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COST EFFECT OF COMPONENT COMMONALITY: MANUFACTURING COST PERSPECTIVE

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Abstract

The aim of the paper is to analyze the measurement of component commonality and its cost effect from the manufacturing cost perspective. The unit of analysis is a new subassembly, i.e. a motor support of a roll conveyor. Component commonality is discussed using three evolutionary stages of the motor support. The researchers have provided cost information for the product development team and have also been questioning the cost efficiency of the proposed constructions. Despite its simplicity, the selected case subassembly illustrates the problematics related to component commonality – analyses at different levels give contradictory results. Detailed analysis of the case subassembly increases the understanding of the phenomena involved and highlights the importance of multiple levels of analysis when discussing component commonality.

1 Introduction

Product costs are mainly determined at the product development stage [see e.g. Turney91]. Literature presents various guidelines for reducing manufacturing costs [see e.g. Hundal97]. However, the impacts of these guidelines are not always completely unambiguous. Especially, some component commonality literature rather straightforwardly states that component commonality in general decreases costs. Labro [03] has made a profound review of the empirical results in the literature related to the topic and concludes that research findings supporting both cost increase and decrease are available. Thus, Labro notes that insufficient empirical evidence exists of the cost effect of component commonality and that more empirical case studies are needed.

Cost of complexity has been discussed in the management accounting literature and several studies have identified the number of components as an important determinant of complexity. However, the cost effect of component commonality has not been discussed in management accounting literature very extensively. Furthermore, measuring component commonality has not been profoundly studied in empirical case studies either. Various authors have discussed the topic [see e.g. Martin & Ishii00], but unfortunately at a rather abstract level. In addition, the development of innovative methods and technical solutions enabling component commonality is a challenging area in which management accounting knowledge and especially an understanding of cost behavior logic are an invaluable asset.

1.1 Objective of paper

The aim of the paper is to discuss the measurement of component commonality and its cost effect from the manufacturing cost perspective. In order to do that, an understanding of the technical solutions that enable standardization is vital. According to Stake [01], issues of product structuring and product architecture are essential for understanding commonality. Thus, component commonality cannot be analyzed separately from the innovations forming the basis of it. The unit of analysis is a new subassembly, i.e. a motor support of a roll conveyor. Component commonality is discussed using three versions of the subassembly:

- The first version has been used in project deliveries for several years.
- The second version is a new innovation that simplifies the construction of the motor support significantly decreasing manufacturing costs.
- The third version makes it possible for only one motor support subassembly to be used in all end product models. Thus, the third version is an outcome of a commonality innovation.

First, theory related to component commonality and its measurement is discussed briefly. Second, the evolutionary stages of the case subassembly are introduced and analyzed with some basic component commonality measures. However, component commonality is not the objective in itself; rather, the company must aim at increased profitability. Therefore, the different measures used for estimating component commonality are compared to the manufacturing costs (incl. direct and indirect manufacturing costs) of each version. Third, component commonality is analyzed from the subassembly commonality perspective. That, on the other hand, shows the case subassembly in a new light and illustrates the importance of finding proper levels of analysis when discussing component commonality.

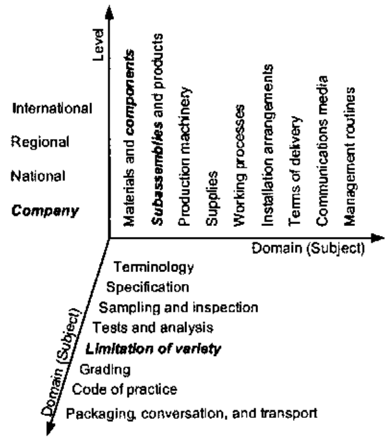
1.2 Research method

In the literature, standardization and component commonality have been discussed at a rather general level and more practical case descriptions have been demanded [Labro03]. The case selected for this article enables detailed analysis of the technical requirements of component commonality as well as its cost effect. The case also illustrates the value of in-depth case studies when trying to understand complex phenomena such as component commonality. In the case company, the researchers have provided cost information for the product development team and have also been questioning the cost efficiency of the proposed product constructions.

Because of the strong commitment of the researchers, action research [Coughlan&Coghlan02] seems to be a sensible choice of research method. In action research, commitment to the organizational goals is seen as a benefit and not only as a factor distorting the results [Gummesson93]. All the figures presented in this paper are real-life-based – the same figures have been presented to the case company management. The figures are presented with the permission of the company management.

2 Component commonality in literature

Commonality is a rather complex concept. In general, it means that two or more objects share some characteristics [Stake01]. According to Stake, it can be understood in a number of different ways, ranging from standardization of parts to the re-use of various conceptual solutions within a product or product family. Thus, commonality can take place at different levels of abstraction and detail, as also illustrated by Sanders [72] in Figure 1.



