement of the network cooperation. Instead it seems to be the social requirements, especially trust, that plays the major role (e.g. there is a risk that measures are falsified by the partner). This is not surprising, though, and the issue of trust is probably a problem faced by countless other maintenance networks. Applying open-book accounting could be one way to improve trust between the members of the case network. Although implementation of OBA requires trust between the partners, OBA may actually contribute the building of trust if the disclosed data is not misused. According to the representatives of Company X there is, however, interest towards the closer cooperation and deeper network thinking despite the challenges they involve.

6 CONCLUSIONS AND FUTURE RESEARCH

The first research question of this thesis was to find out how the existing value and the potential value co-created in the future can be evidenced with the value-based life-cycle model and with the FAM-model. In case of the value based LCM it was shown that if the cumulative present value of maintenance net profits is positive in the inspection period, monetary value has been created through maintenance of the rod mill.

It seems that during years 2008-2013 monetary value has been created through maintenance, although high maintenance costs in certain years have probably kept the created value at a quite low level. In the future it might be possible to co-create value by increasing the share of proactive maintenance. This is based on a view that proactive maintenance is cheaper than corrective maintenance. It is also assumed that due to increased proactive maintenance, the probability of unexpected maintenance stoppages decrease, resulting in higher utilization rates of the rod mill. On the other hand, removing one rod mill from use due to overcapacity may result in increased utilization rates of the remaining mills.

With the FAM-model it is possible to review company's profitability when fixed assets and operational working capital is taken into account. It seems that profitability of Company X has been mostly on satisfactory level during years 2008-2012, probably caused by high amount of fixed assets on company's balance sheet. Results of the FAM-model scenarios show that transferring some of the fixed assets, inventories and accounts receivable of the equipment provider and the maintenance company to the balance sheet of Company X, may result in increased *ROI* and shortened cycle time of operational working capital at the network level. This is possible, because although the actual amounts of each factor remain the same in the network, the transferred amounts have a lower effect on Company X compared with the other two members. Centralizing e.g. inventories to the one member may also provide economies of scale, which is likely to result in lowered storage costs per unit.

The second research question was to find out how the co-created value could be shared equitably between the network members in order to reach a win-win situation. In the value-based LCM scenarios Company X could provide e.g. bonuses to the service provider, if the set utilization rates are achieved. The price of a maintenance service could also be defined using equations (1)-(5) presented in chapter 2.3.

The flexible asset management operations could be compensated e.g. by providing a discount for Company X for taking the transferred assets on its balance sheet. This discount is assumed to increase the profitability of Company X, compensating the decrease in *ROI* it suffered due to the FAM operations. The compensation could also be decided directly through price using equations (6)-(8) presented in chapter 2.3.

The third research question was to find out the possible factors that prevent value co-creation and sharing in the current maintenance contract practices of the case network. It seems that the technical details in contracts are not the main issue for deeper cooperation, because the contracts do not prevent e.g. the exchange of cost information and a mutual measurement system is under development. Instead it seems that the basic “pitfall”, the lack of trust, is a dominant obstacle to create and share value as proposed in the scenarios. However, despite the challenges there seems to be an interest towards a deeper cooperation, at least from Company X’s point of view.

This thesis has two obvious limitations. The first concerns the information needed for the flexible asset management model and for the value-based life-cycle model. While some maintenance information of the rod mill was provided by Company X, some information needed for the LCM had to be estimated by the author. Using more accurate data would give more realistic results. In the FAM-model, the public financial statement information of Company X was used. For the purposes of this thesis the financial statement information was appropriate, but in real decision making situations e.g. the facility level information would probably be more useful. However, the estimated information and the created scenarios were reviewed together with representatives of Company X in order to reach a mutual view.

The other limitation is that only the customer company participated in this thesis. The service provider and the equipment provider are taken into account, but only at the level of thought. Again, for more realistic results also the service provider's and equipment provider's real point of view and numerical information should be included in calculations.

