LUT University
Industrial Engineering and Management
Master’s Thesis

Niina Ekqvist

COST STRUCTURE OF INDUSTRIAL CRANES IN DIFFERENT COUNTRIES – INSTALLATION COST PERSPECTIVE

Examiners: Professor Timo Kärri & University lecturer Tiina Sinkkonen

ABSTRACT

Author: Niina Ekqvist

Title: Cost structure of industrial cranes in different countries – Installation cost perspective

Year: 2019 **Place:** Vaasa

Master's Thesis, Lappeenranta University of Technology, Industrial Engineering and Management.

78 pages, 22 figures and 1 table

Supervisors: Professor Timo Kärri & University lecturer Tiina Sinkkonen

Keywords: cost management, cost estimating, cost structure, product cost reporting, cost estimation accuracy

This study aims to find out the average cost structure of standard industrial cranes. Focus of the study is in the installation costs where the biggest uncertainty and the cost reduction potential lie. The study is conducted as a case study in which data from five case countries is collected, analysed, and cost structures are compiled and compared. Additionally, a current level of cost estimation accuracy is evaluated and possible improvements in cost estimation, cost accounting and site operations are considered.

Literature overview focuses on cost management and cost estimating. Research objectives of this part are related to the challenges in cost accounting and engineering. Main concepts are introduced and previous studies about cost engineering, especially cost estimating, are examined.

The greatest challenge of this case study was the disintegration of the cost data. Thus, the need for harmonizing product cost reporting was raised. Current level of the cost estimation accuracy was not satisfactory; thus, improvement needs were seen especially in installation cost estimations. One suggested way was to exploit previous knowledge and experience more efficiently. It was also discovered that product life cycle cost and other value creating factors as reliability of the crane and availability of spare parts should be considered in the selling process.

TIIVISTELMÄ

Tekijä: Niina Ekqvist **Työn nimi:** Teollisuusnostureiden kustannusrakenne eri maissa asennuskustannusten näkökulmasta	
Vuosi: 2019	**Paikka:** Vaasa
Diplomityö. Lappeenrannan teknillinen yliopisto, tuotantotalous. 78 sivua, 22 kuvaa ja 1 taulukko Tarkastajat: professori Timo Kärri & yliopisto-opettaja Tiina Sinkkonen	
Hakusanat: kustannusrakenne, kustannusarviot, tuotekustannusten raportointi, kustannusten hallinta, kustannusarvioiden tarkkuus	

Diplomityön tavoitteena on selvittää standardien teollisuusnostureiden kustannusrakenne eri maissa. Työssä keskitytään tutkimaan asennuskustannuksia, jotka eivät ole niin hyvin tiedossa kuin muut tuotekustannukset, ja joissa on suurin potentiaali kustannussäästöille. Tutkimusmetodina käytetään casetutkimusta, jossa esimerkkiprojekteja on kerätty viidestä eri maasta. Caseprojekteiksi valitaan tyypillisiä toimitusprojekteja, joiden kustannusdata kerätään, analysoidaan ja vertaillaan keskenään. Lopputulemana saadaan prosentuaaliset osuudet nosturin tuotekustannuskategorioille. Lisäksi työssä arvioidaan kustannusarvioiden tarkkuutta, ja annetaan parannusehdotuksia kustannusten estimointiin, kustannuslaskentaan ja asennustoimintaan liittyen.

Työn kirjallisuuskatsaus keskittyy kustannuslaskennan ja -arvioinnin teorioihin. Teoreettisen osuuden tavoitteena on tunnistaa kustannuslaskentaan liittyviä haasteita, jotta niitä voidaan peilata caseyritykseen.

Suurimmaksi haasteeksi tutkimuksen tekemisessä nousi kustannusdatan pirstaleisuus yrityksessä, minkä vuoksi nostettiin esiin tarve tuotekustannusten harmonisoinnille. Myös kustannusten arvioinnista löydettiin kehittämisen varaa, etenkin asennuskustannusten estimaatit eivät olleet riittävällä tarkkuustasolla. Tarkkuutta voitaisiin kehittää mm. hyödyntämällä entistä paremmin tietämystä ja dataa edellisistä projekteista. Tutkimuksessa havaittiin myös, että tuotteiden elinkaariajatteluun siirtyminen voisi tuoda etuja tuotteiden hinnoitteluprosessissa. Arvoa asiakkaille luodaan elinkaaren eri vaiheissa mm. nosturin toimintaluotettavuuden ja vara-osien saatavuuden kautta.

FOREWORDS

This thesis is dedicated to my dear mother, Terhi, who sadly passed away during this process. I wish she could see me finally graduating. I owe her everything.

This study was conducted already in 2011. However, I jumped into the (working) life and publishing my thesis was delayed for several years. Thus, I would kindly thank everyone at LUT university for their flexibility and gentle push towards finishing my degree. Special thanks go to my supervisor Timo Kärri for his support and advices regarding this thesis. You are all doing a great job in providing students the foundation for their careers.

I would like to thank also my supervisor in the case company for his support with this study, and for the years we worked together. The case company and its people gave me invaluable support and experience that I have been able to exploit on my career.

Finally, I want to thank my family and friends for being there for me. My husband and children have taught me what really is important in life and have brought balance between work and personal life. I couldn't be more grateful at this very moment!

Vaasa, 28th March 2019

Sincerely,
Niina Ekqvist

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

AACE	the Association for the Advancement of Cost Engineering
CBR	Case-Based Reasoning
CBS	Cost Breakdown Structure
CM	Contribution Margin
DAS	Drawing Automation System
DSS	Decision Support System
ERP	Enterprise Resource Planning
GAO	the Government Accountability Office
IPS^2	Industrial Product-Service System
KM	Knowledge Management
LCC	Life-Cycle Costing
LL	Lessons Learned
OEM	Original Equipment Manufacturer
PCE	Product Cost Estimation
SDC	Standard Duty Crane
TCM	Total Cost Management
VE	Value Engineering
WBS	Work Breakdown Structure

LIST OF FIGURES AND TABLES

1 INTRODUCTION

1.1 Background

Accurate, up-to-date and easily available cost information is essential for decision-making, as the product cost information is used in pricing, cost estimating, profitability analyses, make-or-buy decisions etc. Unfortunately, cost accounting and cost management in international companies has its challenges because of diverse cost accounting practices and separated systems. This challenge has been recognized in Konecranes and measures have been taken. Project for harmonizing and activating product cost reporting in Konecranes was launched in 2009. In addition, global SAP ERP system implementation project has been set in train which will resolve some problems, also around the area of cost reporting and cost management.

In 2010, orders received for equipment business area totaled 1004.9 million Euros, from which share of industrial cranes was around 45 %. Industrial cranes sales thus accounts for almost half of the equipment sales. Industrial cranes business unit is further divided into three business lines: standard duty cranes (SDC), heavy duty cranes, and work station lifting systems. Volumes of SDC are the highest of the industrial cranes business line. Therefore, potential cost saving in this product line is significant. Need for further research related to recent product cost harmonization project emerged. This thesis aims to fulfill the need of clarifying costs of industrial cranes, and therefore, to produce support information for decision-making. (Konecranes 2010, p. 63)

1.2 Research problems, objectives and limitations

The objective of this thesis is to examine the total costs of industrial cranes focusing on the costs of final installation and site operations. Research problems of this thesis are as follows:

How the total costs of standard industrial cranes are divided into cost categories?

How big proportion installation costs are from the total costs?

How the cost structures differ in chosen case countries?

What is the current level of cost estimation accuracy and can it be improved?

The main research question is how the total costs of standard industrial cranes are divided into cost categories. The objective of this research is to examine the cost structure of an average industrial crane. Focus of this research is on the tag end of a cost breakdown structure because the biggest uncertainty lies in those costs, i.e. the installation/site operations costs. After clarifying the cost structures and proportions of installation costs, these average cost structures of each case country are compared, and differences are reported. Additionally, a current level of cost estimation accuracy is evaluated and possible improvements in cost estimation, cost accounting, pricing, and site operations are considered.

Research is limited to three standard duty crane models which are introduced in chapter 4. These crane models are chosen as the sales volumes of these models are the biggest. Countries in scope are limited to five countries which are chosen because of their importance for the case company. Chosen case countries are Finland, Germany, Hungary, China, and USA. Other limitations are related to the cost categories. Because costs of the components including material, labor, and other production costs are well known already, there is no need to concentrate on how these costs are incurred. Concentration of the research, thus, is on the site operations and final installation costs as estimating those costs is the most challenging part of product cost estimating. This research doesn’t focus either on the freight costs because freight costs are changing all the time, and it is not very worthwhile to find out the accurate freight and transportation costs, as the information would be outdated quickly.

Theoretical part of this thesis concentrates on cost accounting and cost engineering. Research objectives of this part are related to the challenges in cost accounting and engineering. Main concepts are introduced and previous studies about cost engineering, especially cost estimating, are examined. Theoretical research problems are as follows:

How total costs of industrial products are composed of and how these costs can be estimated?

What are the biggest challenges in cost engineering and how these challenges can overcome?

How cost estimating accuracy can be improved?

1.3 Research methods and data

Cost data for research is collected from the case company's selected locations in Finland, Germany, Hungary, China, and USA. For each case country 8-10 projects from years 2010-2011 are chosen, and data and cost information about these projects is collected and analyzed. Used research method is case study, where the main case is the case company, and sub-cases are case countries and recent standard duty crane projects. The projects have been sought to choose in such a way that they would represent an average project of crane manufacturing, delivering and installing. The hierarchy of the cases is shown in Figure 1. Also, action research method is applied in this research. Action research aims for activity development through examining current activities and practices, and by understanding the new way of acting. Activity research is often sketched as a spiral which starts from the planning and goes through planning-observing-reflecting-replanning-action-observing-reflecting-circle aiming to develop the activities or operations. Action research in this thesis goes through examining current practices in site operations and cost accounting aiming to spot the strengths and weaknesses in those practices, and by giving suggestion how to develop the weakest links. (Aaltola & Valli 2001, p. 158-177)

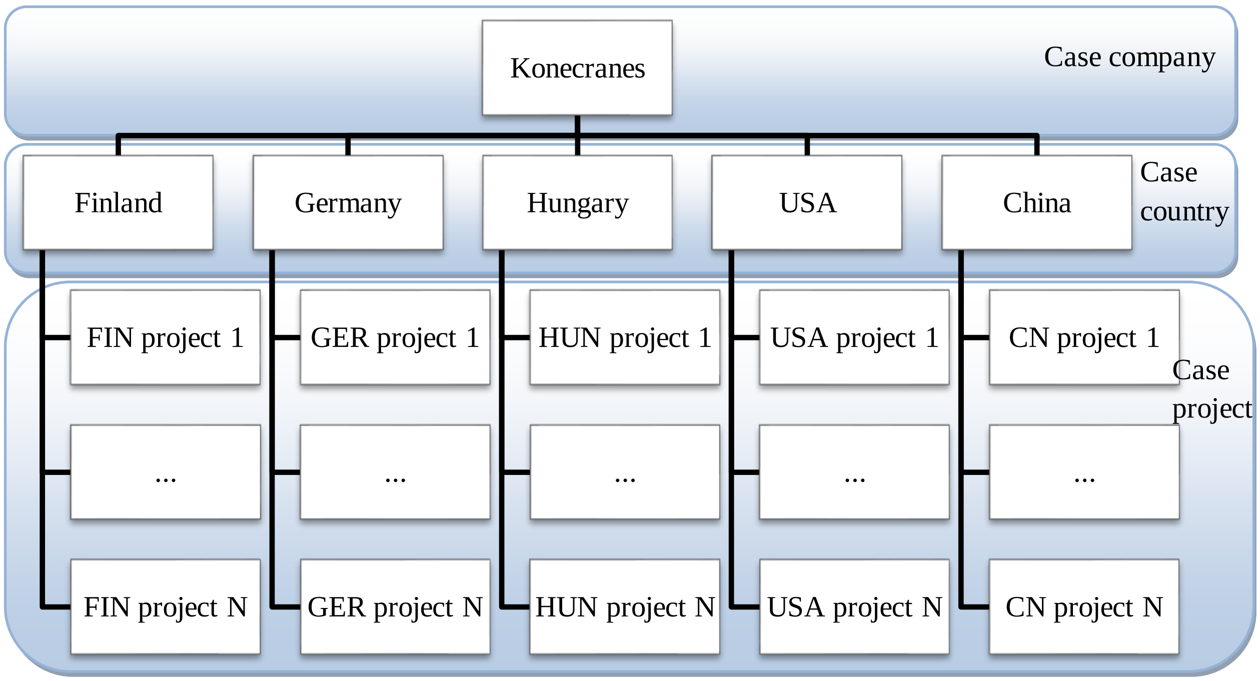

Figure 1. The hierarchy of the case study.

1.4 Research structure

This thesis is divided into two parts: first theoretical part and then the actual research; empirical part. The theory is reported in chapters 2 and 3 where previous literature and research about cost management and cost engineering is discussed. These chapters create a base for the actual research. In chapter 4, the case company and the products in scope are introduced, and the current practices are explained. In chapter 5, the actual research process is explained, and the analysis and results are discussed. Chapter 6 describes the conclusion and gives suggestions for developing the current practices and describes the needs for further research. The structure of this thesis is shown in Figure 2.

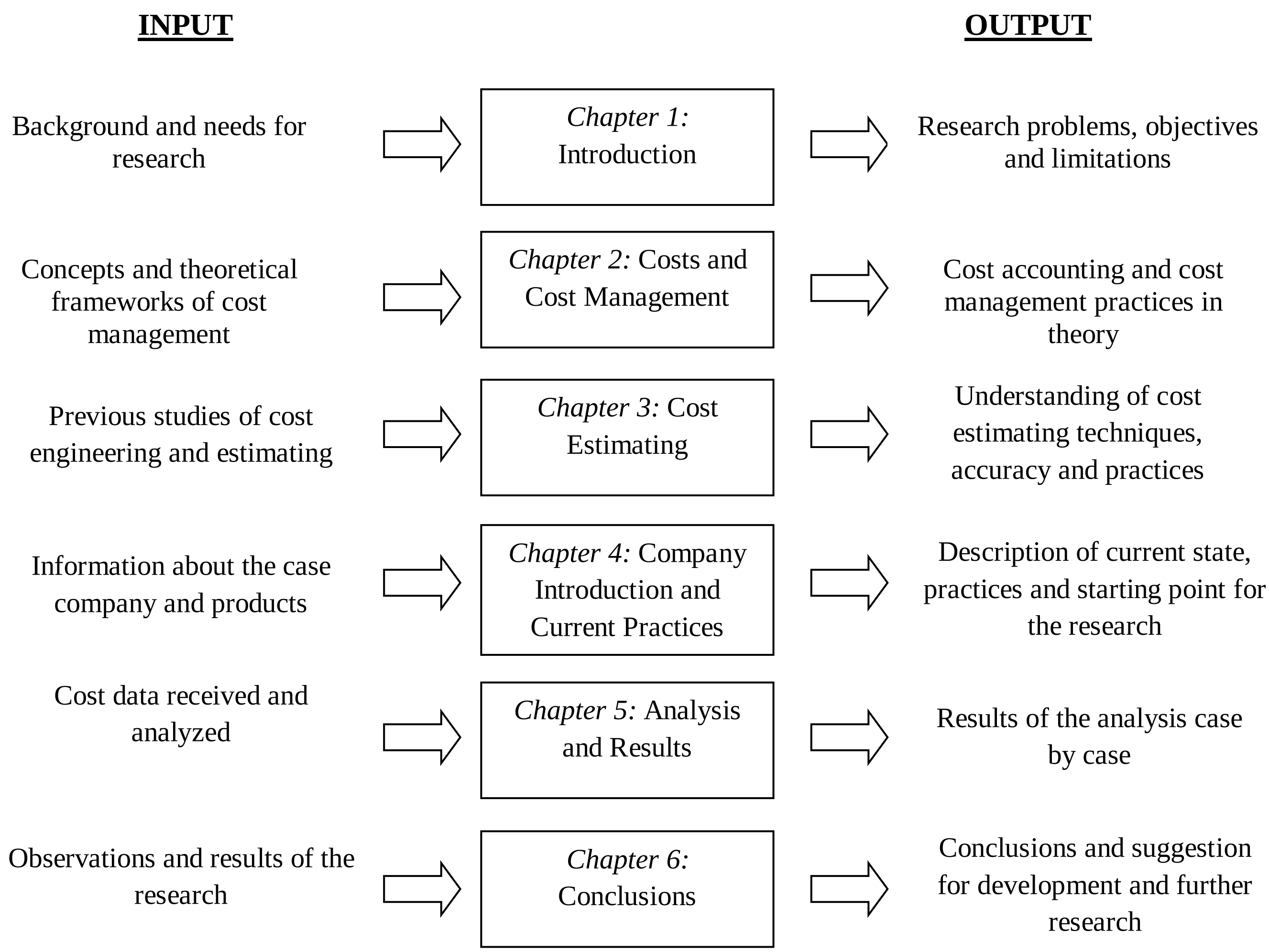

Figure 2. Structure of the thesis.