In the figure, the standardization perspectives of this study are bolded. The objective of the case company is to limit the variety of components and subassemblies at the company level, i.e. to introduce component commonality. However, component commonality is not the ultimate objective; rather it is seen as a way to increase sales volume and improve profitability. Considering the elements of profitability, namely costs and revenues, this paper focuses on costs. The success of component commonality is thus measured from the cost perspective. Solutions enabling the selected customer demand to be completely fulfilled with the lowest costs are considered to be the best.

2.1 Component commonality

Component commonality [Labro03] or component sharing [Fisher et al.99] can be defined as the use of the same version of a component across multiple products. Component commonality is seen as a way to offer a higher variety of products with lower variety in their production, which allows for economy of scale since a common component can be produced in larger volumes [Stake01]. Furthermore, component commonality is claimed to improve predictability of component use and also to decrease inventory capital [Baker et al.86]. When the same component can be used with several end products, the accuracy of demand forecasts of components increases. It is no longer necessary to estimate the sales volumes of individual end products because the demand of common components is more related to the total sales volume. Furthermore, the same service level can be offered with decreased inventory levels, which increases the capital turnover. When discussing component commonality, it is also necessary to consider its impact on revenues [see e.g. Kim&Chhajed00]. Component standardization, for example, can be divided into internal and external component commonality, depending on whether the commonality decision has an effect on the customer value [Robertson & Ulrich98]. Modularity also comes close to component commonality. Modularity is one way to reduce problems related to number of product variants by increasing the degree of commonality [Baldwin&Clark97]. The unit of analysis, however, is slightly different.

According to Perera et al. [99], component standardization – practically the same as component commonality – means that several components are replaced by a single component that can perform the functions of all of them. According to Perera et al. [99], there are three possible situations for standardizing components:

- Component standardization within a product: Several unique components in a product are replaced by one common component.
- Component standardization among products: Several unique components in different products are replaced by one common component.
- Component standardization among product generations: Common components are used in different products or in upgraded products across the time frame.

Component commonality, however, might not be quite that simple. Numerous additional levels for analyzing component commonality can also be found. In addition to the situations stated above, component commonality can also be analyzed, for example, at different subassembly levels. Furthermore, differences between subassemblies and components are not that clear-cut either.

2.2 Measuring component commonality

In this paper, a component is defined as a part that cannot be divided into smaller units with their own ID codes. Thus, a component is seen as very context-specific; what is merely a component for one company can be the end product for another. Components in combination form all sorts of subassemblies. In this paper, however, a subassembly is considered to be a combination of components and subassemblies that is stored at some point of the process and that also has an ID code of its own. Components and subassemblies together form different systems, and eventually products that a company actively sells to its customers. Therefore, the concept of the product is equally context-specific. The after-sales perspective naturally might alter the situation regarding the definition of a product or component, but this paper discusses new product business only.

Number of components is seen as a proper measure of component commonality [see e.g. Labro03]. However, when discussing different types of commonality indexes [see e.g. Martin&Ishii00], Stake [01] mentions that in many formulas components, subassemblies, or subsystems could be used to estimate the degree of commonality between them. Analyses done at different levels might give contradictory results. Thus, it is not self-evident which level should be used in measurements. Since the objective is overall profitability, the eventual contradictions must be solved by choosing the right alternative from the corporate perspective. Therefore, cost efficient designs require analyses also at the highest level impacted by the decision. On the other hand, acquiring detailed data about the different alternatives requires analyses at the lowest levels, i.e. component and subassembly levels.

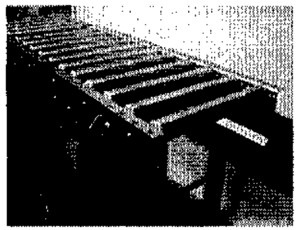
2.3 Cost effect of component commonality

It is rather difficult to identify unambiguously the literature discussing the cost effect of component commonality, because the existing management accounting, operations research, and product development literature touching the topic overlap. Especially in the field of operations research, the cost effect of component commonality can be identified as a separate topic. Labro [03] has written a profound review of the literature on component commonality. On the basis of her analysis, Labro states that management accounting literature includes lots of material related to the cost of complexity and that the number of components has been identified as a significant variable describing the complexity of products and processes. On the basis of Turney [91], it is easy to arrive at the interpretation that component commonality has an impact particularly on various indirect costs.

Literature on machine design, and especially literature discussing product development, presents various rules of thumb for reducing manufacturing costs. However, these rules of thumb have been separated from the original contexts and that is why the generalizability of those design principles is not clear-cut either. Labro [03] and Nobelius and Sundgren [02] criticize strongly that part of the literature on component commonality which rather straightforwardly states that component commonality in general reduces costs. In her literature analysis, Labro names studies that between them have produced many divergent conclusions. Thus, no simplified conclusions about the cost effect of component commonality can be made. Therefore, more detailed case descriptions are needed in order to determine the true nature of the cost effect of component commonality.

