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Present and Future of Life Cycle Costing: Reflections from Finnish Companies

1. Seeing the Big Picture

Life Cycle Costing (LCC) is a way of thinking where attention is paid to the total costs that occur during a product's entire life cycle (see e.g. Jackson and Ostrom 1980; Booth 1994; Woodward 1997; Asiedu and Gu 1998). The total costs can be observed from diverse points of view – for example, from the viewpoint of the product's supplier or of the product's user or owner, or even more broadly from the point of view of society. Life cycle costing implies that the total costs of a product can be influenced beforehand and that the various cost factors are interrelated. A decrease in costs in the case of one aspect (for example, using cheaper but

heavier material when manufacturing a passenger car) can lead to an increase in costs in another aspect (higher fuel consumption). Thus, to avoid partial optimization, costs must be studied with regard to the whole. Knowing the life cycle costs of a product is one of the basic requirements when one is considering, for example, the outsourcing of functions and ownership, or when one wants to offer one's capacity for use by the other organizations in the supply chain.

The essential thing in LCC is to comprehend the interaction of the cost items that cumulate among the relevant stakeholders during the different life cycle stages. Continuing prod-

uct development can lead to progressive solutions that lower the societal costs derived from pollution of the environment, but on the other hand these solutions will result in higher manufacturing costs as construction requires more expensive components and materials. The production of more expensive materials can, in turn, have a greater environmental effect and thus add to the societal costs. With this approach, one quickly notes that an extensive and detailed implementation of life cycle costing easily leads to highly diversified and laborious analyses of cause and effect. However, in an individual organization it is possible to adopt a much simpler starting point. The thorough surveillance of the acquisition and operational costs of a specific product from the point of view of one actor – the company itself – can by itself expose the true cost structure of a product and reveal several interesting causalities.

The costs that are caused by the acquisition, operation, and maintenance of a product are the main focus of life cycle costing when the viewpoint is that of the product's buyer. Customer-perceived life cycle costs start with the acquisition of the product and usually end when the product is no longer used. Notable cost factors are, for example, the following: acquisition, operation, maintenance, shutdowns, and disposal. In addition, many products can have indirect costs that may be extensive. In the analysis of information technology life cycles, it has been observed that as much as one third of all acquisition and operation costs of a computer can come in the form of so-called covert support at the workplace. This means that colleagues help one another in information technology –related problems, for example, regarding viruses or software updates. Covert support costs come from work hours that are spent on these extraneous activities.

The history of LCC dates back to the 1960's when the US Department of Defence started to assess the long-term cost effects of products when making purchasing decisions. Despite the long history and potential usefulness of LCC, its use has been quite limited at the practical level (see e.g. Lukka and Granlund 1996; Woodward 1997). Challenges in evaluating future costs and dealing with uncertainties regarding different factors affecting life cycle costs may have restricted its use. However, it could be more reasonable to accept some inaccuracies in life cycle cost calculations than not try to evaluate life cycle costs at all.

In the future, the interest in life cycle costing can be expected to increase for many reasons. As the total costs of many products often substantially exceed the initial purchase costs (Barringer and Weber 1996; Asiedu and Gu 1998), rational customers would be willing to buy a product that generates the lowest costs in the long run. The trend to outsource also creates a need for both customers and suppliers to get to know the total cost of the ownership of a product. In analyzing the long-term cost effects of products or in arriving at make-or-buy decisions, a longitudinal assessment of costs is needed.

2. Life Cycle Costing “In Theory”

It is possible to identify two distinct dimensions of life cycle costing: 1) estimating costs on a whole life cycle basis and 2) monitoring the occurred cost throughout a product's life cycle (Taylor 1981; Woodward 1997). LCC is actually more a way of thinking than merely a costing tool because in addition to the management of costs, it focuses on the long-term performance of products by employing a variety of manage-

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ment accounting methods. A basic assumption providing motivation for the LCC approach is that it is usually possible to affect the future costs of a product beforehand, either by planning its use or by improving the product or asset itself (Markeset and Kumar 2004). The need for life cycle costing becomes evident when examining the longitudinal cost structure of investment products: The sum of the life cycle costs of a product often substantially exceeds the initial purchase price. In addition, the costs of alternative products do not necessarily behave similarly in the corresponding phases of their life cycle (Barringer and Weber 1996). However, there is evidence that products are usually purchased simply on the basis of the initial purchase cost (e.g. Ahmed 1995; Järvinen et al. 2004).