Although the numerical results of this thesis do not describe the real situation very well, the basic idea how the models could be used is presented. On the other hand, identifying at least some obstacles preventing deeper cooperation might serve as a conversation opener between the network members.

This thesis is a very case-specific study, but despite that the author sees it can be utilized also in other industrial maintenance networks. It is obvious that every network has unique issues, but as previous studies show, there are many problems that are more or a less common to all industrial maintenance networks. In the future research it would be interesting to include also the other members of the network in studies as well as to use more accurate data. This way perspectives of all network members could be taken into account. And if all members are included, it could perhaps improve the trust between the members, because this kind of involvement alone requires that the members trust each other at least on some level.

7 SUMMARY

In this thesis two decision making models – the value-based life-cycle model and the flexible asset management model – were applied to Company X, the customer company of an industrial maintenance network operating in mining industry. The network consists of Company X, service providers and equipment providers. Because only Company X participated in this thesis, the service provider and the equipment provider used in this study are fictional. The thesis had two objectives: first was to concretize the potential benefits the use of the FAM-model and the value-based LCM can bring to the case network, the second was to identify possible obstacles for co-creation and sharing of value in the current maintenance contract practices of the case network.

The thesis is a typical case study. The data for the models was partly provided by Company X, partly collected from public financial statement information. Some data was estimated by the author. The interview of the network's current maintenance contract policies was conducted as a discussion with the two representatives of Company X.

The past maintenance data of the rod mill was reviewed through the LCM and the profitability of Company X in recent years was inspected with the FAM-model. It seems that value has been created through the past maintenance operations of the rod mill. Results of the FAM-model, in turn, indicate that Company X's *ROI* has mostly been on satisfactory level during the past few years. This is likely caused by high amounts of fixed assets on Company X balance sheet.

A total of four scenarios were developed to create value in the future: two for the value-based LCM and two for the FAM-model. The results of the value-based LCM scenarios show that potential value might be created by increasing the share of proactive maintenance of the rod mill in the future. Results of the FAM-model scenarios show that transferring some of the fixed assets, inventories and accounts receivable of the equipment provider and the maintenance company to the balance sheet of Company X, may result in increased *ROI* and shortened cycle time of operational working capital at the network level.

Co-created value should be shared equitably between the members of a network in order to keep the whole network competitive. It was proposed that value created in cooperation in the value-based LCM scenarios could be shared e.g. by providing bonuses to the maintenance service provider for achieved utilization rates or by sharing the created value directly through price using the proposed equations. The flexible asset management operations could be compensated e.g. by providing a discount for Company X or the compensation could also be decided directly through price, like in the value-based LCM scenarios.

The main obstacle for creating and sharing value as proposed in the scenarios seems to be the issue of trust between the partners: there is a fear that the other party may act opportunistically. The process of creating and sharing value as proposed in the scenarios is also seen as a big process, where responsibilities are hard to define. However, despite the challenges there seems to be an interest towards deeper cooperation.

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Appendix 1. Customer sheet of the value-based life-cycle model

	Year	2008
COSTS		Clear Entries!
Customer ltd.		
Operational maintenance costs		**0,0 €**
Labour costs		
Energy costs		
Material costs		
Quality costs		**0,0 €**
Quality control costs		
Disposal and processing costs of low-grade products		
Costs of outsourcing and logistics		**0,0 €**
Outsourcing costs		
Logistics costs (procurement)		
Environmental costs		**0,0 €**
Cleaning costs		
Processing costs		
Supervision costs		
Asset management costs		**0,0 €**
Costs of current assets		
Costs of fixed assets		
Other costs		**0,0 €**
Costs of tools and instruments		
Research and development costs (R&D)		
Costs of occupational safety and accidents		
Training and negotiation costs		
Rest of the costs		
Annual costs in total		**0,0 €**
Cumulative costs of the planning period		**0,0 €**
The share of corrective maintenance costs of total annual maintenance costs		
The share of proactive maintenance costs of total annual maintenance costs		
Interest rate of costs		
The present value factors based on the interest rate of costs		1,000
The present value of annual costs		**0,0 €**
Cumulative present value of costs of the planning period		**0,0 €**
Cumulative present value of corrective maintenance costs		
Cumulative present value of proactive maintenance costs		