3 Technical innovations enabling component commonality

The paper is based on a case study in a machine construction company specializing in material handling equipment. Until now, the company has been a project supplier managing complete material handling and production equipment projects, mostly for the food industry. Net sales of the case company in 2003 were about 8 MEUR and the company had 48 employees. Despite its project management expertise, the company has been developing mass-customized standard conveyors. In the case of standard conveyors, the development of roll conveyors has advanced furthest. A picture of a prototype is presented in Figure 2.



The company is planning to offer the standard roll conveyor modules in several different lengths and in three different widths (400, 500, and 600 mm). The modules can then be used for assembling different conveyor systems according to customer requirements. In driven roll conveyors, the case company has started to use a so-called flat belt drive, in which a plastic belt moves below the rolls and causes them to rotate. The drive, on the other hand, is attached to the conveyor by means of a subassembly called a motor support.

3.1 Evolution of motor supports

The evolution of motor supports is illustrated in Figure 3. The motor support earlier used in project deliveries is Version 1. It consists mostly of sheet metal parts that are manufactured with a laser and then welded together. However, the number of parts and components is rather high and the case company management has not been completely satisfied with its performance either. Furthermore, manufacturing costs turned out to be much higher than expected when modeled by the researchers. New and innovative ideas were needed for improving the subassembly.

A completely new way of thinking about a motor support was introduced by the sales director, i.e. Version 2. Instead of a sheet metal frame, axles identical to those used also for the flat belt at both ends of the conveyor form the body of Version 2. With that innovation, the number of parts in the subassembly is reduced dramatically. The core of the motor support is a thick steel plate, i.e. body sheet, that is welded to the axles and which the motor and gearbox combination is bolted to. A hole has been made for the drive shaft that goes through the body sheet. For different gearboxes, several sets of bolt holes were needed, which, however, was not a problem. Two standard gearboxes were selected and holes were machined for each one. Thus, with two sets of holes, both standard gearboxes could easily be attached to the same body sheet. Despite the new and innovative ideas, Version 2 presented an unexpected problem. When the size of the gearbox increases, also the length of the drive shaft increases, and when that happens, the drive wheel is no longer in line with the flat belt. So, if that Version were used, one motor support would be needed not only for each conveyor width but also for each gearbox. Thus, enabling two different gearboxes to be attached to the same motor support did not seem such a good idea after all.

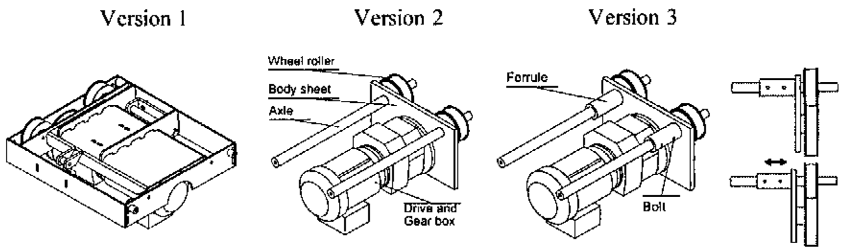


Figure 3. Evolution of motor support subassemblies.

The technical director came up with an innovative solution to the problem, i.e. Version 3. Instead of welding the steel plate to the axles, two ferrules would be welded to it. The ferrules would enable the steel plate to be attached to the axles according to Figure 3. When the drive shaft length increases, the body sheet and thus also the drive wheel can be repositioned to the right place by moving the steel plate parallel with the axles, which is illustrated in the right-most picture in Figure 3. The body sheet is fastened to the axles with the bolts in the ferrules. The innovation also enables the body sheet to be attached to the conveyor in the assembly phase, which means that different conveyor widths would not need separate motor support subassemblies either. Therefore, because of the standardized construction, only one motor support subassembly is needed for attaching all the standardized drives to all the roll conveyor widths used by the case company.

The impact of different constructions on component commonality can be estimated by comparing the Bill of Material (BOM) of each version. Table 1 illustrates the changes taking place between the different versions. The table shows the number of parts (how many parts the subassembly has in total), the number of components (how many different parts, i.e. ID codes, the subassembly has), the number of subassembly-specific components (components used only in motor support subassemblies), and the number of common components (components used in other products or subassemblies as well). All these measures, in the end, give some background information regarding component commonality.

Table 1. Number of parts and components in different Versions.

	Number of parts	Number of components	Number of subassembly-specific components	Number of common components
Version 1	36	19	17	2 (19-17)
Version 2	12	6	2	4 (6-2)
Version 3	18	8	3	5 (8-3)

Version 1 has 36 parts and 19 components, most of which are subassembly-specific. With Version 2, the number of parts and components decreases to a third. However, considering component commonality, the number of motor support specific components drops to two, but at the same time two additional common components are needed. With Version 3, all the measures increase slightly. Attaching different motor sizes with one motor support subassembly requires one additional subassembly-specific component, i.e. the ferrule. The bolts, on the other hand, are common components. Two ferrules and four bolts increase the number of parts by six in total and the number of components by two.