Life cycle costing was first used for the forecasting of future costs in the acquisition phase of products (Asiedu and Gu 1998; Emblemståg 2003). From the outset, life cycle costing has been discussed in many different long-term cost management contexts, but LCC is not the only approach to good decision-making in such cases. For example, the total cost of ownership (TCO) approach is usually associated with determining the total cost of ownership of a particular product (Ellram 1995; Wouters et al. 2005). The TCO approach tends to emphasize the costs associated with buying a particular product from a particular supplier (e.g. Ellram 1995), whereas life cycle costing focuses primarily on costs incurred after the purchasing, and pre-transaction costs tend to be de-emphasized. However, on the practical level these approaches are quite similar: the main goal of both is to obtain comprehensive long-term cost information about particular products or activities.

The starting point in product life cycle cost estimation is to understand the product's life cycle and the activities that are performed during its phases. From the customer's point of view, the focus in LCC is on costs incurred through operation, maintenance, support, and disposal of products. Life cycle costing is concerned with optimizing total costs in the long run, which requires considering trade-offs between different cost elements during the life phases of a product (e.g. Taylor 1981). For instance, an increase in initial purchase cost may secure a reduction in the maintenance cost in the long run. Many of the cost drivers are connected with the operation and maintenance of products, and it is therefore necessary to map also the factors that influence these activities during a life cycle (Markeset and Kumar 2000). Cost drivers may differ from one product to another, which makes the identification of the main cost drivers both important and challenging (See e.g. Janz et al. 2004). An important feature of LCC is that the effects of indirect costs are taken into consideration. For example, the downtime costs resulting from unavailability of products may turn out to be considerable in the long run.

In addition to the estimation of future costs, an essential feature of LCC is cost monitoring during a product's life cycle (Taylor 1981; Woodward 1997). It is essential to know the cost incurred for a particular product or service and to understand the behavior of different cost elements in the different phases of the life cycle. The aim is to monitor the actual costs against predicted life cycle costs and to determine the cumulative costs throughout a product's life cycle. In this interpretation, the focus in LCC changes during the product's life cycle. At the beginning of the life cycle, LCC corresponds

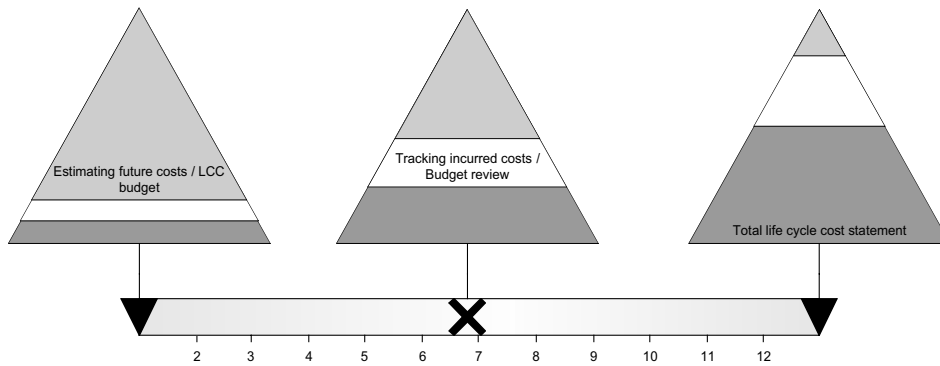


Figure 1 The changing focus in life cycle costing during a product's life cycle (Adapted from Suomala et al. 2004).

mainly to the estimation of future costs. Over time, the focus in LCC shifts to monitoring the incurred costs; the estimation of future costs will be increasingly based on the analysis of past cost. Figure 1 illustrates the evolving focus in the LCC approach.