2 COSTS AND COST MANAGEMENT

2.1 Costs

Cost is the monetary amount i.e. the value of an activity or an asset which is sacrificed or forgone to achieve a specific objective. Budgeted cost is the forecasted or estimated cost, actual cost is the cost incurred. Costs are divided into direct and indirect costs. Direct costs are costs that are directly related to completing an activity, or an asset. They can be traced to this cost object in a cost-effective way. Assignment of direct costs is thus called cost tracing, whereas, indirect costs cannot be traced to the particular cost object in a cost-effective way. Indirect costs are those resources that are needed to support the activity or asset, but these costs are also related to other activities. Assignment of indirect costs is called cost allocation. (Horngren et al. 2009, p. 53-54; Amos 2007, p. 1.1-1.2)

The two basic types of cost-behavior patterns are fixed costs and variable costs. Fixed costs don't change during a certain defined period of time, and they are not depending on the volume or the level of an activity. Variable costs depend on the volume of a work activity or asset, so they change in total at the related level of changes in the volume of an activity. Both variable and fixed costs can be either direct or indirect. Generally, costs can be divided as shown in the Figure 3. (Horngren et al. 2009, p. 56-57; Amos 2007, p. 1.3)

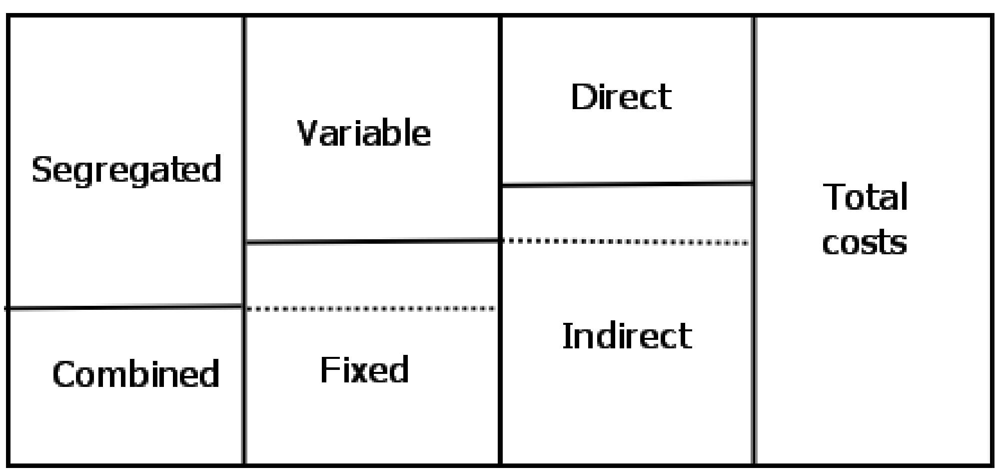

Figure 3. Cost division (Neilimo & Uusi-Rauva 2007, p. 55).

2.1.1 Cost accounting and cost allocation

Cost accounting is a tool for providing information for management accounting and financial accounting. It uses the methods of business accounting to measure, analyze and report both financial and nonfinancial information which is related to the costs of acquiring, or using resources in a company. Cost accounting and cost management are important assets for successful management of companies. (Horngren et al. 2009, p. 30; Neilimo & Uusi-Rauva 2007, p. 37)

As indirect costs constitute a large share of overall costs assigned to cost objects, allocating these costs has four different purposes. First, cost allocation provides information for economic decisions, so it helps managers in decision making. Secondly, cost allocation is a good motivator for managers and other employees. Third reason is to justify costs or compute reimbursement amounts. And last, incomes and assets are measured through cost allocation. There are also four different criteria that are used in cost allocation decisions. These criteria are cause and effect, benefits received, fairness or equity, and ability to bear. Cost-allocation base is one way how company can link an indirect cost, or group of indirect costs, to a cost object. An example of a cost-allocation base is machine-hour. The reason why companies usually use the cost driver of indirect costs as the cost-allocation base, is that there is a certain cause-effect relationship between the changes in the level of a cost driver, and changes in indirect costs. (Horngren et al. 2009, p. 124, 527-528)

2.1.2 Total costs of a product

Accurate product cost information is vital, because major of the decision making is performed based on the product cost information. This cost information is used, for example, in pricing, estimating the costs of the new products, and profitability analyses. Traditional way of calculating product costs is to divide costs into three different categories: direct material, direct labor and indirect costs of manufacturing. Traditional way, however, doesn’t show the actual costs very well because allocating general indirect costs is quite complicated, and might result in distorted product costs. On that account, companies have been moving from the traditional way to activity-based calculations. By using activity-based costing, defining the product costs is improved because of better way of allocation the costs of support activities. Maskell (2006) suggests using value stream costing as a way solving the standard cost problem. He also states that using standard costing distorts product costs, and thus misleads people and results in unfavorable decisions about pricing, profitability, make-or-buy and so on. Value stream costing suits especially for lean manufacturing companies, and it takes into consideration all the costs in the value stream. Costs included in value stream costing are shown in Figure 4. Value stream costs are usually calculated weekly or monthly, and it considers all costs as direct costs, so the value stream contains almost no allocations. (Brimson 1992, p. 235-252; Maskell 2006, p. 27-35)

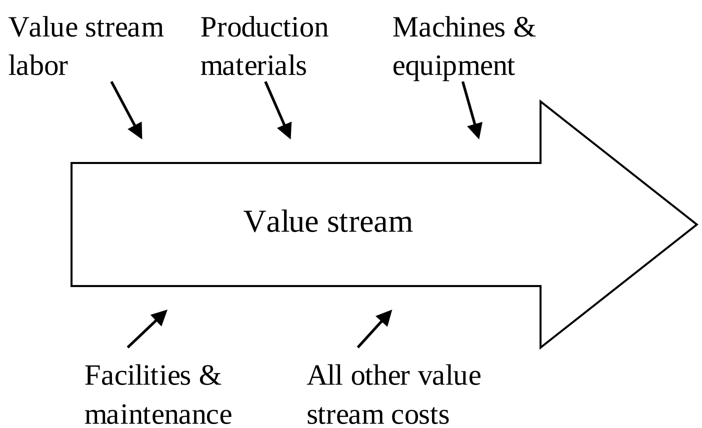

Figure 4. Value stream costs (Maskell 2006, p. 28).

One way to look at the total costs of a product, is life cycle costing (LCC) which is designed for cost management and focuses on long term performance of the products. LCC approach has one basic assumption that future costs of the products can be affected beforehand by planning the use of the product, or by improving the product or the asset. At early stages, the focus of the LCC is on estimating the future costs, but later, the focus will change into monitoring and tracking incurred costs. At the very end, the focus is on total life cycle statement. Fabrycky & Blanchard represented a cost breakdown structure for total product costs through its life cycle, which is shown in Figure 5. (Asiedu & Gu, p. 886-888; Lindholm & Suomala 2007, p. 651-654)

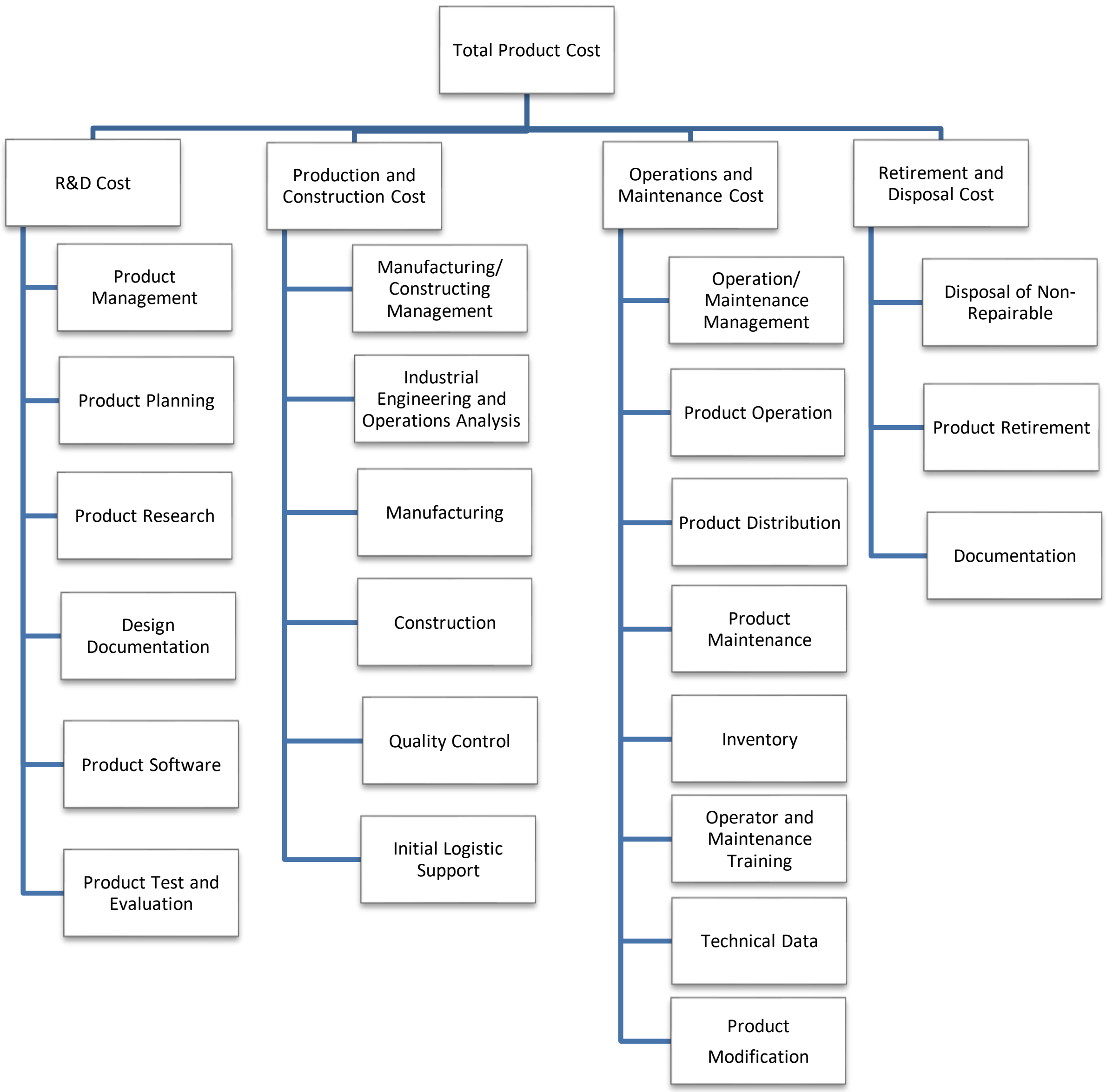

Figure 5. Fabrycky's & Blanchard's total product cost breakdown structure (Asiedu & Gu 1998, p. 887).

Operations and maintenance costs constitute the biggest portion of the total product costs. Unfortunately, these costs are also the most difficult to estimate and forecast. Maximum availability and maximum customer satisfaction are received by producing a product that is reliable and easily serviceable. Serviceability can be improved particularly through product design. The case products of this thesis are standard, established products so the R&D costs are relatively small, and that's why, excluded from the total product cost. Production and construction costs are quite well known already, and the main costs of this category are costs of the components, steel structures, manufacturing, and assembly. Operation costs of this case include freight costs, and the site operation costs which are the focus of this research. Although the retirement and disposal costs are excluded from the cost calculations of this research, these costs are not fully ignored or left behind, when considering the total costs of industrial cranes. (Asiedu & Gu 1998, p. 888)

2.1.3 Initial cost of equipment

In this thesis, the term, total cost of an industrial crane, is used. This term is in practice the same as the initial cost of equipment, when considering the whole life cycle cost of a product. Initial cost is divided to hard costs and soft costs. A hard cost means the basic cost of the machine, so basically the material and labor costs of the components, manufacturing costs, and assembly costs. Soft costs are, for example, foundations, freight, debugging, taxes, and installation. An example about hard and soft costs is presented in "Skills & Knowledge of Cost Engineering" using a transfer stamping press line as an example equipment. Costs in this case where divided as follows:

The basic cost of the machine:	$1 500 000	Hard costs = $ 1 500 000
The cost of foundations	$ 400 000	Soft costs = $ 600 000
The cost of freight	$ 40 000	
Taxes	$ 60 000	
Installation	$ 100 000	
= Total cost	**$ 2 100 000**	

(Amos 2007, p. 6.6)

During the past decades, equipment users have, however, changed their decision criteria from initial cost to total lifetime cost of equipment ownership. That's why, equipment manufacturers should examine also the whole life-cycle cost of their products. One example about life cycle costs is the LCC elements for pumps which are: system design, acquisition cost, installation, operation, energy, maintenance and disposal. What comes to industrial cranes, the cost elements are nearly the same. Noteworthy from this example is that one should know how different LCC elements interact. As an example: installation cost optimization can have a negative effect on the maintenance costs, so the whole life cycle costs might be rocketed, even the installation costs are decreased. That's why, we cannot ignore the maintenance, retirement, and disposal costs of the products, even though these costs are not included in the total cost calculation of the industrial cranes. (Carsten & Erickson 2007, p. 32)

2.2 Cost management

Total cost management (TCM) is a concept introduced by AACE international, and it is defined as "*the effective application of professional and technical expertise to plan and control resources, costs, profitability and risks. It is a systematic approach to managing* *cost throughout the life cycle of any enterprise, program, facility, project, product or service.*" The TCM process creates the basis for cost management before the cost occurs. Medley (1994) states, that managing costs before they occur, requires six things. First, the implementation of TCM requires a life cycle perspective for managers to fully appreciate the long-term and short-term cost impact on the decision making. Secondly, managers need to be familiar with the factors that affect costs either in a positive, or a negative way. These factors can be related to, for example, the political system, economy, legal or financial systems, location, or internal policies. Thirdly, cost managers need to be aware of the cost implications of the events, as they occur. By knowing the factors that influence costs, managers are able to create and maintain an ongoing awareness of the cost implications of the events, and the risks they bring with. Fourthly, managers need to be familiar with the tools available for cost management. These tools include cost estimating and engineering, planning and scheduling, economic and financial analysis, performance measurement, and management methods. Fifthly, managers must have a sense of responsibility for responding to the circumstances, in a timely manner. And the last required matter for cost management is planning the implementation of cost management throughout the life cycle; this plan should be based on the strategy. (AACE International 2009; Medley 1994, p. GVT.2.1-2.7)

Traditionally has been stated that 80-95 % of the product costs are determined by the design of the product, therefore, cost management should focus on the design phase, not manufacturing. However, research done by Cooper & Slagmulder (2004) suggests otherwise. They found out that it is possible to manage cost throughout the product life cycle. Therefore, a company shouldn't focus only on reducing costs in production or manufacturing, but throughout the product life cycle. From the supplier's perspective, the after sales period is critical both in the terms of total product revenues and generated profit. They introduce five techniques for managing costs, from which each one is critical factor in the company's integrated approach to cost management. These major techniques are:

1) Target costing: applied in product design phase, and objective is cost reduction.

2) Product-specific kaizen costing: applied in manufacturing phase, objective is cost reduction.
3) General kaizen costing: applied in manufacturing phase, objective is cost reduction.
4) Functional group management: applied in manufacturing phase, objective is cost reduction.
5) Product costing: applied in manufacturing phase, objective is cost containment.

(Cooper & Slagmulder 2004, p. 45-46)

Target costing technique is defined as a profit planning and cost management system. There are six key principles for target costing, which are: price led costing, customer focused, design centered, cross-functional teams, value chain involvement, and lifecycle cost reduction. Target cost technique is hence usually applied during the design phase, and the aim is to reduce costs of a new product by closing the gap between estimated target cost and cost projections for the new product, based on current designs and manufacturing capabilities. Target cost is simply calculated by deducting profit from the price of the product. (Ansari et al. 2006, p. 20-21; Cooper & Slagmulder 2004, p. 46)

One difference between target costing and kaizen costing is, that target costing is usually applied in the product design phase, and kaizen costing in the manufacturing phase. Shank and Fisher (1999) however think that target costing may be applied also during the manufacturing stages of the product life cycle. Target cost is derived from estimating the selling price and eligible profit, and it is a financial target for the total cost of a product. Kaizen costing doesn’t focus on market prices as target costing does, but the focus is more on the continual incremental product cost improvements. The product-specific technique aims to correct any possible cost overruns during the early manufacturing stage, by redesigning a new product, and the focus of general kaizen costing is on the way how product is produced. (Shank & Fisher 1999, p. 73-74)

In the functional group management, production processes are grouped and treated as different profit centers, instead of cost centers. That how, employees and managers can be motivated through understanding their contribution to the company, as instead of working in the production line, they are a part of a profit center. Also, by using functional group management, the most efficient and profit increasing production processes can be chosen, even if the costs might increase at the same time. Product costing is a tool for providing information, and that way coordinating the efforts of four cost reduction techniques. (Cooper & Slagmulder 2004, p. 47-48)

2.3 Industrial pricing

Long-run pricing approaches exploiting product cost information, have been divided into market-based and cost-based approaches. Marked-based approaches are usually used by companies that operate in highly competitive markets. In less competitive markets, companies whose products differ from each other, can use either market-based or cost-based approaches as support techniques for decision-making concerning pricing. Cost-based pricing is likely to be applied in markets where demand is very difficult to predict. Noble and Cruca (1999) have introduced ten different strategies for pricing an industrial product, these strategies are shown in the Table 1. They have included some related strategies for those ten main pricing strategies. These related strategies are either part of the main strategy or are similar to the main strategy. In cost-based pricing situation, they suggest the use of cost-plus pricing, while suggested related strategies are contribution pricing, rate-of-return pricing, target return pricing, contingency pricing, and markup pricing. Most commonly used inputs for pricing are work breakdown structure (WBS), historical records, cost estimations, and cost management system. Pricing outputs include project acquisition, business decisions, and lessons learned. (Amos 2007, p. 2.2; Horngren et al. 2009, p. 459-460; Noble & Cruca 1999, p. 437-438)

Table 1. Pricing Strategies for Industrial Pricing (Noble & Cruca 1999, p. 438).