(continues)

(appendix 1 continues)

COST SAVINGS		
Customer ltd.		
Operational maintenance costs		**0,0 €**
Labour costs		
Energy costs		
Material costs		
Quality costs		**0,0 €**
Quality control costs		
Disposal and processing costs of low-grade products		
Costs of outsourcing and logistics		**0,0 €**
Outsourcing costs		
Logistics costs (procurement)		
Environmental costs		**0,0 €**
Cleaning costs		
Processing costs		
Supervision costs		
Asset management costs		**0,0 €**
Costs of current assets		
Costs of fixed assets		
Other costs		**0,0 €**
Costs of tools and instruments		
Research and development costs (R&D)		
Costs of occupational safety and accidents		
Training and negotiation costs		
Rest of the costs		
Annual cost savings (average costs - annual costs)		**0,0 €**
Cumulative cost savings of the planning period		**0,0 €**

(continues)

(appendix 1 continues)

OPERATIONS-RELATED INFORMATION	Clear Entries!
Customer ltd.	
Production-related information	
Theoretical maximum operating time (h)	
Batch production: Share of operating time allocated to product I (%)	
Batch production: Share of operating time allocated to product II (%)	
Batch production: Share of operating time allocated to product III (%)	
Maximum production speed (tn/h) / (pcs/h)	
Batch production: Maximum production speed (tn/h) / (pcs/h)	
Product I (batch)	
Product II (batch)	
Product III (batch)	
Annual maximum capacity (tn) / (pcs)	
Average production speed (tn/h) / (pcs/h)	
Batch production: Average production speed (tn/h) / (pcs/h)	
Product I (batch)	
Product II (batch)	
Product III (batch)	
Utilization rate (%)	
Annual operating time matching the utilization rate (h)	
Annual production in total (tn) / (pcs)	
Maintenance-related information	
The share of maintenance of maximum operating time (%)	
The share of corrective maintenance of maintenance in total (%)	
The share of proactive maintenance of maintenance in total (%)	
The share of underutilization excl. maintenance stoppages (%)	
The share of maintenance performed during manufacturing (%)	
The share of maintenance performed during underutilization (%)	
Product-related information	
Unit production costs (€/tn) / (€/pc)	
Product I (batch)	
Product II (batch)	
Product III (batch)	
Profit margin ratio (%)	
Product I (batch)	
Product II (batch)	
Product III (batch)	
Product margin (€)	
Batch production: Product margin (€)	
Annual profits in total (€)	
Lost profits caused by a one hour stoppage in production (€)	
Annual losses caused by capacity underutilization (€)	

(continues)

(appendix 1 continues)

MAINTENANCE-RELATED PROFITS AND LOSSES	
Customer ltd.	
Lost profits caused by maintenance operations	
Maintenance hours in total (h)	
Maintenance hours allocated to corrective maintenance (h)	
Maintenance hours allocated to proactive maintenance (h)	
Lost profits caused by annual maintenance (€)	
The share of corrective maintenance of lost profits (€)	
The share of proactive maintenance of lost profits (€)	
Average profits gained from maintenance changes	
Corrective maintenance profits	
Proactive maintenance profits	
Maintenance profits in total	**0,0 €**
Cumulative profits of the planning period (maint. + cost savings)	**0,0 €**
Interest rate of profits	
The present value factors based on the interest rate of profits	1,000
The present value of cost savings	**0,0 €**
The present value of maintenance-related profits	**0,0 €**
Cumulative PV of profits of the planning period (maint. + cost savings)	**0,0 €**