In order to be able to monitor costs throughout a life cycle, adequate costing data needs to be collected. In this respect, companies' costing practices form the basis for cost monitoring during the life cycle and here the ability to assign costs to specific products is central. In addition to financial information, the collection and analysis of operational data is an essential part of life cycle costing because this data can be utilized in identifying relevant cost drivers for products. It is likely that quite a lot of information for LCC purposes exist in different forms; the problem is that the data is not brought together in a coherent way (Taylor 1981; Wouters et al. 2005). In fact, the unavailability of adequate costing data is considered to be one of the main barriers to implementing total cost analysis approaches (e.g. Ellram 1995).

3. Life Cycle Costing "In Practice"

3.1 Core findings from the literature

The literature on life cycle costing is mostly conceptual in nature and there is only little evidence about the applications of the LCC approach or about the extent of its use. Instead, the potential benefits of LCC and the technical issues regarding applying the approach have received much attention in the literature (Asiedu and Gu 1998; de Vasconcellos and Yoshimura 1999; Markeset and Kumar 2000). However, some studies have explored the utilization of LCC. For instance, the study of Lukka & Granlund (1996) revealed that none of the Finnish companies they studied utilized the LCC approach. According to Hyvönen & Vuorinen (2000), six percent of Finnish companies have used LCC. On the other hand, when Jackson & Ostrom (1980) studied the utilization of the LCC approach in decision-making related to purchasing among US companies, they found that as much as 25 percent of companies had uti-

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lized the approach. However, the practical application of approaches similar to LCC, such as total cost of ownership (TCO), has been quite limited, as shown by Ellram & Siferd (1993). They report that only a small number of the companies they studied utilized TCO.

Summing up, previous studies indicated that the adoption of the LCC approach has been relatively limited at the practical level. Looking more closely, the reported results concerning the use of the total cost analysis approaches seem to differ more or less. Several explanations can be offered. First of all, given the multidimensionality of LCC, it is fair to assume that the interpretation of the LCC or other total cost analysis approach may vary from one study to another. In addition, the adoption of the LCC approach has been more common in particular industries, such as in the military and construction sectors (Woodward 1997). Thus, the companies and represented industries studied have obviously an effect on the results. The adoption of LCC and other total cost analysis approaches may also depend on organizational function. For example, according to Wouters et al. (2005), the purchasing and maintenance functions are the main users of total cost information. Finally, the study of Järvinen et al. (2004) indicates that in most organizations the possible responsibility for LCC is incumbent on only a few individuals. Therefore, the obtained results depend on the functions and individuals involved in the study.

When LCC is perceived to include both forecasting and tracking of costs on a whole-life basis, it might be difficult to define exactly what is life cycle costing and what is not. Thus, while it can be assumed that investments are planned with a long-term perspective in companies (capital budgeting), this is not perceived to be life cycle costing. It is also possible that cost moni-

toring is not perceived as life cycle costing even if costs are monitored at some level throughout a product's whole life cycle. Overall, because the application of LCC relies on the availability of cost information, the normal product costing practices affect companies' abilities to utilize the approach. If companies fail to sufficiently track product costs, it is unlikely that the total costs of the ownership of fixed assets can be measured consistently and accurately. The main problem in cost accounting seems to be the allocation of cost to activities and products (Lukka and Granlund 1996; Sievänen et al. 2001). The slow adoption of ABC (Activity-Based Costing) among Finnish companies (Laitinen 1995; Hyvönen 2000) suggests also that there are inabilities to allocate costs fairly to products. Also the competency to measure total costs in the long run has been perceived to be low in many companies (Milligan 1999).

Some studies which focus on the methods of planning and valuing investments help to show companies' abilities to accomplish long-term cost estimations. The study of Collan & Långström (2002) suggests that more than half of companies do not have specific decision support systems for investment planning. It is also surprising that payback, which neglects long-term cost effects, has been a quite general method for planning investments (Keloharju and Puttonen 1995; Liljebloom and Vaihekoski 2004). These results indicate that in general decision makers are often not provided with adequate information about long-term cost effects of investment alternatives.