	Pricing strategy	Description	Related strategies
New product Pricing	Price Skimming	Set initial price and then systematically reduce it over time.	Premium Pricing, Value-in-Use Pricing
	Penetration Pricing	Set the price low to accelerate product adoption.	
	Experience Curve Pricing	Set the price low to build volume and reduce costs through accumulated experience.	Learning Curve Pricing
Competitive Pricing	Leader Pricing	Initiate a price change and expect others to follow.	Umbrella Pricing, Cooperative Pricing, Signaling
	Parity Pricing	Match the price set by the overall market or the price leader.	Neutral Pricing, Follower Pricing
	Low-Price Supplier	Strive to have the lowest price in the market.	Parallel Pricing, Adaptive Pricing, Opportunistic Pricing
Product Line Pricing	Complementary Product Pricing	Price the core product low and complementary items higher.	Razor-and-Blade Pricing
	Price Bundling	Offer the product as part of a bundle of several products.	System Pricing
	Customer Value Pricing	Price one version of the product at very competitive level by offering fewer features.	Economy Pricing
Cost-based Pricing	Cost-Plus Pricing	Establish the price of the product at a point that gives a specific percentage profit margin over the costs.	Contribution pricing, Rate-of-Return Pricing, Target Return Pricing, Contingency Pricing, Markup Pricing

New product pricing situation is excluded from this discussion because case products are not new, but standardized products. Also, the competitive pricing situation is not entirely applicable for this case. That's why, the focus of the discussion is on complementary product pricing, customer value pricing, and cost-plus pricing. In cost-based pricing the consideration is in the internal costs of the company. The basic cost-based pricing formula is cost base plus the markup component. For example, if the full unit cost is 1000 € and intended markup is 20 %, the prospective selling price is: 1000 € + (0.20 x 1000 €) = 1200 €. (Horngren et al. 2009, p. 467)

In complementary product pricing, the main product is sold for a low price, while the price for complementary products or services is much higher. Customer value pricing has become common in industrial markets, where the appeal of value-prices products varies by the intensity of product usage and geographical scope of usage. As an example, low intensity crane users are much more price sensitive than heavy users, when acquiring the crane. Other important factors for the customer might include the reliability of the machine, availability of spare parts and service, and the growth rate of the customer's business. In conclusion, the initial acquiring price is not always the most important factor for a customer, but the complementary service and spare parts, and reliability might be much more valuable. In this kind of situations, the customer value pricing strategy or complementary product pricing can be applied. (Noble & Gruca 1999, p. 442)

Market-based pricing begins with setting a target price which is the estimated price customer is willing to pay. The process of developing the target prices and target costs has five steps:

1) Developing a product that satisfies the needs of the potential customer
2) Choosing the target price
3) Deriving a target cost

4) Performing cost analysis
5) Performing value engineering to achieve the target cost

Value engineering (VE) is a method for acquiring and applying knowledge, and it enables the realization of life cycle cost and cost effectiveness of projects. It evaluates systematically all the value chain elements. The objective of the method is to optimize cost or performance of a facility or a system, and to achieve a quality level that satisfies the customers. In VE method functions are defined and classified, and through this process most potential and valuable functions can be spotted. (Horngren et al. 2009, p. 460-462; Naderpajouh & Afshar 2008, p. 363-364)

2.4 Conclusion

Accurate cost information is essential for companies to be able to make appropriate decisions about product pricing, new product cost estimates, and profitability. Total product costs include costs that belong to certain product, through its life cycle from design to disposal, i.e. R&D costs, production and construction costs, operations and maintenance costs, and retirement and disposal costs. However, in this thesis calculation of the product cost is limited to cover the product life cycle only till the product i.e. industrial crane is installed and signed over to the customer. Therefore, the aim is to find out the initial cost of the equipment. As equipment users have been moving from considering the initial cost of the equipment, to considering the whole life cycle cost of equipment ownership, some attention needs to be given for the costs occurring after the equipment has been delivered. When analyzing and evaluating total costs of the case products, the affection of the installations to the usage, maintenance and retirement of the product should also be considered. Installation cost reduction can have a negative effect on product reliability and serviceability, and thus detract customer’s image of the original equipment manufacturer and affect the customer’s decision, when choosing the equipment deliverer. Whole life cycle cost management techniques introduced were target costing, kaizen costing, functional group management, and product costing. From these techniques functional group management and product costing might be best possible techniques to apply in the case company.

Several industrial product pricing methods were introduced in this chapter. Out of these methods, noteworthy is customer value pricing, as the customer value of the industrial crane varies greatly by the intensity of the usage and geographical scope of the usage. Low intensity crane users look at the price much more than heavy users, so the intensity of the crane usage should be found out at the offering stage, for being able to compete in the bidding. Other factors that influence the customer's decision in buying an industrial crane, include reliability of the machine, availability of spare parts and service, and the growth rate of customer's business. When considering those customer requirements, the case company is very competitive, as the service network of the corporation is wide, and spare parts are easily available around the world. As these after sales services add more value for the customer, they should also be marketed and used as a selling argument, even more efficiently by the crane sales persons.

3 COST ESTIMATING

While scanning through the publication databases, can be observed that the literature and previous studies about cost estimating, have been focusing on cost estimates mainly in the construction or software industries. That's why, it can be challenging to examine these publications critically enough to be able to apply these theories and conclusions to this particular case. AACE (the Association for the Advancement of Cost Engineering) International is in 1956 founded non-profit professional educational association. They have several publications in the field of cost engineering, for example a monthly issued technical journal called Cost Engineering. In this thesis the cost engineering terminology defined by AACE International is used. AACE defines cost estimating as follows: *"A predictive process used to quantify, cost, and price the resources required by the scope of an asset investment option, activity, or project. As a predictive process, estimating must address risks and uncertainties. The outputs of estimating are used primarily as inputs for budgeting, cost or value analysis, decision making in business, asset and project planning, or for project cost and schedule control process"*. Cost estimating is usually used for establishing a project budget, but it can also be used for determining the economic feasibility of a project, evaluating project alternatives, or proving a basis for project cost and schedule control. (AACE International 2009, p. 8; Dysert 2006, p. EST.01.1)

The basic steps of cost estimating are the same in costing or pricing any investment activity. First step is to understand the scope of the activity to be able to quantify required resources. Usually cost estimation begins with establishing the project scope and the format of providing information for business decisions. Next step is to apply cost to the quantified resources, and then to apply pricing adjustments. Finally, outputs are organized into the format that supports decision-making. When estimating cost of equipment Uppal (1996) suggests that cost information can be collected using one of the following methods:

- Previous project equipment costs
- Preliminary vendor quotations

- Published equipment data
- Computerized estimating programs
- Firm lump-sum quotes definition of terms

Basically, there are three different sources for acquiring cost-related data: published cost information, costs from similar projects and project equipment costs, and historical data from company's own systems and files. (Amos 2007, p. 9.1; Uppal 1996, p. EST.10.1; Uppal 1997, p.168-C)

3.1 Primary cost estimating techniques

Niazi et al. (2006) introduces a hierarchical classification of cost estimation techniques. They divide product cost estimation (PCE) techniques into qualitative and quantitative techniques. Qualitative techniques are further categorized into intuitive and analogical techniques, and quantitative into parametric and analytical techniques. This hierarchical classification of PCE techniques is shown in the Figure 6. Cost estimation literature introduces several different kinds of classification of cost estimation techniques. In the cost engineering literature by AACE International, cost estimation methods have been divided into two categories: conceptual and deterministic, which is also called detailed estimating. The difference between these two categories is, that in conceptual methods the variables are usually not direct measures of the item being estimated, whereas, in deterministic methods they are. Using a conceptual method requires lots of data collecting before the estimate preparation, and using deterministic method requires effort during the actual estimate preparation. There are plenty of conceptual estimating methods; most common ones are end-product units, physical dimensions, capacity factor, various ratio or factors methods, and parametric modeling. (Amos 2007, p. 9.4-9.5; Niazi et al. 2006, p. 563-569)

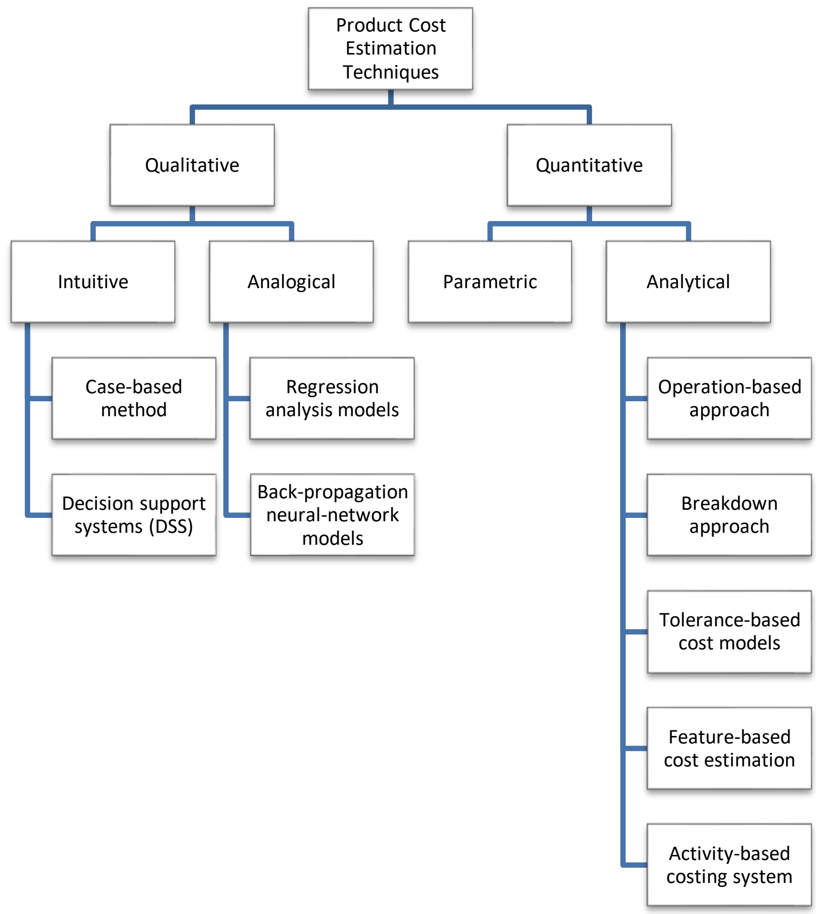

Figure 6. Product Cost Estimation Techniques (adapted from Niazi et al. 2006, p. 569).

Intuitive estimation methods are based on exploiting the previous experience and knowledge. Knowledge used in these techniques may be stored as series of rules, decision trees, judgement etc. Case-based method is often called case-based reasoning (CBR), and it uses the information of previous cases in estimating new product costs. CBR has been one solution for matching previous cases to new cases, working as a problem-solving paradigm. CBR cycle is shown in Figure 7 and is described as four “REs”: 1) Retrieve similar cases, 2) Reuse information and knowledge from the previous cases to solve the current case problem, 3) Revise the proposed solution if needed, and 4) Retain the knowledge from new experience in order to utilize it in future cases. In the Figure 6, the abbreviation LL refers to lessons learned, which is introduced in chapter 3.3. (Naderpajouh & Afshar 2008, p. 365; Niazi et al. 2006, p. 564)

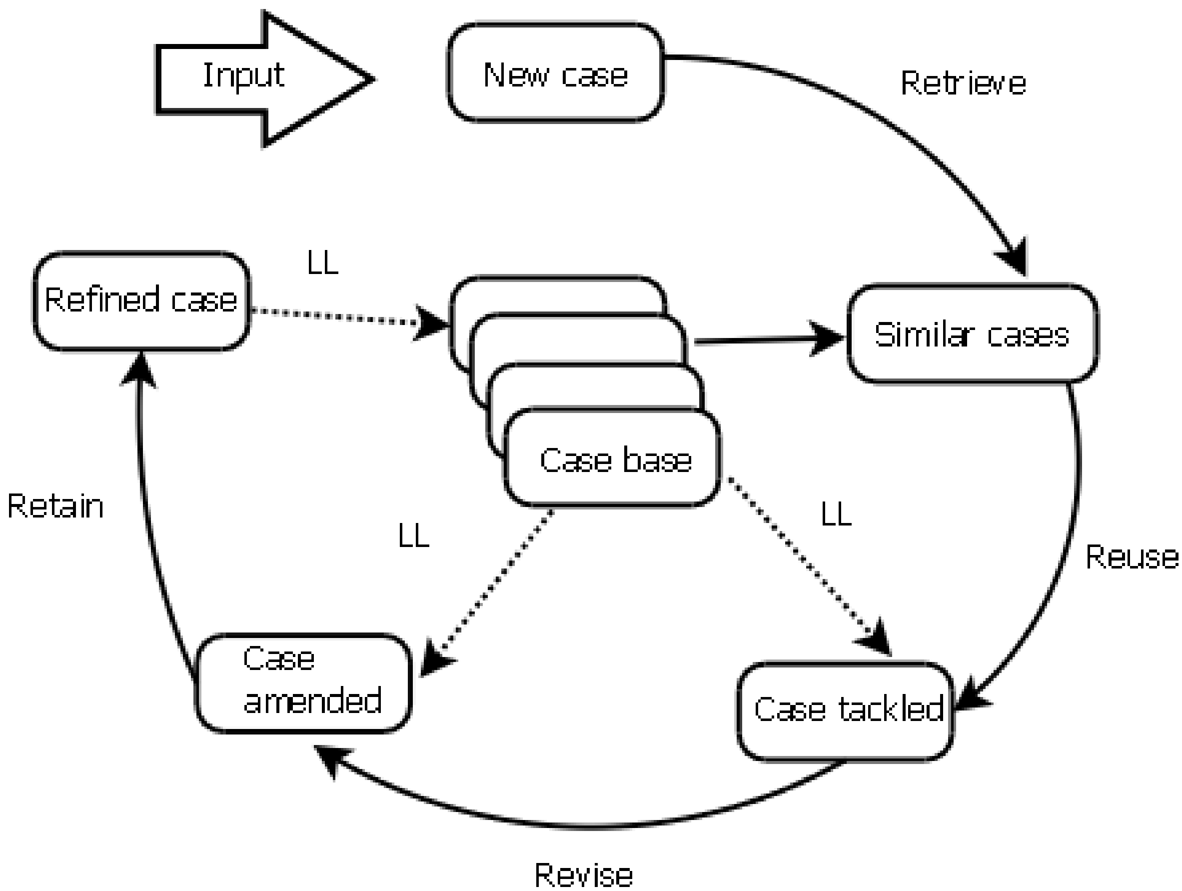

Figure 7. CBR cycle (adapted from Naderpajouh & Afshar 2008, p. 365; Watson 2004, p. 676).

Decision support systems (DSS) are interactive computer-based systems aiming to help decision-making. They are useful tools in evaluating and comparing different alternatives. They are a great help in retrieving, summarizing, and analyzing data that is relevant to current case problem. There are five DSS types introduced in "Decision support systems resources", which include communications-driven DSS, data-driven DSS, document-driven

DSS, knowledge-driven DSS, and model-driven DSS. DSS can be exploited in cost estimating and decision-making process not only for acquiring support information, but for discussing the rules cost estimators apply, when making decisions according to the support information. (Decision Support Systems Resources 2011; Niazi et al. 2006, p. 564; Power 1997)

Parametric models are mathematical representations of cost relationship e.g. between the equipment cost and its key parameters like weight, volume, and complexity. Parametric cost estimation techniques suit well for preparing early conceptual estimates, and for example, in situations where local unique conditions need to be considered in estimates. To be able to estimate equipment costs by using parametric models, historical data is needed. By applying this cost data about recent projects, using regression models and statistical tests, a final model can be created. Parametric estimating usually includes seven stages which are: 1) determining the cost model scope, 2) collecting data, 3) normalizing data, 4) analyzing data, 5) data application, 6) testing, and 7) documentation. (Amos 2007, p. 9.11-9.12; Shabani & Yekta 2006, p. 26)

In general, cost estimating methods are divided into two different groups: conceptual and deterministic (detailed). One example of detailed estimating activities associated with a process or industrial project has been introduced by AACE International. In this example preparation of detailed estimate includes, for example preparing project estimate basis and schedule, preparing direct field cost, indirect field cost and home office cost estimates, preparing cost risk analysis or contingency determination, and validating the estimate. Lesson to be learned from this example is estimating the equipment installation costs. As it has been stated also earlier, estimates shouldn't be prepared only by the estimator, but also construction assistance is needed, when special installation methods are used. In the case of installing process equipment, installation work hours are usually based on weight and equipment dimensions and are typically determined from curves of historical data.