3.2 Recent findings from the industry

The authors gathered the empirical observations of the present practices in life cycle costing in Finland in spring 2004 through a questionnaire

study aimed at industrial companies representing different industries. Both supplier organizations and customer organizations were presented in the study. The focus was on product life cycle costs experienced by customers. From altogether 43 useful responses, 31 were obtained from the representatives of suppliers and 12 from the representatives of customers.

Utilization of life cycle costing

First of all, the utilization of life cycle costing seems to be quite rare since one third of the respondents are involved with LCC annually and one third even less frequently. However, the rest of the respondents are involved with LCC monthly or more often. Because almost 70 percent of the respondents are involved with LCC annually or more often, it can be assumed that LCC is used to some extent in most of the companies. This level of utilization of LCC is higher than previous studies have indicated (Lukka and Granlund 1996; Hyvönen 2000). According to responses concerning the time frame of involvement with life cycle costing, LCC is possibly often associated with the capital budgeting process and thus many people perceive that they are quite rarely involved with it.

Life cycle costing is applied for different kind of purposes in customer organizations. In about half of the cases, LCC is used to compare alternative investment options. LCC calculations are done in the purchase phase always or quite often in 40 percent of the cases and in the rest of the cases LCC calculations are done only sometimes or not at all. Over 40 percent have assessed the economic life cycle of products with LCC and one third has used it for budgeting purposes. However, less than 20 percent of customer organizations do not utilize LCC at all.

The provision of LCC calculations from suppliers to customers in the purchase phase is not common among studied companies since in over half of the cases calculations are not usually provided or they are not provided at all. Correspondingly, about one third indicated that calculations are provided only sometimes and only 14 percent indicated that provision of LCC calculations is quite general. Quite consistently, according to the study of Jackson & Ostrom (1980), 81 percent of LCC calculations were internally generated, 15 percent were externally generated at the request of customers, and only 4 percent were voluntary generated by suppliers. However, there seem to be differences between industries because for example in the field of rail transport customers often get at least limited LCC calculations from suppliers (Järvinen et al. 2004).

While LCC is often perceived to represent somewhat long-term costing, the calculations do not cover the entire life cycle perspective in many cases. It is quite common that the calculations cover only the warranty period or a case-specific period of time, such as the duration of a service contract. In addition, penalties related to the fulfilment of life cycle costs are not included in contracts connected with purchases in most cases. Jackson & Ostrom (1980) also reported that only in a few cases does the supplier guarantee that life cycle costs will not exceed the estimations. On the other hand, contractual agreements on the fulfilment of life cycle costs are usually made in the field of rail transport (Järvinen et al. 2004).

Perceptions on life cycle costing

Most of the suppliers indicated that customers are interested in life cycle costs of products in the purchase phase but they are not very inter-

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ested in LCC calculations. At the same time, the most important factor affecting the purchasing decision was purchase price. Life cycle costs were the most important factor in only 12 percent of the cases. However, it was believed that the significance of information provided by life cycle costing will increase in the future. It became also evident that it is difficult for customers to evaluate the long-term cost effects of products because enough information about life cycle costs is not obtained from suppliers.

It was an interesting observation that all the customers who make their own LCC calculations for purchasing decision-making indicated that life cycle costs are the most important factor affecting the purchasing decision. Also according to the study of Jackson & Ostrom (1980), over half of the customers who had used life cycle costing accorded quite high importance to life cycle costs in making a purchase decision. One of the main barriers to use information provided by LCC is that calculations done in the purchase phase are not considered reliable. In connection with this, the study of Jackson & Ostrom (1980) revealed that confidence in LCC was higher among users than among non-users of LCC. On the other hand, questioning the reliability of LCC calculations was common in the field of rail transport, even though the application of the approach was general (Järvinen et al. 2004).

Monitoring of costs during the life cycle

Monitoring of life cycle costs is not comprehensive at the level of specific products in many cases. First of all, it seems that cost monitoring is not consistent regarding different cost factors since costs related to maintenance and operation are often monitored more accurately than

other cost factors such as energy costs and indirect costs. However, these cost factors can be considerable in some cases. For example, the downtime costs resulting from unavailability of machines may turn out to be significant in the paper manufacturing industry and large energy costs are typical for transportation. In addition, costs of similar products are not monitored consistently in one third of the cases. It is quite common that cost monitoring is more comprehensive for new products than for old products. On the other hand, in some cases costs are not monitored at the level of individual machines and equipment; rather the costs of many products are monitored as a whole.

Carrying out of actual cost calculations on the basis of historically collected LCC data is not systematic and comparison of the results of preliminary and actual cost calculations is also uncommon. Thus learning from estimation errors in LCC calculations is impossible in many cases. Also the utilization of historically collected LCC data of products when purchasing new products is not common among customers. It is thought that data are not exploitable because of, for example, the long life cycles of products and the development of technology. However, historically collected data can indicate the connection between cost drivers and the way of using or maintaining products. For example, regardless of the type or technology of railway car, the cleaning costs will mainly depend on the cleaned area. Thus, the collected financial data and performance-related data on the cleaning activity can be usable when estimating the future cleaning costs of different railway cars.

The utilization of historically collected LCC data is also more or less occasional among suppliers. In about half of the cases, data are

utilized to select factors affecting product reliability and as a basic data for future supplies. One third uses historically collected data to identify critical cost factors. Suppliers' possibilities to utilize empirical data depend on the information they obtain from customers during a product's life cycle and in many cases the provision of information is perceived to be insufficient. However, the situation may improve because it was strongly believed that monitoring of life cycle costs would increase in the future.

Problems and development needs

Identifying the problematic issues and potential targets for improvement is crucial for further development of life cycle costing. First of all, the field of life cycle costing in general seems to be problematic. For example, the following things were mentioned by the respondents:

- "The unfamiliarity of the concept"
- "Uncertainty regarding benefits of LCC"
- "LCC is not regarded as important"

Most of problems seem to be connected with the application of LCC in practice. The observations that can be seen to associate with this were for example:

- "The unavailability of adequate and reliable input data"
- "The lack of uniform practices"
- "Difficulties in defining some of the cost factors"
- "Evaluation of the effects of the changes in a product's operational conditions"
- "Existence of the factors of uncertainty"

Inadequacies of the input data and non-uniform costing practices were considered

problematic issues in many cases. Also the long life cycles of products were seen as making life cycle costing difficult. In addition, the key concepts and measures are often perceived to be inconsistent. Previous studies have also indicated similar problems in total cost analysis approaches. For example, the study of Jackson & Ostrom (1980) revealed that there were substantial differences in the way the LCC approach was applied among the US companies they studied. When Ellram & Siferd (1998) studied the practices related to the application of the TCO approach, they found that the lack of input data and the fact that there is no standard approach to TCO were the main barriers to utilizing TCO.

There are many areas in which change is considered necessary in current life cycle costing practices. The most important targets for development were improvement in utilizing the historically collected LCC data and standardization of LCC regarding the calculation methods and key concepts of LCC. Increasing cooperation in LCC between suppliers and customers was also regarded as important. The improvement in the quality of information obtained from suppliers in the purchase phase and improving the collecting of reliable product specific data in the operating phase of products were seen as essential targets for development among customers. From the suppliers perspective the quality of LCC information obtained from one's own suppliers and the obtaining of LCC data from customers in the operating phase will require development.

4. Conclusions

The history of LCC dates back to the 1960's when the US Department of Defence started to assess the long-term cost effects of products

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when making purchasing decisions. The need for life cycle cost management becomes evident when examining the longitudinal cost structure of investment products: The sum of life cycle costs of many products often substantially exceeds the initial purchase price. However, in spite of the long history and potential usefulness of LCC, its use has been quite limited on the practical level. Challenges in evaluating, for example, future costs and dealing with the uncertainties of different factors affecting life cycle costs may have been among the factors that have hindered the practical applications of life cycle costing.