Estimator needs to make sure that all labor associated with the pieces of equipment and all the other activities, like testing, are considered. Situations where installations are conducted by subcontractor, and cases that require special installation, materials should also be identified and estimated. (Amos 2007, p. 9.4-9.17)

3.2 Cost estimating accuracy

The concepts of reliability and accuracy of an estimate have been defined as follows:

"Reliability of an estimate refers to the closeness of the initial estimated value(s) to the subsequent estimated values. Accuracy of an estimate refers to the closeness between the estimated value and the (unknown) true value that the statistics were intended to measure." (Boeschoten 2005, p. EST.20.1)

Accuracy of the estimate is usually represented as a +/- percentage range around the point estimate, in along with the level of confidence. The Government Accountability Office (GAO) has created a list of nine basic characters, that have an effect on the accuracy and reliability of cost estimates. These characters are:

1) Clear identification of task
2) Broad participation in preparing estimates
3) Availability of valid data
4) Standardized structure for the estimate
5) Provision for program uncertainties
6) Recognition of inflation
7) Recognition of excluded costs
8) Independent review of estimates
9) Revision of estimates for significant program changes

(Garrett 2008, p. 17)

Cost estimating is one key factor to the success of a project. Thus, accurate cost estimates are critical in project management. The cost estimate doesn't serve only the budget establishment but works as a scheduling and cost control tool for projects. Term cost engineering is used for this combination of estimating, scheduling, and cost control. Because cost estimating is only predicting the expected final cost, uncertainty and possibility for errors at some level, are related to the cost estimate. Thus, there is always a possibility that predicted costs might overrun or underrun. Especially in site operations several uncertainties exist. When considering the uncertainties, an amount that is often called contingency, is added to the created point value, which then forms the final estimate cost. (Amos 2007, p. 9.1-9.19; Wang & Huang 2000, p. 131; Dysert 2006, p. EST.01.1)

Lund (2005) states that accuracy of project estimates in many cases is not fully understood. and accuracies are not valid until estimators can state confidence about the estimate. On the other hand, one can't determine confidence. He suggests that this riddle can be solved by estimators by accepting the inevitable, establishing standard accuracies, establishing deliverable standards, and/or helping others to understand the estimates better. Of course, all the uncertainties cannot be eliminated by improving cost estimate accuracy, but one should anticipate these uncertainties, and ponder how they can be managed. (Lund 2005, p. 61-62)

"Accurately forecasting the scope, cost and duration of future projects is vital to the survival of any business. Cost estimators develop the cost information that business owners or managers need to make a bid for a contract or to decide on the profitability of a proposed new product or project. They also determine which endeavors are making a profit." Cost estimating has been described as a combination of science, art, and voodoo. The science part is quite clear and simple, specifying an accurate composition of the estimate. In the art part, the judgement and knowhow of the estimator is needed, because although there are databases, historical data and information about required resources and

costs available in every company, using this data requires evaluation of the characteristics of the specific project, and evaluation of how standard costs should be modeled to fit these characteristics. The voodoo part is mainly about anticipating future in business, usually meaning anticipating the changes in the market and economic conditions and evaluating the sources of risk. Certified cost engineer William Kraus emphasizes in his article in Cost engineering journal that qualified, experienced, and knowledgeable people cannot be replaced in the parts of art and voodoo. Computers are a great aid in searching for the historical data about costs, but still the evaluation and judgement by an estimator is needed, in order to be able to receive more accurate cost estimates. (Kraus 2008, p. 3-4)

3.3 Knowledge management in cost estimation

As stated earlier, the ability for judgement and extensive use of experience are required in addition to manipulation of known information in the cost estimation process. According to a research into versatile manufacturing companies, the cost estimation process and pricing cannot be separated, but must be regarded as a one single process. Kingsman & de Souza (1997) have introduced a model of cost estimation and pricing that focuses on the factors that have an impact on the process at the different decision stages. Knowledge about the manufacturing processes and practical experience-based knowledge are both needed in the cost estimation and pricing process. Much of the information required for this decision-making process is incomplete and imprecise, so it needs to be analyzed also by a human, not only by a computer. Computerized estimating methods, however, are a great tool for saving time and making estimates more accurate. (Kingsman & de Souza 1997, p. 119-122)

The cost estimation process and its stages can be seen in Figure 8. The process model of cost estimation and pricing includes four critical decision stages: three internal decisions whether to continue with bidding process or not, and one external decision where customer decides whether to approve or reject the bid. In these decision stages, the information should be collected so that it could be utilized in similar decisions in the future. Six different estimator roles can be identified in the process: enquiry evaluator, estimation time evaluator, time estimator, prime cost assembler, price evaluator, and final price producer. These roles are usually divided up among several people, but one estimator can also have several roles in the process. There are 11 stages in the process, and they are categorized to stages that require judgements or decisions, and stages that include actions and information transfers. (Kingsman & Souza 1997, p. 125)

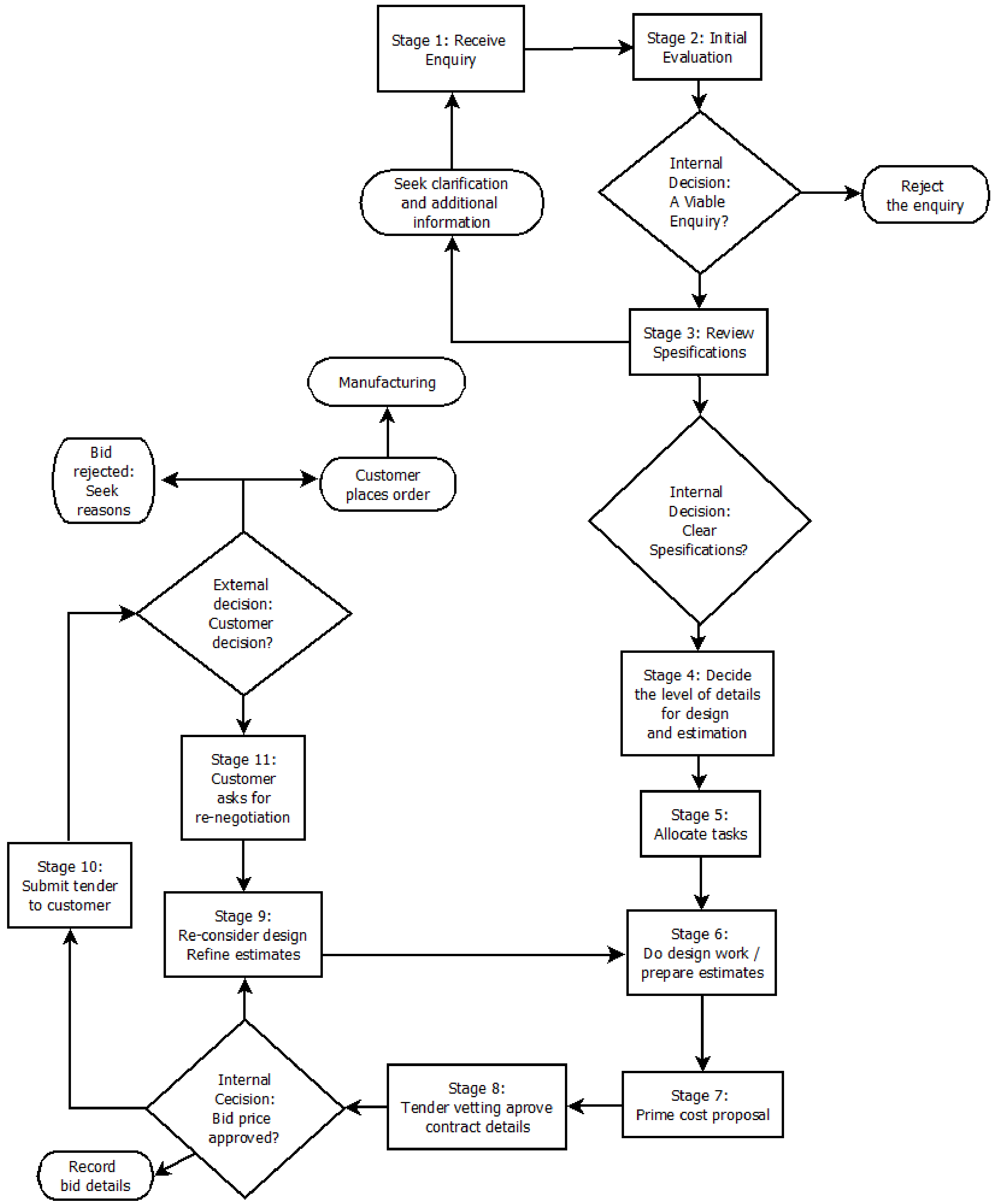

Figure 8. Cost estimation process (Kingsman & Souza 1997, p. 126).

Final price of the product can be calculated as follows:

$$Price = final\ estimated\ cost + risk\ with\ cost\ variances + risk\ with\ mistakes\ by\ the\ estimator + mark\text{-}up\ on\ materials + profit\ margin \quad (1)$$

Companies rarely compare their estimates with the actual cost, which leads into situation that cost estimator doesn't know how large the cost variances are, and hence, how accurate the cost estimations really are. The ratios between actual and estimated costs can be ranging both ways extremely. And that's why, it is important for a company to learn from the past cases and possible mistakes made in estimation process. By calculating the risk with cost variances, company prepares to inaccuracies of cost estimate. Risk with mistakes by the estimator includes adjustments to compensate possible errors made by the cost estimator. Sources of these errors can be, for example, the limited time for preparing the estimations, reliability of information provided by the customer, confidence in the cost/time ratios used in the costing system, dependency on others' estimates, and a lack of self-confidence. Mark-up on materials is just a preparation for possible changes in the costs of materials caused by inflation, shortage of suppliers, or expected variation in exchange rates. (Kingsman & de Souza 1997, p.128-129)

Knowledge management (KM) has become more and more important asset for companies. One of the most essential knowledge management tools is the exploitation of previous experience, or so-called lessons learned (LL). Lessons learned means the valuable knowledge which is learned through previous experiences and projects. Watson (2004) has described one way of capturing and reusing the LL from the installation of engineering equipment. In this case, a case-based reasoning system has been designed to support the installation of heating ventilation and air conditioning equipment. The goals of using this system included reducing the installation specification and quotation time, reducing the margin of error build-in to pricing, and eliminating the need of checking every detail of the specifications by head office engineers. The problem in this system was that system didn’t offer relevant LLs to engineers, thus, LL couldn’t be applied efficiently enough during design and installation. Improvements to the systems were made by enhancing the role of knowledge management. When preparing estimation for new projects, system offers files including drawings, technical specifications, bill of quantities, and notes or so-called trouble tickets from previous similar cases. By saving and reusing trouble tickets, lessons from previous cases can be learned and reused. Improved system offers reminders of lessons learned information at two stages. At the first stage, the set of all similar installation records are sent, so that LL can be reused in the current cases. During the installation stage, a reminder is also sent to engineers to encourage them to create trouble tickets about the current case. (Jeon 2009, p. 13-14; Watson, p. 672-677)

3.4 Challenges and risk analysis in cost estimating

Manufacturing companies which both produce the equipment and deliver it installed, are facing more difficulties in the cost estimation process than, for example, solely assembling companies. Cost estimation process becomes even more complex when a company needs to estimate the indirect and semi-direct costs, because these costs are very difficult to predict with traditional costing and pricing approaches. In cases that include bidding process, even more challenges arise because cost estimation process needs to be completed very quickly which can lead to overestimation or underestimation. The risk of making large errors rises when the estimation time is short. Thus, it requires speed, accuracy, and consistency to make a successful estimating and bidding. While preparing bids for turnkey projects, equipment manufacturers need to consider multiple factors that may affect their final bid. These factors include for example site conditions, type of equipment, and project location. Some of these conditions are known, while some are imponderable which brings on major challenges in making accurate cost estimates. One possible solution for meeting these challenges has been introduced in paper about bid preparation in turnkey power plant projects written by Noor et al. (2006). They suggest using range estimating techniques along with cost estimating templates. Curran (1989) also states in his paper that cost estimating methods alone are not enough, but analysis of uncertainty and risk is needed while making cost estimates. Range estimating is a tool for considering the risk and sensitivity of the cost estimates, so it is not a cost estimating tool but aims to improve cost estimates. Range estimating helps to eliminate or reduce the risk of cost overrun. (Kingsman & de Souza 1997, p. 121, Noor et al. 2006, p. OWN.05.1-OWN.05.4, Curran 1989)

Risk ranging example about turnkey power plant projects is, of course, not fully applicable for other industries but some lessons could be learned from it. In this case example, cost estimating templates were used for base cost estimates. Cost estimating templates utilize data about former similar projects, and the aim is to compare prior estimates with the actual cost data. The key factor is the ability to choose most suitable reference from earlier projects and apply that data for new cost estimating template so that one doesn't need to start filling a fully blank template. That's how filled-in form only needs to be tailored to meet the specific requirements for a project. By using templates, some of the uncertainty is reduced but also some residual cost risks and unknown factors need to be considered in the estimate. When the base cost estimate has been finished and inspected, risk range estimating should be performed. First task of the risk ranging exercise is to identify the potential risks that could impact the base cost estimate. Risk lists created for previous projects can be used. As previous experience is exploited in risk ranging, the prepared risk list only needs to be reviewed so that it is applicable to the current project. When the list of risks is finished, the risks are grouped into categories. After risks are identified and grouped, the question how the base cost estimate could be affected by the listed risks is answered so that the risk range can be captured. (Noor et al. 2006, p. OWN.05.1-OWN.05.4)

When talking about risks, uncertainty, and potential cost overrunning the term contingency should be perceived. AACE International defines contingency as follows: *"An amount* *added to an estimate to allow for items, conditions, or events for which the state, occurrence, and/or effect is uncertain, and that experience shows will likely result, in aggregate, additional costs".* The most common elements and characteristics of contingency include for example covering all the unforeseen elements of cost within a defined project scope, in association with the risk of overrunning the target cost with a certain probability of occurrence, and intention to cover additional costs that might occur during a project because of incidents, like abnormal start-up problems. Contingency estimation can be done by using one of the contingency methods that are divided to deterministic and probabilistic methods. Examples of deterministic methods are overall value method and item by item value. Probabilistic techniques are further categorized to independent and correlated methods which both are further divided into direct and simulation techniques. Sources of risks and uncertainty have been studied in the construction industry. These sources could be considered also when estimating the risks and uncertainties of site operations. These project-specific uncertainties that might raise a risk that should be considered in the project contingency are:

- The project delivery system
- Project state of technology
- Project location
- Project complexity
- Logistics
- Project definition stage
- Quality of design
- Project schedule
- Project procurement plans and policies

In addition to these project-specific uncertainties, items typically covered by contingency include estimating inaccuracies and errors, variability of labor productivity, availability and skills, incomplete design, and varying material and equipment costs. However, contingency usually excludes changes in scope, human errors, natural disasters, unexpected work stoppages, inflation etc. (AACE International 2009, p. 5; Amos 2007, p. 9.22; Moselhi 1997, p. A.06.1-A.06.3)

3.5 Towards better collaboration and industrial product-service system

As integration of the product life cycle has been growing, the importance of service delivery has been increased which brings more challenges to cost estimating. Uncertainty in service delivery causes difficulties in anticipating costs at the bidding stage of the performance-based contracts. Service uncertainty is driven by the quality of information flow and knowledge across the service network. Service uncertainties may be classified based on demand and supply sources. Demand sources of uncertainty are usually associated with service complexity and the delivery urgency. Uncertainty is affected by the complexity of the delivered equipment, usage conditions, usage levels, and customer's willingness to pay. Sources of service supply chain uncertainty include scale, technological novelty, skill requirements, quantity of subsystems, degree of customization, and requirement changes. Other challenges in service cost estimation include sustaining the reliability level, large reliance on the service network for be-spoke parts and the quality of parts, and challenges in predicting support costs. (Erkoyuncu et al. 2011, p. 1223-1235; Roy & Erkoyuncu 2011, p. 5)

Industrial product-service systems (IPS²) represent a new way of delivering value for customer during the whole product life cycle. They are a combination of product and services that provide higher customer value in business-to-business markets. IPS² is characterized as an integrated product and service offering that delivers values in industrial applications. IPS² has been noticed to deliver competitive advantage for the manufacturers. However, to be able to benefit from IPS² one needs to understand the uncertainties that have an effect on the value creation during the product-service projects. Higher value creation for customer can be reached through shifting from mere product sales to value sales. Thus, the contact phase between customer and original equipment manufacturer (OEM) will extend to whole product life cycle from design and development to the actual use of the product. This results in better knowledge of the usage of OEM's products which can raise opportunities for the OEM. As customers are concentrating on their own core competencies and outsourcing secondary tasks, they demand flexibility, quality, fast delivery dates, and reasonable prices from their suppliers. These requirements demand supplier's development from leadership in technology to leadership in use. Motivations for the OEM to shift from technology leadership to leadership in use are, for example, the rise of customer loyalty, opening of new business fields, development of market shares, and information about the use of its products for creating innovations. Integration of products and services and development of product-service systems enables the suppliers contact their machines through the whole product life cycle, and thus a possibility to optimize them. (Erkoyuncu et al. 2011, p. 1224; Meier et al. 2011, p. 1175-1177)

Intensive collaboration between the factory and the service organization brings also more value to the customer, because this way they can buy the installation service with most expertise, and at competitive price. Advantages of equipment installation conducted by the OEM include offering the best knowledge of installation and usage of the equipment for the customer, eliminating the extended communications as serving the customer as single-source provider, offering the best project coordination time-efficiently, and bringing the familiarity with the equipment, installation expertise, and equipment usage training. OEMs also have the best connections to the sub vendors, so it is possible to offer the installation at competitive price. Fast installations also create more customer value as the equipment will be ready to use quicker. (Ditzer 1998, p. 118-120)

3.6 Conclusion

Cost estimating process begins with understanding the project scope and perceiving the information needed in decision-making in costing and pricing a product. Cost information used in cost estimations can be gathered from the published cost information, cost data saved about previous products, and other historical data from company's own systems and files. All this information is available also in the case company and can be utilized in cost estimates. Cost estimation techniques include both qualitative and quantitative methods. Qualitative methods can be applied in situations where previous experience and knowledge is available to be exploited. CBR method is one of the suitable techniques for the case company as information of the previous cases is available. The challenge, however, is that this information is much dispersed, and thus difficult to collect. One solution for gathering and saving knowledge and experience is lessons learned and use of the trouble tickets. That is one way to retain valuable information about previous cases and learn from earlier experience.