The recent observations of life cycle costing in Finnish context indicate that, in general, utilization of LCC is rare. As a result, the long-term cost structure of investment goods seems to be relatively poorly known among many companies. Overall, people seem to be rather seldom involved with life cycle costing. This suggests that LCC might be primarily associated with capital budgeting and the financial assessment of investment alternatives rather than be perceived as part of continuous long-term cost and profitability management. Nevertheless, the provision of LCC calculations by suppliers to customers in the acquisition or bidding phase was not very common, although practices differed to some extent, depending on the industry. In contrast with these findings, it was quite surprising to find that most of the users of products perceived that they had utilized LCC at least in some context. Also, it was expected that utilization of LCC would increase in the future.

In those cases where life cycle costing was applied, it was most often utilized to compare alternative products in the acquisition phase. Ironically, observations indicate that the effect of life cycle costs on purchasing decisions

is typically minor; there are many other issues that were perceived to be more important. Describing quite well the short-termism of modern cost management in practice, purchase price was perceived to be the most important factor affecting a purchasing decision even if people were well aware that the life cycle costs of many products could substantially exceed the initial purchase price. What may partly explain this is the perception that due to the uncertain elements associated with life cycle costing, long-term calculations are unreliable. However, there seems to be a connection between costing practices and decision-making criteria prioritization: The users of LCC tend to emphasize the role of life cycle costs as a decision criterion when assessing investment alternatives. In general, according to suppliers, customers' interest in life cycle costing is clearly weaker than their interest in life cycle costs. As understandable as this may be due to the amount of effort needed for careful LCC, it cannot be denied that it is difficult to base a purchasing decision on life cycle costs if the cost calculations are not done in the first place.

The focus of life cycle costing evolves during the life cycle of a product. In the beginning, the primary emphasis would be on the forecasting of future costs. This requires methods that can quantify the uncertainty that is inherent in ex ante evaluations. In addition, to provide a source of intelligence for evaluating future costs, LCC should be able to produce and utilize the information regarding past costs and the historical behavior of different cost elements. Thus, during a life cycle, the focus of LCC shifts more and more to cost monitoring and management. Part of this process is comparing incurred costs with original estimations and thereby reducing the uncertainty associated

with the economics of the rest of the life cycle. Ideally, at the end of a life cycle, the complete cost history of a product would have been tracked and understood. Unfortunately, the empirical observations suggest that the possibilities for successful cost management on the basis of life cycle costing are poor in many cases. Incurred costs and performance are not monitored adequately at the level of specific products. In addition, the collected cost information is not analyzed systematically and comparisons of actual costs with estimations are made only occasionally. Further, the observations indicate that suppliers, according to their own perception, do not receive enough product cost data from customers during a life cycle. For that reason, the application of life cycle costing is perceived to be difficult and suppliers' ability to learn from the actual cost behavior of their products is restricted.

The empirical observations identified a number of issues that should be focused on when considering the development of life cycle costing in the future. First, the lack of adequate costing data was considered to be one of the main problems in LCC. Improvement of this situation calls for both more accurate product-specific data collection and analysis inside companies and more active collaboration between supply chain organizations. By this means it is possible to learn more about the connection between product costs and operating conditions or practices. Second, life cycle costing is a multidimensional approach and products' life cycle costs can be examined from a number of different perspectives and for several purposes. Consequently, the methods and concepts related to life cycle costing require both clarification and standardization. Third, the attitudes of individuals toward LCC by and

large determine the future of LCC. As mentioned earlier, some scepticism exists, but on the other hand LCC has clearly produced positive reactions as well. The development of LCC could be essentially supported by providing good examples of the effects of its use in different organizations.

The amount of academic research focusing especially on life cycle costing as a domain of management accounting has been very limited. However, taking into account the potential of the LCC approach and the challenges related to it, further research in the field is important. To improve current LCC practices, we would need to act rather than to observe. Much interventionist fieldwork – case studies – is needed before we will know enough about the effective implementation and the utilization of LCC in companies. Through this work, however, it could be possible to construct feasible costing systems that can produce cost information that corresponds to existing long-term cost management needs. However, probably even more work is needed to embed the outcomes of these systems in real actions by individuals inside organizations. ■

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