Cost estimating accuracy often is one of the biggest stumbling stones. Estimating, forecasting, and predicting are not an easy task as there are several uncertainties and possible risks included in the cost estimates. Cost estimating accuracy may be improved by identifying the tasks clear enough, involving several participants in estimate preparations, gathering valid data, recognizing the inflation and excluded costs, predicting uncertainties and risks, and receiving independent reviews of the estimates. Use of previous experience is also essential in cost estimating. The important of experience-based knowledge and ability for judgement cannot be overemphasized especially when talking about installation and site operations costs. Historical data and information create the base for cost estimating but using this data efficiently requires evaluation and judgement of experienced people. That's why, installation cost estimation should be done in co-ordination with an estimator and someone who knows the field of site operations well.

The challenges in cost estimation are often raised because of limited information and data received, short estimation time, and multiple uncertainties and possible risks involved. To be able to prepare for possible changes and risks, contingency is usually added to the estimates. Uncertainties that might raise a risk and that should be considered in the project contingency include, for example, characters of project delivery system, project location, complexity, logistics, and project schedule. Risks and uncertainties can be managed at some level by using experience-based knowledge and judgement, and by evaluating the possible risks in the estimation phase. If a machine is not only manufactured but also delivered and installed by the OEM, more challenges are faced. Thus, also uncertainties related to the service part of the product need to be considered. Service uncertainty is driven by the quality of information flow and knowledge in the service network, so the importance of the co-operation between participants of the supply chain and service network is essential. One solution for improving product and service delivery is the adoption of an industrial product-service system.

4 COMPANY INTRODUCTION AND CURRENT PRACTICES

Konecranes is an industry-leading group of lifting businesses, and world-leading lifting equipment manufacturer. The company offers a complete range of advanced lifting solutions to many different industries worldwide. It serves customers in manufacturing and process industries, nuclear industry, shipyards and harbors with productivity enhancing lifting solutions and services. The business areas of Konecranes are divided into two main groups: equipment and service business. These business areas are further divided into several business units as shown in the Figure 9. This research concentrates on industrial cranes business unit which is marked in red color in the Figure 8. Industrial cranes-business unit has three different business lines from which the research concentration is on smaller industrial cranes i.e. standard duty cranes. (Konecranes 2011)

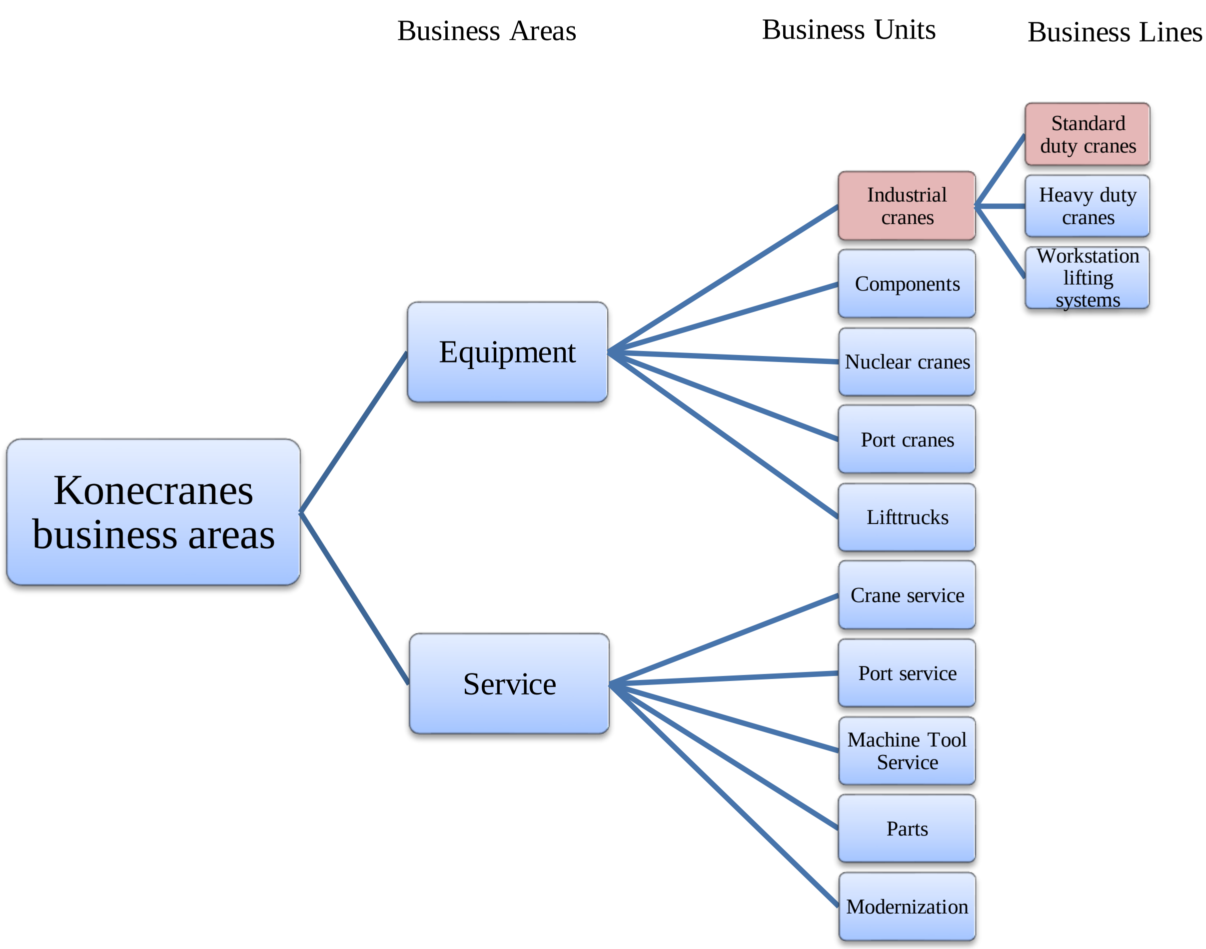

Figure 9. Konecranes business areas (Konecranes 2010B, p. 2).

Products in scope of this research are standard duty industrial cranes. The main components needed usually includes one or at some cases two hoists, two pieces of end carriages, two pieces of bridge drives which are also called traveling machinery, one bridge panel, power supply package which includes bridge power supply and trolley power supply, and control system which may include push button or radio controlling system. Total costs of the cranes include costs of crane components, cost of main girder and assembly of the crane, freight costs and crane installation costs. Crane component costs refer to the cost of the components listed above. Two sample pictures of the products in scope are shown below in Figures 10 and 11. SP code means the strategic product code. SP11 code products are profile industrial cranes and SP12 products box industrial cranes. Box and profile refer to the shape of the main girder. Main girder is the girder between the crane runways and they are usually manufactured locally by subcontractors.

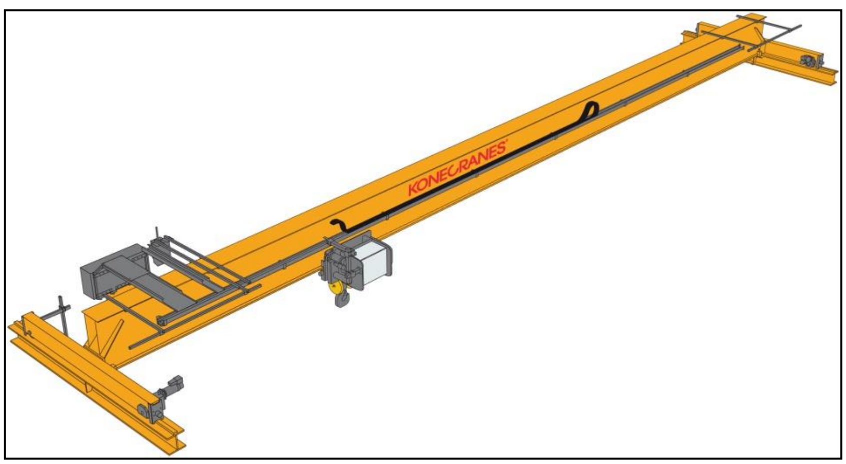

Figure 10. SP12, single girder 5 ton, span 18 m

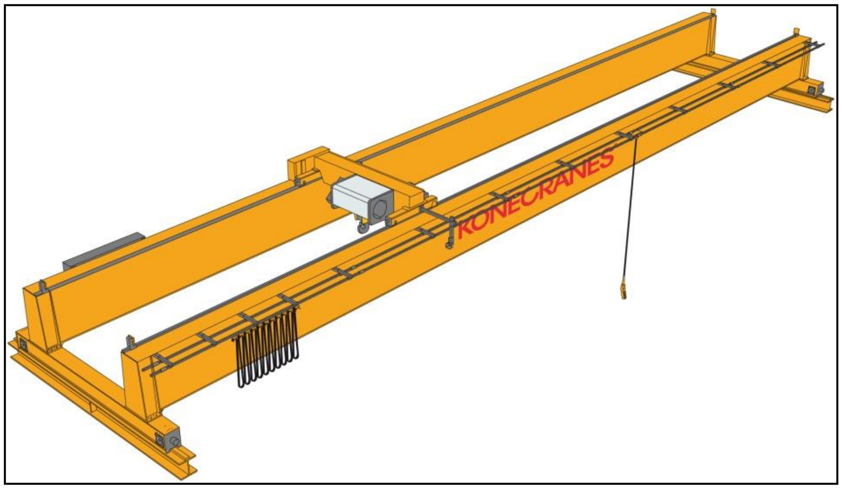

Figure 11. SP12, double girder 20 ton, span 20 m

4.1 Crane sales, cost estimation and pricing process at Konecranes

Crane offers are compiled with the sales configuration tool called Markman. This tool has been one of the key success elements for Konecranes in the field of standard cranes because by using this tool basically no manual design is needed which reduces costs and, that how, the company is able to compile better offer than competitors. It is also possible to compile an offer very quickly, in less than half an hour, which is also one competitive edge for Konecranes. Markman has been used in SDC offer calculations since 1990's. There are around 500 to 600 Markman users in the SDC business area, and most of the countries where Konecranes is represented are using Markman.

Usually in SP 11 and SP 12 projects experienced sales person is the key factor in the project. They can calculate project costs quite accurately already at the bidding stage, so that there is no much need for adjusting in later phases. Standard offer can be made in around 20 minutes if sales person is well-experienced. More time is demanded when the product is more complicated and additional features or manual adjustments are needed. Sales person's experience is also essential for cost optimization. Customers also need to know well what they require from the crane, and how and where the crane is going to be used to prevent possible claims after crane delivery. Even small adjustments can have significant effects on the total price of the crane. So, if no special components or characters are needed, standard and automatic selections should be used to make the most competitive offer as possible.

Crane sales offer is compiled by first creating the crane technical calculations in which all the components are defined. After crane technical calculation is finished technical drawings can be created with DAS (Drawing Automation System). DAS has been in use since 2003 in Konecranes. DAS can be used for creating the drawings fast and efficiently, so that further designing is not necessarily needed. Thanks to DAS, design costs are relatively small or there are no design costs at all in the total costs of standard duty cranes. For example, CAD drawings and 3D drawings can be viewed, printed, and attached to the offer sent to customer. By running technical calculations, only the crane ex works can be calculated and priced so also the calculation of delivery items is needed. First distances to the site are entered. These include the journey of the crane transportation, and the travel kilometers of the erection team and mobile crane. Then further information about crane delivery is entered including the transportation method and possible special packing and loading needed. That way, packing and transportation costs are calculated. Transportation costs are thus estimated automatically by multiplying transportation distance with estimated cost/kilometer. Costs of the crane erection work are estimated automatically according to the technical data of the crane entered earlier. These work hours can be however adjusted manually if needed, and if additional information about the site has been received. Erection hours are usually estimated by the sales person who adjusts the hours according to the information about the site. As an example, two totally different kind of cases are explained below:

- In case A, the site is a brand-new factory which is not operating at the time crane will be installed, and it is possible to drive the crane delivery truck inside the factory to the actual place where crane is going to be operating at. In this case can be presumed that there is no need to adjust the erection hours or to add any additional erection costs like accommodation costs because erection is assumed to finish in less than one working day.

- In case B, the site is an already operating factory where space is limited, and it will be difficult to get the crane inside the factory. The space where crane is going to be installed is narrow, and there is a possibility that crane cannot be erected without a hitch. In this case, the sales person or other Konecranes representative who visits the site before cost estimation and offer making, needs to estimate if more erection hours will be needed than suggested.

Other factors that have an effect on the site operations costs include, for example, erection tools and equipment and number of workers needed. Mobile crane and erection platform costs are usually calculated automatically according to the type of the model crane and working time needed. Costs of delivery items also include commissioning costs like compulsory inspection costs and test load costs. After all these data has been entered, total costs of the crane can be calculated at the pricing section. Costs and offer prices are calculated automatically but they can be adjusted by adding discounts, and by adjusting intended CM2-% or CM2 for each cost item.

When calculations are ready, an offer to the customer can be created. Information needed at this stage includes customer data like contact information and delivery address, terms, times and status including delivery time, length of the warranty period, and payment terms. After offer has been created and sent to the customer, offer is managed through ProCom system. If the offer is accepted by the customer, the status will be changed into an order when manufacturing factory is noticed, and the crane manufacturing stage can begin. Order is managed through several systems by project managers.

4.2 Site operations process

Site operations process, which is shown in Figure 12, begins already when sales order is received which is the milestone for starting the site planning. Site operations manager should be participating the sales phase so that cost estimating for site operations could be made accurate enough. Site manager can also participate in project planning concerning project schedule and budgets. In SDC projects, this is not certainly needed because the projects are relatively small and project cycle is short. When the planning is ready, and when customer gives permission, site manager has checked the readiness, and relevant components are ready to be shipped, site resourcing phase begins. During this phase, site kick-off meeting is usually held to be able to organize the facilities, equipment, mobile cranes, and necessary permissions for site personnel. After site resourcing is finished and all the goods have arrived at the site, the installation begins. Installation usually consists the preparation of the erection like reinstalling parts that have been removed for transportation, the actual erection of the crane, and electrical and functional testing. When the installation is completed, and equipment is ready for customer acceptance testing, commissioning phase begins. This stage includes milestones: equipment ready for testing, provisional test acceptance has been received, and it ends when the customer has signed the final acceptance. After that, the equipment can be assigned to the customer, and site can be closed. Site operations process ends completely when the customer has been informed that the site has been demobilized. (Konecranes 2010C, p. 10-17)

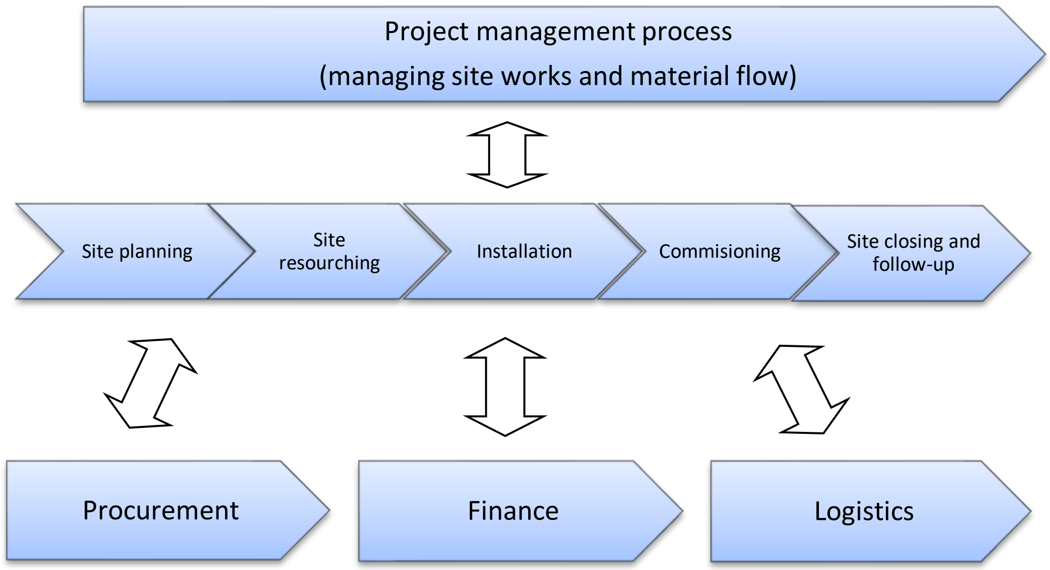

Figure 12. Site operations process (Konecranes 2010C, p. 9).

Crane installation costs are highly influenced by the characters of production environment where the crane is going to be operating in. The most challenging cases are the production sites which are in operation while crane is supposed to be installed. Other challenges include narrowness of the facilities and roadways, the level of crane build-up and operating height of the crane. (Hartikainen 2005, p. 61)

4.3 Current practices in product cost reporting

Widespread, international companies may face some challenges because of different kind of company cultures and local practices. As well in Konecranes, there have been some challenges in global accounting as, for example, product cost reporting practices hasn’t been fully harmonized. That’s why, recently new harmonized calculation rules and reporting procedures have been introduced. The aim is to be able to see the product cost development and differences between selected locations. Harmonization means a process by which accounting moves away from total diversity of practice. Harmonization process then results in the state of harmony where the participants cluster around one method of accounting, or limited number of almost similar methods.

Currently there are several ERP and other IT systems in use at Konecranes. This may sometimes inflict on data modification when transferring data between different systems and sometimes even confusion which system to use. Different departments or cost centers may be using different systems for their reports and data needs to be moved sometimes even manually between systems. Thus, data is often modified and differences between figures that should be the same may be remarkable in some cases.

4.4 OneKonecranes – towards industrial product-service system

OneKonecranes is a business process harmonization and development program, which aims for achieving business efficiencies through harmonization. Three core subjects of the program are improved operational efficiency, better customer relationship management, and transparent data for management decision-making. In chapter 3.5 IPS-systems were briefly discussed. As IPS² represent a new way of delivering value for customers during the whole product life cycle, OneKonecranes process aims to combine global network and resource benefits with the ability to serve customers locally, connect global business knowledge together, and harmonize processes. That way Konecranes can deliver more value for customer more efficiently and consistently. Expedients used to reach this goal are global capacity utilization, pre-engineered and harmonized products, use of global data, harmonized financial systems that enable comparable reporting and effective sales funnel management. For harmonizing IT systems global SAP ERP system implementation project has been started. To be able to harmonize financial practices and systems also developing and harmonizing the reporting needs to be done.

OneKonecranes process has been depicted in Figure 13. It introduces the factors, functions, and systems during the product life cycle. There are three core processes: product, sales and delivery that are supported by five functions: engineering, procurement, manufacturing, people and finance. As stated in chapter 3.5 intensive collaboration between the sales organization, factory, and the service organization brings more value to the customer. As well Konecranes is aiming to serve customer as one single-source provider, which brings competitive edge. Therefore, functions of OneKonecranes need to collaborate and develop harmonized practices. During the product life cycle, costs should be more visible to all the functions. Cost accumulation should be noticed and reported in every process phase. This demands collaboration and transparency between different functions. OneKonecranes project therefore might be one good stepping stone for harmonizing also financial practices and systems, and product cost reporting through the whole corporation. (Konecranes 2010D)

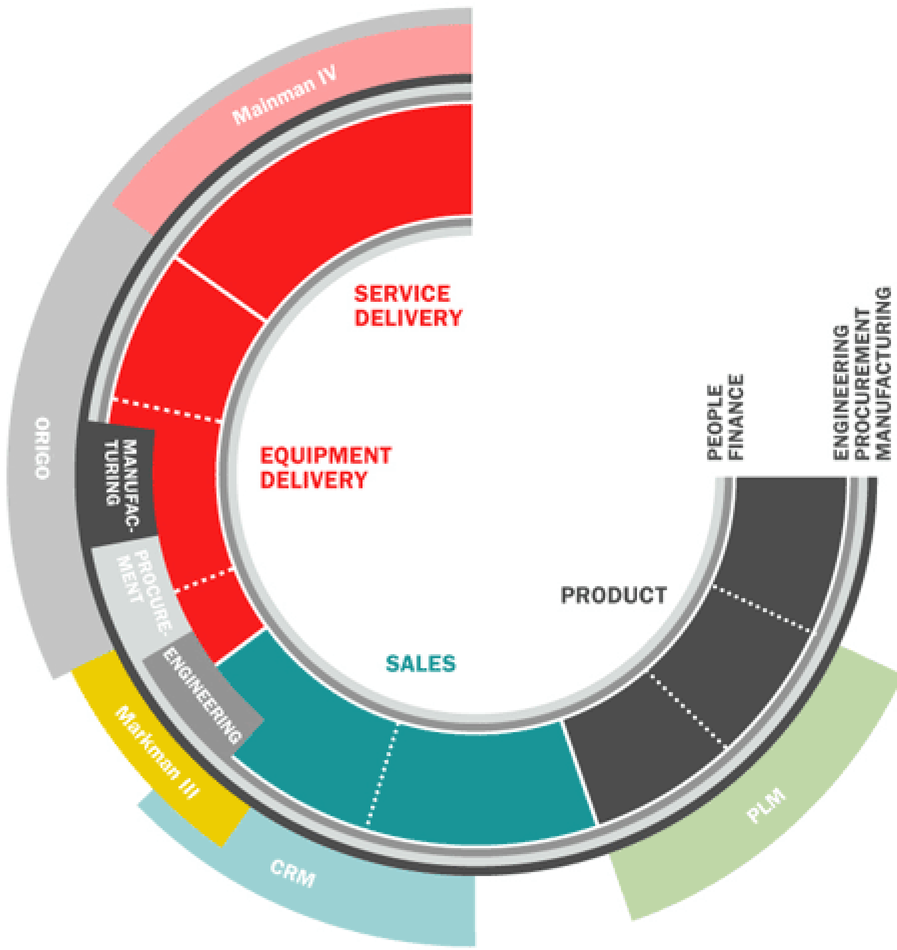

Figure 13. OneKonecranes process (Konecranes 2010D).

5 ANALYSIS AND RESULTS

Total costs of industrial cranes have been divided into four categories: components, steel structures and external manufacturing, freight, and installation costs. Freight costs are referring to the crane delivery costs; component freight is included in component costs. Classification of site operations costs has been dissimilar in different countries. For example, in Germany site operation/installation costs have been divided into four categories: work hour costs and traveling, lifting equipment rents, installation material, and other site costs. In Finland the traveling costs and daily allowances have been separated from the work hour cost. There hasn't been any harmonized practice in dividing the total costs, so choosing the cost categories is challenging. Cost data is very spread out and there can be even large differences between entered figures in different systems. That's why, it is quite challenging to be able to separate out certain costs.

Cost data for this research was collected by requesting cost data about around ten recent SDC projects from business controllers from each case country. Requested data included: order/project number, crane description, sales price, total costs divided into costs of component and freight, and total site operations cost, which were further separated to work hour costs, traveling costs, lifting equipment rents, installation material and other site operations costs. In addition, cost estimates for total crane costs and installation costs were requested. After receiving these cost details, CM2 and the proportions of the cost categories were calculated. Cost data was collected to one summary spreadsheet and average cost structures for each case country and average cost structure of all the cases together were formed. In this chapter, this analysis is explained case by case, and then results are introduced and compared with each other.

5.1 Case Finland

Data collecting for SDC projects in Finland was carried out by searching cost data from several systems. First nine recent projects (from years 2010 and 2011) were chosen because of their SP and model, and because of their character as the aim was to find average projects. When these projects were selected, data about site operations was gathered from the ERP system of Konecranes Service Finland. As well, the total costs of cranes have been saved to this ERP system and the costs have been divided into cost categories which include among others:

- Components and loading
- Machines and purchases
- Steel structures
- Work hour costs
- Daily allowances and traveling

This division of costs seemed rough, and the data seemed not reliable enough to be used without comparing it with the data received from other systems. That's why, more detailed data about components, manufacturing and freight was searched from the other ERP system called iLM by searching for confirmation of orders by project numbers. Through this system detailed information about sale prices of design and project management, components, steel structures, and freight was collected. This data and data received from Service's system were compared and costs were divided into four cost categories: components, steel structures and other external manufacturing, freight and installation. There was some variation between the total costs calculated and total costs saved in Service's ERP system. Calculated numbers were 86-112 % from the total costs saved to Service's ERP system and their roundup table. These differences can greatly be explained by the different ways of calculating costs. In ERP system, total costs include adjuncts which were excluded from the total cost calculations as the aim was to find out actual total costs without adjuncts added to internal purchases. After the actual sales prices were acquired also post-calculations were run from the iLM ERP system. From these post-calculations the actual costs without any adjunctions were received. These costs are the actual costs of components including material and labor costs. Actual costs of the crane ex works could be collected but defining the actual installation and transportation costs was more challenging. The actual working hour and traveling costs of the installation could be received from the Service's ERP system, but other installation costs, like installation material and lifting equipment rents had to be estimated according to received invoices and by reducing estimated adjuncts from the sales prices of the internal transactions.

Average cost division of Finland's projects was: components 46 %, steel structures and external manufacturing 38 %, freight 4 %, and installation 12 %. This cost structure is shown in Figure 14. Installation cost variation was from 5 % to 20 %.

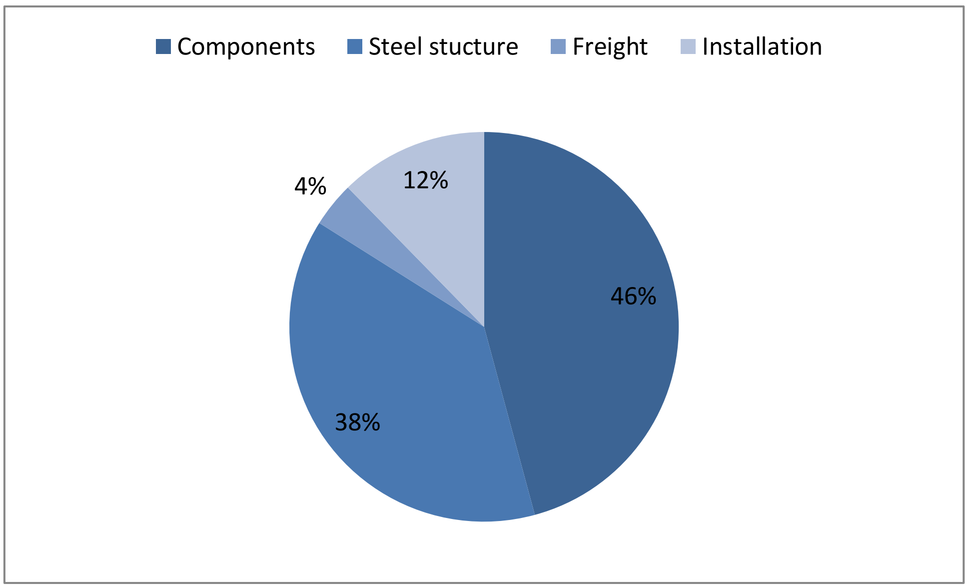

Figure 14. Average cost structure in Finland.

Cost estimation accuracy in Finland was the lowest of all the case countries. Indexes of the site cost estimation accuracy are shown in Figure 15. Seems that installation costs tend to overrun more often than underrun. For 7 projects actual and estimated installation work hours were collected. Actual installation hours were received from Service's round-up spreadsheets, and estimated hours from Markman offer reports. Average actual installation hours were over two times more than the estimated ones. However, these estimated and actual work hours cannot be directly compared as the Markman offers include only the estimated erection hours. The actual incurred installation work hours, however, might include also, for example, testing and commissioning hours. Unfortunately, these actual work hours cannot be revised, because work hours are reported as total and have not been separated out for each site operations activity.

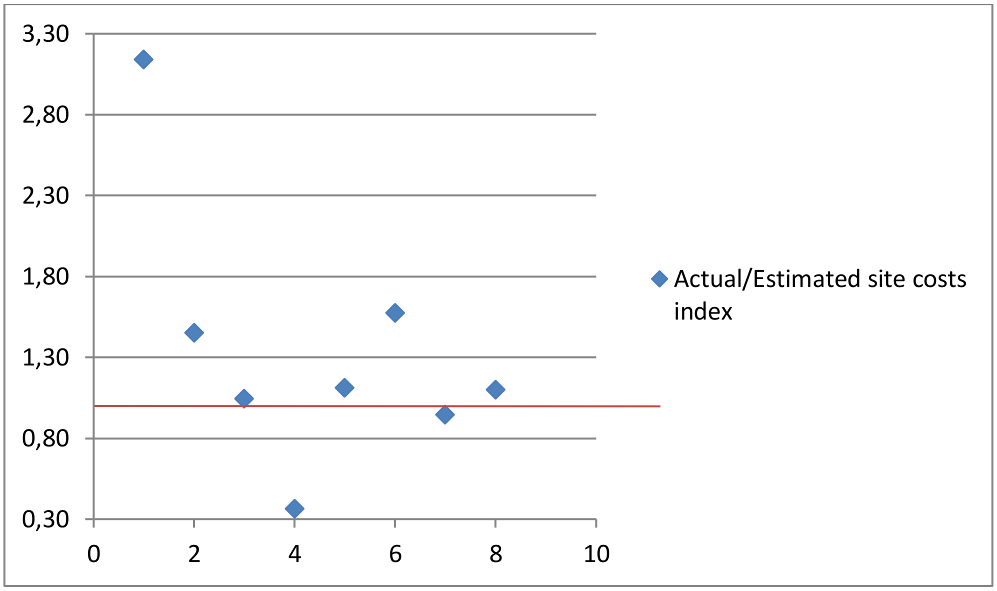

Figure 15. Site cost estimation accuracy in Finland.

5.2 Case Germany

Case projects were selected and cost data about these recent SDC projects in Germany was received from the local controller. Total costs were divided into costs of components, freight, and site operations. Installation/site operations costs were further divided into work hour costs, lifting equipment rents, installation material and other site costs. Also budgeted costs/cost estimations about installation costs were collected for these projects. Total site costs were 58-179 % from the estimated ones, site cost accuracies can be seen in Figure 16. Compared to site cost estimations in Finland, estimations were more accurate as the mean value was 107 % in Germany and 134 % in Finland.

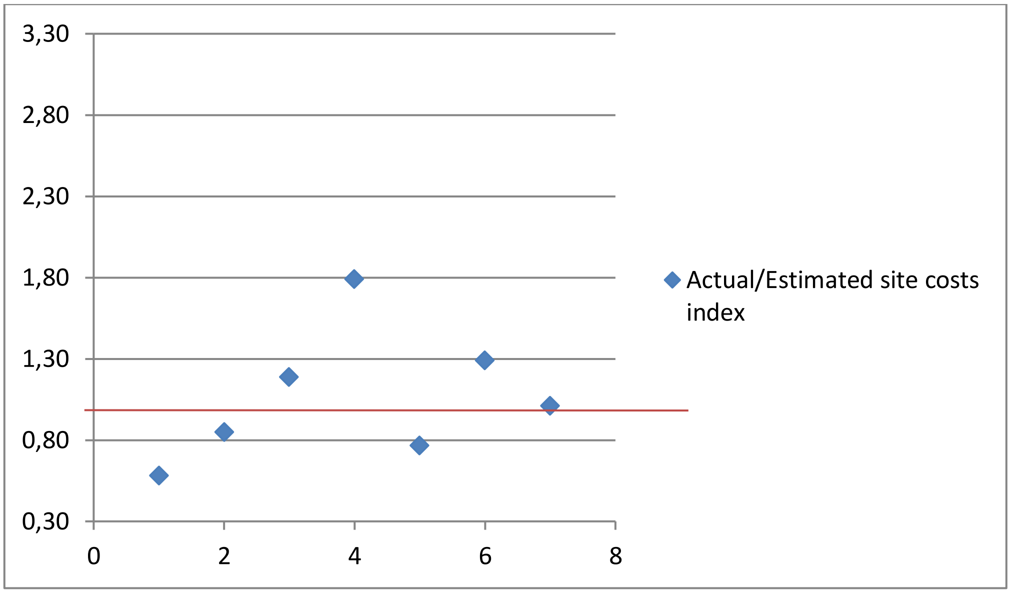

Figure 16. Site cost estimation accuracy in Germany.

Average cost structure of case Germany was: components (including steel structure) 82 %, freight 4 %, and installation 14 %. As can be seen in the Figure 17, the cost structure in Germany is very similar to the one in Finland.

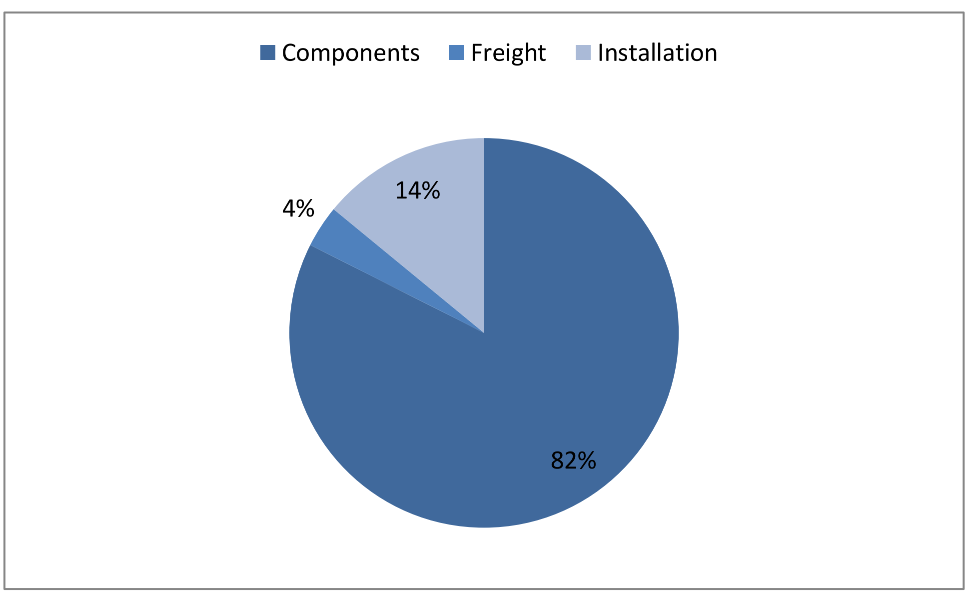

Figure 17. Average cost structure in Germany.

5.3 Case Hungary

The challenges in case Hungary were derived from the small amount of SDC projects. Because the volume in Hungary is quite low compared to other case countries, it was challenging to receive cost data about products in chosen scope to be able to compare these projects with the projects of other case countries. Comparing the case Hungary with other countries was difficult also because the cost division of the received sample projects was slightly different; costs were divided into three categories which were component costs, other costs, and installation costs. Installation costs were further divided into work hour costs, installation material costs, and other site costs. Other site costs consist mainly of subcontracting cost of the installation. The advantage of including Hungary to one of the case countries was to receive more data about cases where installation is subcontracted, and not conducted by Konecranes' own service staff. As well in most of the cases in China, installation is subcontracted and in each case in USA the installation is completed by the subcontractors. That's why, it is possible also to consider also the cost differences between installations conducted by own service staff and subcontracted installations.

Average cost structure of SDC projects in Hungary is shown in Figure 18. One of the example projects was manufacturing and delivering a 60-ton SP12 crane which doesn't quite fit to the scope and was thus excluded from the analysis. There were also four projects which included more than one crane. Costs in those projects were divided and then re-evaluated. From case projects share of component costs is 58 %. Other costs which include locally purchased materials accounts for 27 %. Average proportion of installation is 15 % and the variation from 8 % to 39 %. Unfortunately, cost estimations for installation costs were not received and thus cannot be compared with other cases.

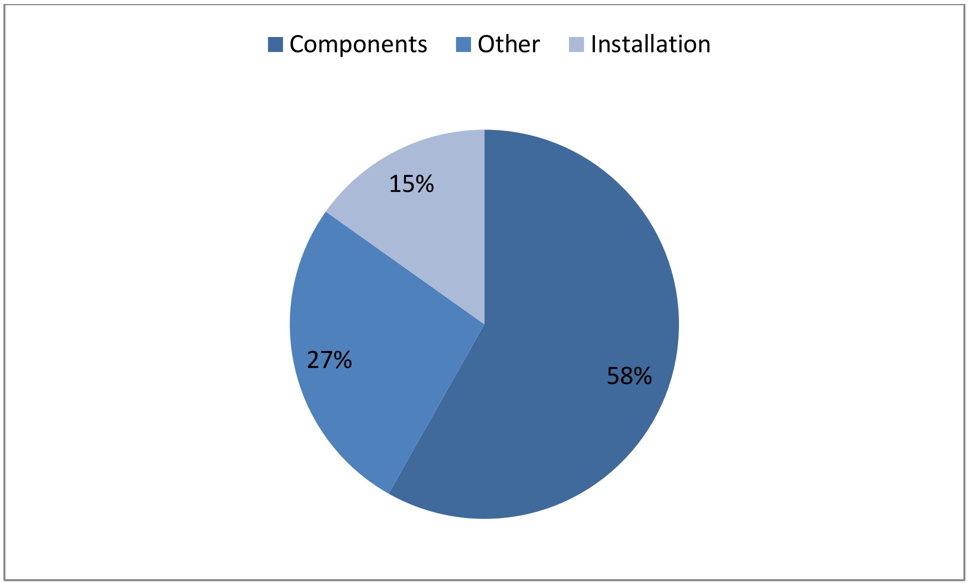

Figure 18. Average cost structure in Hungary.

This average cost structure differs a bit from the sample case which was also received for the research. This was a sample SP 12, 5-ton SDC project which costs were calculated according to previous standard cases. In this example, the proportions were as follows: components 62 %, steel structures 21 %, freight 5 %, and installation 12 %. According to previous SDC cases in Hungary the proportion of installation costs is 10-15 % in most of the cases. Because the calculation of the example case is derived from wider range of previous projects than the cases received for this research, these proportions are used in the evaluation of all the case countries in total.

5.4 Case China

Local business controller sent samples about SDC projects in China. The biggest difference between China and other case countries is that SDC projects in China are much bigger and one project often consists of manufacturing and delivering more than one crane. Among the sample projects there was even one project which consists of seven cranes which were all different models. Therefore, more effort was needed to be able to obtain cost data which would be comparable at some level with other case countries. The challenge was also to evaluate the actual costs and prices because naturally the prices for projects consisting of several cranes vary from the prices of projects with one single crane. For eliciting cost data about certain cranes of the projects, iLM system was used. First sales-order queries were run for gathering the crane numbers and definitions of the cranes under received order numbers. After clarifying the crane specific order numbers post-calculation queries could be done. Currency rates were estimated by searching for saved currency rates from iLM system. Average cost structure in China is shown in Figure 19. Component costs accounts for 44 %, steel structures 37%, freight 3 %, and installation 16 %.

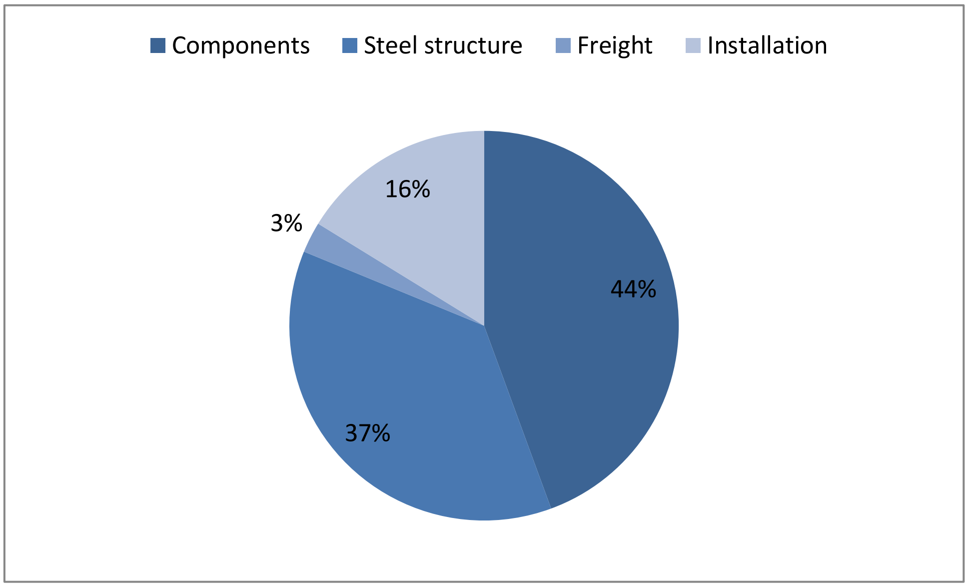

Figure 19. Average cost structure in China.

In addition, cost summaries of SDC projects delivered in December 2010 were received. From these summaries cost estimation accuracy of the installations was calculated. Total 14 projects were delivered in December 2010. Out of these 14 projects, in two projects installation was not included in the contract. Even though these projects were not the same as the projects used for constituting the average cost structure, these 12 projects were used along with the actual case projects to evaluate the cost estimating accuracy in China to receive bigger sampling. As shown in Figure 20, the actual installation costs were higher than the estimated ones in most of the cases.

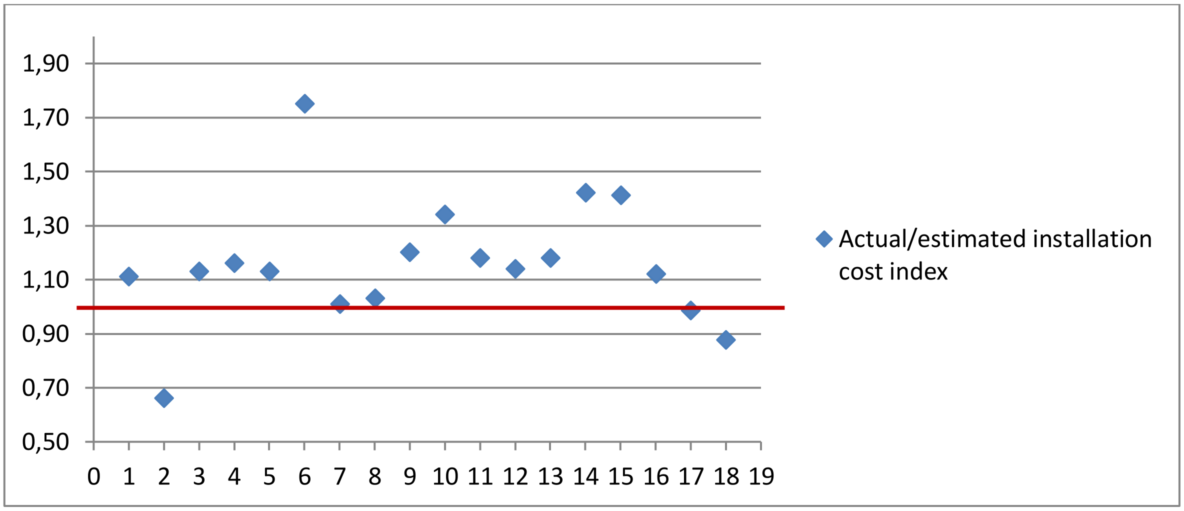

Figure 20. Installation cost estimation accuracy in China.

There was a major change made in completing installations in 2010 as the responsibility of installations was moved from Konecranes industrial crane organization to Konecranes Service organization. Earlier IC organization sold and handed over the cranes to the customer but from 2010 on Konecranes Service is completing the installations either by using their own staff, or by using subcontractors. The main reason for this change was the disaffection with the state of site operations and warranty period process. Earlier the installation was completed by subcontractors that IC had hired, and the responsibility moved to Service after the crane was installed, and the warranty period began. In some cases, the installation wasn't completed in a way that it satisfied the customer as the installation was incomplete at the point where crane was handed over to the customer, or there were some other problems occurred during the installation. If problems had occurred during the installation and the subcontractor hadn't clean the mess, Service organization which took over at the beginning of the warranty period was the one to blame. That's why, currently the site operation process in China is much more like the one, for example, in Finland as Service is informed when the crane leaves the factory and is ready to be installed. The effects of this change have been very positive, and the current state of installation is much better than before although there is still some lack of resources, and in many cases the Service must buy the installation for subcontractors. But it can already be seen that the current model in which IC is responsible for project management and Service for site operations is working well.

5.5 Case USA

Case projects from USA consist of five SP11 projects where maximum load is varying between two to five tons and four SP12 crane projects (5-25 tons). As with case Finland and China post-calculation queries from iLM system were made to receive the actual costs for USA projects. Sales-order queries for these projects were also made to receive the order and delivery dates to assure the use of correct currency rates. Figures were then exchanged into Euros by using the currency rates saved to iLM system. Cost structure of industrial cranes in USA is shown in Figure 21. Average proportion of components was 36 %, steel structures 32 %, freight 6 %, and installation 26 %.

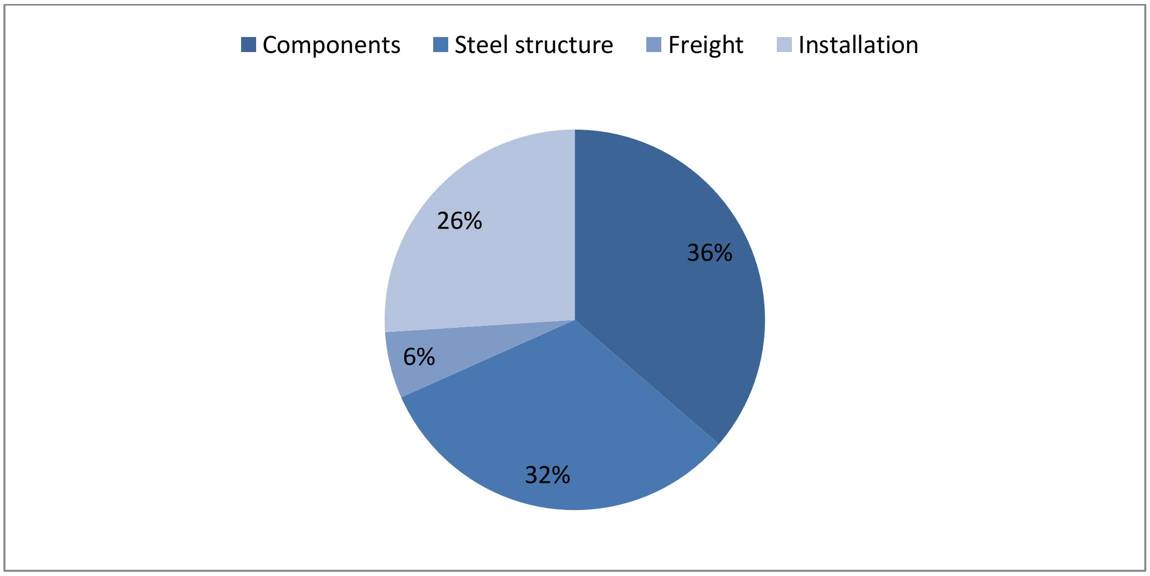

Figure 21. Average cost structure in USA.

Installations are usually completed by subcontractors in USA. The proportion of the installation costs from the total costs was the biggest in USA of all the case countries. Average proportion was 26 % and the variation was also the greatest, from 11 % to 54 %. Even though the proportion of the installation costs was high and estimating these costs is challenging, actual total costs were very close to estimated costs. This may be explained by the use of subcontractors in installation. It is better known how much subcontractors invoice than to estimate work hours required for site operations.

5.6 Comparison between the cases

In three out of five case countries crane installation is in most projects subcontracted; in Hungary, China, and USA. The proportion of installation costs was also a bit higher in those countries than in Finland or Germany. Therefore, can be stated that installation can be completed more cost efficiently by the Konecranes' own service organization. If the installation is conducted by subcontractors, there is still someone from Konecranes Corporation involved in the site operation process. Usually the crane handover is performed by Konecranes representative. This of course increases installation costs a bit in subcontracted installations. According to the cost division of total installation costs, the proportion of Konecranes own staff work hour costs is quite small in USA, around 6 % of the total installation costs. However, in Hungary and China these work hour costs are around 15 % of the total installation costs. In Germany and Finland, the work hour costs account for 70-80 % of the total installation costs. The rest of the costs are lifting equipment rents, installation material costs and other site costs.

The common state of will at Konecranes is that installations would be conducted by Konecranes Service. However, the installation of the crane is not very productive business for Service organization as it requires lots of time, and resources are then taken away from the main business of Service organization i.e. the crane maintenance and modernizations. As a whole though, it is most profitable for the whole Konecranes Corporation that the installation would be completed by Service staff. The justifications for this statement are the cost-effectiveness of the installation completed by Service staff, the direct customer contact for Service as they complete the installation and natural handover of the crane. It is a great benefit for Service organization that they receive the customer contact already in the installation phase, so it will be easier to maintain these contacts during the whole crane life-cycle.

Costs of the different industrial cranes in different countries are not straightly comparable with each other because even the products in scope are standardized products, case projects show that costs differ in each case. Every detail influences the total price of the crane, so the final price is highly affected by the customer requirements. However, the cost structures and CM2-% in different countries can be compared with each other. There were three products in scope: SP11 profile crane, SP12 single girder crane and SP12 double girder crane. If cases are compared according to their model, can be observed that the cost proportion of installation is smaller in bigger cranes. Average proportion of installation for SP11 cranes is 19 %, for SP12 single girder cases 18 % and for SP12 double girder cases 14 %. The proportion of component and manufacturing costs naturally rises when the size of the crane grows. When examining the freight costs, the same kind of observation as in installation costs, can be seen. The proportion of freight costs is smaller the bigger the crane is. For SP11 average proportion of freight costs is 5 %, for SP12 single girder cases 4 % and for SP12 double girder cases 2 %. The reason for this is the same as for installation costs: the share of component costs and the costs of steel structures rises with the size of the crane which descends the proportion of freight and installation costs.

Cost estimation of total crane costs was quite accurate in each of the case countries, thus it can be stated that Markman sales configurator is practical and useful tool at least in the sales and cost estimation process of SDC projects. However, the level of installation cost estimating accuracy was much lower. There are several uncertainties included in the crane installation process and the question is, how to predict the unpredictable, and how to perceive the uncertainties in the cost estimates. In Chapter 3.4, concept of contingency was introduced, and this would be one possible way of managing the uncertainties. One way of managing uncertainties would be first creating a risk list which would include all the typical risks included in the site operation process, and then utilizing this risk list in future cases by estimating which are the possible risks for the particular case, and according to that evaluation adding a certain contingency to the final cost estimate.

Unfortunately, it was not possible to gather bigger cost data sampling because of restricted time resources. Sampling of less than 10 cases is not big enough to put two and two together but indicative conclusions can be made anyway. Results of the research confirm the assumptions about relatively high proportion of installation costs from the total crane costs. Fortunately, the results of the research will be utilized in the decision-making about the practices of completing installations and in possible cost reduction efforts in site operation costs. These indicative results could be the trigger for catching more attention to cost estimating practices, more efficient exploiting of the previous knowledge and global knowhow and the importance of accurate product cost reporting. It has been stated that the crane delivery process is the most efficient in Finland and Sweden. This knowledge and efficiency could be exploited more in other countries too. The significant factors in crane sales and delivery process include cost management, direct customer contact and natural handover in installations which are completed by Konecranes Service and uncomplicated collaboration between the groups involved in the process. As the OneKonecranes project highlights: it is important to appear as one functional entity for the end customer.

5.7 Further research

Within the limits of this research, focus was on the installation costs and the challenges and problems related to those costs. Therefore, this research lacked a wider discussion on the other costs i.e. material, labor, production, and logistics costs. However, for the cost reduction purposes also these other costs should be examined more precisely. Further research would be needed also in the field of installations. This research highlighted the challenges in installation cost estimating. To be able to improve installation cost estimating further research would be needed. Research should focus on the installation cost estimating practices in different countries and aim to create a harmonized installation cost estimating processes through finding and analyzing the best practices in cost estimating at Konecranes globally. In addition, research of the dilemma: “how to predict the unpredictable” would help to estimate how big contingencies should be added to the cost estimates. There are several unpredictable uncertainties included in installation and site operations. These uncertainties should be specified by examining the unusual cases of crane installations as this research focused only on the average, normal SDC projects.

Interesting area of further research would also be the question of spreading the use of Service staff in installations. According to this thesis, it would be more cost-efficient and more valuable if the installations would be completed by Service staff. However, to be able to assure that spreading the use of Service staff would be profitable in the long run, analysis about managing current resources and enchasing the human resources of the Service organization, and the analysis of the received benefits, should be done. According to the research of the crane total costs till the crane handover, it seems most cost-efficient that the installation is completed by the Service staff. However, the crane installation itself is not very profitable business, but the received benefits like straight customer contact and natural handover may be so remarkable that installations could be completed even unprofitably. Cost analysis of the whole life-cycle of the crane should be thus examined.

6 CONCLUSIONS

The main research problem was to find out how the total costs of industrial cranes are composed of. The chosen cost categories were: components, steel structures and other external manufacturing, freight, and installation. Average cost structure of standard duty cranes is shown in Figure 22. This cost structure was received by calculating the cost divisions for each case country and for each case project. Some of the case projects didn't include for example installation costs at all and were therefore excluded from the total average cost structure calculations. Because the cost structure in some of the cases was notably different from the others these cases were not included in the evaluation of total cost structure because the aim is to find average proportions of the cost categories. As conclusion the proportion of installation costs from the total costs is relatively big: average 16 % and the variation from around 5 % to 54 %. These proportions are surprisingly high as the assumption of several quarters in the beginning was that installation costs account for maximum 15-20 % of the total crane costs.

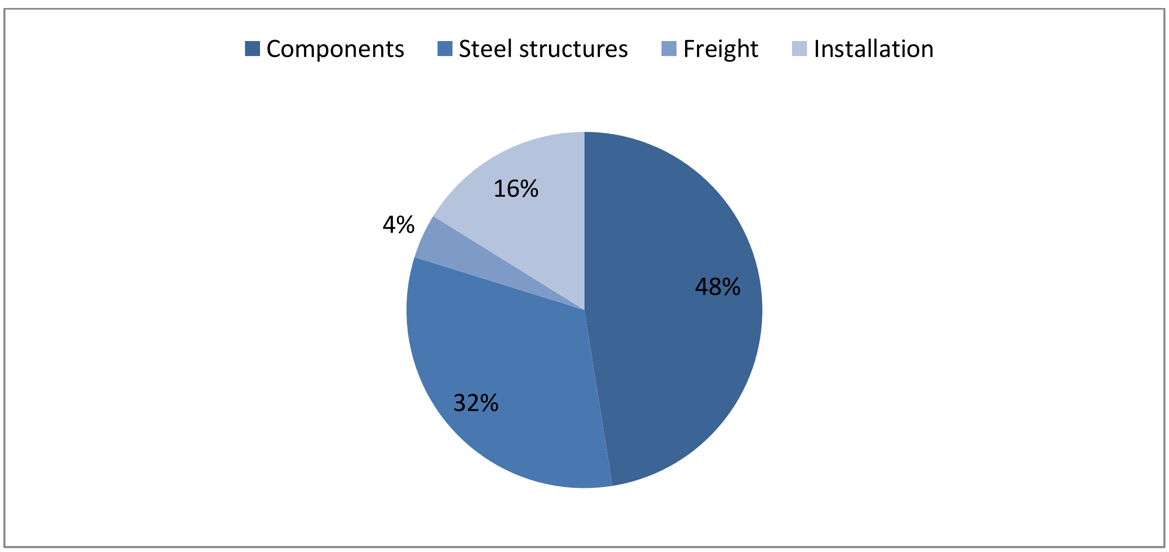

Figure 22. Average cost structure in case countries.

Although installation costs are relatively high, there are several black spots included and that's why managing these costs is challenging. It can be seen that estimating installation costs is quite difficult which may result in low installation budgets, and thus costs often overrun. One proposed solution for this is more efficient exploitation of previous experience and knowledge. This requires several actions and improvements in product cost reporting and cost estimating. First of all, there are some deficiencies in the breakdown of installation costs. Work hour costs should be specified more clearly, so that it would be easier to estimate work hours needed in coming cases. Installation cost should be also reported or saved into one place which is reachable at least by sales organization, finance and service organization. At the moment in Finland as an example actual installation costs have been saved only to Service's own ERP system, thus costs are not available for people outside Konecranes Service organization. Transparency in costs through the whole corporation would probably make decision-making and cost estimating much easier. As costs are reported more efficiently, exploiting previous knowledge becomes easier. Previous experiences in installations could be used more efficiently also by saving information about installations in a form of trouble tickets, for example. By saving information about past cases lessons could be learned from troubles encountered, and prevent same problems in future. As the competition is high, the prices of installations may not be raised so installations should be completed more efficiently to be able to reduce costs. Results from the country cases show that installations are conducted cheaper and more efficiently by Konecranes service's own staff. The costs of subcontracted installations are high, and these costs cannot be managed by Konecranes company. The knowledge and knowhow of the installations from the countries where installation is completed most efficiently should be transferred to other countries too.

As stated earlier, estimating installation costs is challenging and there is a need for improving installation cost estimations. One suggested way was to exploit previous knowledge and experience, but also installation knowhow in product cost estimations should not be forgotten. Site manager's evaluation would be valuable in installation cost estimates already in sales phase, so that installation budgets could be set more accurately. For more proper installation cost estimation more accurate classification of site operation work hours is needed. If site operation work hours would be separated out to different site operation activities, historical data could be collected more accurately, and estimating the hours needed for certain installation activities would be much easier. Currently work hour costs are invoiced without precise breakdown of costs, so invoiced installation costs may even include costs of repairing a crane that has been installed earlier. Work hour costs could be reported more strictly and hours could be classified under different activies, for example: crane erection 8 hours, electric installation 4 hours, testing 2 hours and commissioning 2 hours = total of 16 hours. Reporting work hour cost this way doesn't require much more time, but the benefits would be remarkable as through cost breakdown of installation, cost estimation accuracy and installation efficiency could be improved. One suggested way of calculating installation costs would be using activity-based calculations.

In general, there are some weaknesses in cost reporting and there certainly is a need for harmonizing product cost reporting. Now when there are several different ERP and IT systems in use, transferring data between these systems results in data modification and even confusion which system should be used in which situation and where to find certain information. Fortunately, global SAP project is already running strong and the implementation of SAP will relieve also product cost reporting. Data searching will become much easier as same system will be used in different locations and by several departments. At the moment, finding accurate and up-to-date cost data has been quite complicated so in future and especially during SAP implementation more focus should be put on saving and reporting actual costs. In SDC projects, crane orders will be saved to SAP system so that sales and costs are divided into three categories: 1) equipment, 2) transportation, and 3) installation. Costs will be directed to these cost categories. All the rows will be reported under crane SP. In SAP it should be easy to report how big proportion installation costs are from the total costs for certain SP in certain unit/country/region etc. If installation is completed by Konecranes Service, discrete service order is created and is related to sales row of the installation. Service order will be entered as internal sales of Konecranes. One important notice for saving the costs in SAP would be to secure that also the actual incurred costs are entered. If Service enters their own service orders into the system also actual costs without any internal margins or other adjuncts should be saved. Installation work hour costs should be also classified more accurately than before so that it will be easier to track down the installation costs.

Apropos of costing and pricing an industrial crane several factors should be considered. As customers are changing their decision criteria from initial cost to total lifetime cost of equipment ownership, in pricing situation the whole product life cycle should be considered. In addition to the initial price of the equipment, there are other important factors too. Customers value especially the reliability of the crane and availability of spare parts and service. These complementary products and services are already available in Konecranes and could be marketed more aggressively. Whereas high prices of installation can be explained to customer by the quality of the installation. When installation is completed well, latter costs of the crane are minimized as crane is installed properly and tested before handover to the customer. Properly installed crane is more serviceable and reliable thus maintenance costs are optimized. Therefore, there are possibilities for adding more value that customers are willing to pay for.

REFERENCES

AACE International. 2009. Certified Estimating Professional Examinee Format of Definitions [www-document]. [Retrieved June 14th, 2011]. From: http://www.aacei.org/educ/cert/CEP/CEP_Examinee_Format-of-Definitions.pdf.

Aaltola, J. & Valli, R. (edited) 2001. Ikkunoita tutkimusmetodeihin 1 – Metodin valinta ja aineistonkeruu: virikkeitä aloittelevalle tutkijalle. PS-kustannus, Jyväskylä. Pp. 217.

Amos, S.J. (edited) 2007. Skills and Knowledge of Cost Engineering. AACE International.

Ansari, S., Bell, J. & Swenson, D. 2006. A Template for Implementing Target Costing. *Cost Management*, Vol. 20, No. 5, pp. 20-27.

Asiedu, Y. & Gu, P. 1998. Product life cycle cost analysis: state of the art review. *International Journal of Production Research*, Vol. 36, No. 4, pp. 883-908.

Boeschoten, S.G.J. 2005. Reliability and Accuracy of Estimates. *AACE International Transactions*, pp. EST.20.1-EST.20.5.

Brimson, J.A. 1992. Toimintolaskenta – Activity-based accounting. Pp. 288.

Carsten, T. & Erickson, B. 2007. Gain a Competitive Edge by Calculation Total Ownership Costs. *Power Engineering,* Feb. 2007, pp. 32-38.

Cooper, R. & Slagmulder, R. 2004. Achieving Full-Cycle Cost Management. *MIT Sloan Management Review,* Fall 2004, pp. 45-52.

Decision Support Systems Resources. 2011 (last modified). [www-page]. [Retrieved August 2nd, 2011]. From: http://dssresources.com/.

Ditzer, W. 1998. Line installations: Who’s the best for the job? *Converting Magazine*, Vol. 16, No. 8, pp. 116-120.

Dysert, L.R. 2006. Is “Estimate Accuracy” an Oxymoron? *AACE International Transactions,* pp. EST.01.1-EST.01.5.

Erkoyuncu, J.A., Roy, R., Shehab, E. & Cheruvu, K. 2011. Understanding service uncertainties in industrial product-service system cost estimation. International Journal of Manufacturing Technology, Vol. 52, pp. 1223-1238.

Hartikainen, V. 2005. Prosessinostureita valmistavan liiketoimintayksikön arvoverkoston kustannusrakenne. Master’s thesis. Lappeenranta university of technology. pp. 101.

Horngren, C.T, Datar, S.M., Foster, G., Rajan, M. & Ittner, C. 2009. Cost Accounting – A managerial emphasis. 13th edition. Pearson prentice hall. pp. 869.

Jeon, J. 2009. Success Factors for a Lessons-Learned System in a Construction Organization. *Cost Engineering*, Vol. 51, No. 5, pp. 13-20.

Kingsman, B.G. & de Souza, A.A. 1997. A Knowledge-based decision support system for cost estimation and pricing decisions in versatile manufacturing companies. International Journal of Production Economics. Vol. 53, pp. 119-139.

Konecranes. 2010A. Annual Report 2010. [Retrieved September 5th, 2011]. From: http://www.konecranes.com/files/attachments/ir/annual_reports/kc_2010_en_v03.pdf. pp. 132.

Konecranes. 2010B. Equipment Business Area Organization and Products. Internal use only. pp. 25.

Konecranes. 2010C. Site Operations and SAP. Internal use only. pp. 19.

Konecranes. 2010D. oneKonecranes Handbook. Internal use only. pp. 40.

Konecranes. 2011. Company web-pages. [Retrieved June 30th, 2011] From: http://www.konecranes.com/.

Kraus, W.E. 2008. Cost Estimating and Analysis. *Cost Engineering*, Vol. 50, No. 4, pp. 3-4.

Lindholm, A. & Suomala, P. 2007. Learning by costing – Sharpening cost image through life cycle costing? *International Journal of Productivity and Performance Management*, Vol. 25, No. 8, pp. 651-672.

Lund, R.D. 2005. Improve cost estimating accuracy. *Plant Engineering,* Vol. 25, No. 7, pp. 61-63.

Maskell, B.H. 2006. Solving the standard cost problem. *Cost Management*, Vol. 20, No. 1, pp. 27-35.

Medley, L.G. 1994. TCM: Managing Cost Before It Occurs. *AACE International Transactions*, 1994, pp. GVT.2.1-GVT.2.8.

Meier, H., Völker, O. & Funke, B. 2011. Industrial Product-Service Systems (IPS²). International Journal of Advanced Manufacturing Technology, Vol. 52, pp. 1175-1191.

Moselhi, O. 1997. Risk Assessment and Contingency Estimating. *AACE International Transactions*, 1997, pp. A.06.1-A.06.6.

Naderpajouh, N. & Afshar, A. 2008. A case-based reasoning approach to application of value engineering methodology in the construction industry. Construction Management and Economics, Vol. 26, p. 363-372.

Neilimo, K. & Uusi-Rauva, E. 2007. Johdon laskentatoimi. Helsinki: Edita Prima Oy. pp. 366.

Niazi, A. & Dai, J.S. 2006. Product Cost Estimation: Technique Classification and Methodology Review. *Journal of Manufacturing Science and Engineering*, Vol.128, pp. 563-575.

Noble, P.M. & Cruca, T.S. 1999. Industrial Pricing: Theory and Managerial Practice. *Marketing Science*, Vol. 18, No. 3, pp. 435-454.

Noor, I., Grumo, M., Kniskern, M.W. & Kopach, A. 2006. Bid Preparation Using Cost Templates and Range Estimating – An Equipment Manufacturer's Perspective. *AACE International Transactions*, pp. OWN.05.1-OWN.05.5.

Power, D.J. 1997. What is a Decision Support System? The On-line Executive Journal for Data-Intensive Decision Support, Vol. 1, No. 3. [Retrieved August 2nd, 2011]. From: http://dssresources.com/papers/whatisadss/index.html.

Roy, R. & Erkoyuncu, J.A. 2011. Service Cost Estimation Challenges in Industrial Product-Service Systems. Functional Thinking for Value Creation: Proceedings of the 3rd CIRP

International Conference on Industrial Product Service Systems, Technische Universität Braunschweigh, Braunschweig, Germany, May 5th-6th 2011. Pp.1-9.

Shabani, M.R. & Yekta, R.B. 2006. Chemical Processes Equipment Cost Estimation Using Parametric Models. *Cost Engineering*, Vol. 48, No. 5, pp. 26-32.

Shank, J.K & Fisher, J. 1999. Case Study: Target Costing as a Strategic Tool. *MIT Sloan Management Review*, Vol. 41, No. 1, pp. 73-82.

Uppal, K.B. 1996. Estimating Engineered Equipment Costs. *Transactions of AACE International*, pp. EST.10.1-EST.10.6.

Uppal, K.B. 1997. Cost estimating made simple. *Hydrocarpon processing*, September 1997, pp. 168-C-168-E.

Wang, C-H. & Huang, Y-C. 2000. A new approach to calculating project cost variance. *International Journal of Project Management*, Vol. 18, pp. 131-138.

Watson, I. 2004. Capturing and Applying Lessons Learned During Engineering Equipment Installation. M.Gh. Negoita et al. (Eds.): KES 2004, LNAI 3215, pp. 672-677.