3.2 Component commonality increases production value

Since component commonality must not be an objective in itself, also the cost perspective has to be taken into account. Because the company has been a project supplier, it has gathered cost information at the component and subassembly level only every now and then. However, component-level cost information is needed for developing a subassembly that fulfills the cost reduction goals set by the management. Consequently, the researchers have built a cost model that produces component-level cost information suitable for product development purposes. The model can be used for determining the production value of products at the component level, including all manufacturing – direct and indirect – costs.

Even if Version 1 was a great improvement compared to the motor support subassemblies used several years ago, its manufacturing costs still turned out to be much higher than expected (111 euros). Because Version 2 appeared to be much more simple compared to Version 1, the case company management assumed that manufacturing costs of the motor support subassembly could finally be reduced significantly. However, the manufacturing costs of Version 2 dropped only about 20 euros, which was rather confusing. In order to explain that, it was necessary to analyze the cost structures of the subassemblies in more detail. Table 2 shows the manufacturing costs of the tree versions divided into material, machining, and welding costs. The cost analysis takes into account all the components related to the motor support except the motor and the gearbox. The total manufacturing cost of each version is shown in the last column with the change in manufacturing costs compared to the previous version in parenthesis. The last row shows the change between Versions 1 and 3.

Table 2. Cost structure of the different motor support versions (in euros)

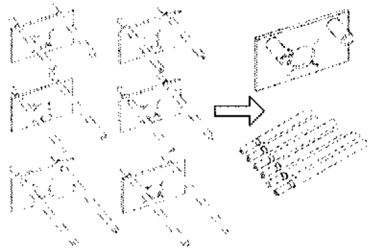
	Material	**Manufacturing**	*Machining*	*Welding*	**Manufacturing costs in total**
Version 1	76	35	*22*	*13*	**111**
Version 2	46	45	*39*	*6*	**91 (-20)**
Version 3	52	45	*40*	*5*	**97 (6)**
					-14 (-13 %)

Version 1 is rather material intensive – materials cover almost 70 percent of the production value. With Versions 2 and 3, material and manufacturing costs are quite close to each other. Material costs of Version 2 are about 40 % lower compared with Version 1, which is in line with management's expectations. However, the production value drops only by 20 euros with Version 2, which is explained by the 50 percent increase in machining costs that the case company management had not expected. The increase in machining costs reduces the overall impact of the decrease in material and welding costs, thus decreasing the total cost reduction. The production value of Version 3, on the other hand, rises about 6 euros, which is explained by the ferrules. Compared with Version 1, total manufacturing costs fall about 14 euros (13 %), which still is a rather good cost reduction. The paper focuses on Versions 2 and 3 because they offer an interesting additional perspective on component commonality.

4 Commonality measurement – wider perspective needed

Considering component commonality, how successful are the new motor support constructions? Component-level analysis as well as production value yielded quite contradictory results. In the literature, the number of parts and components has been considered a measure of a product's complexity [Labro03]. That, however, is not clear-cut but rather dependent on the context. The case company has focused mostly on minimizing the number of parts in individual products while the goal should have been cost minimizing. Despite the lower number of components and lower production value, Version 2 is by no means automatically the optimal solution. Analyzing the number of components is not enough; rather, a subassembly-level analysis must be included as well. The case company aims at selling its products to its dealers, who are responsible for final assembly and installation. The motor support subassemblies need to be welded before they are stored in the inventory because the case company wants to ensure fast delivery and because the dealer network is not supposed to be responsible for any welding work.

The fact that assembly is done by dealers incapable of doing welding supports the use of Version 3. As illustrated in Figure 4, Version 2 requires a unique motor support subassembly for each motor and gearbox combination and for each conveyor width, whereas with Version 3 only one motor support subassembly with standard axles is needed. Drive wheels and belt rollers are identical in all the different motor support constructions, which means that they are no longer topics of interest from the component commonality perspective.



With the standardization innovation (Version 3), the required number of subassemblies can be reduced dramatically. Thus, when analyzing the impact of the standardization innovation, not only the changes in the number of components but also the changes in the number of subassemblies required for the product family must be taken into account. Table 3 summarizes the measures of component commonality used in this paper.

Table 3. Different measures used for analyzing component commonality.

	Number of parts	Number of different components	Number of subassembly-specific components	Number of common components	Number of subassemblies	Number of subassembly-specific ID codes	Manufacturing costs
Version 2	**12**	**6**	**2**	4	6	8	**91**
Version 3	18	8	3	**5**	**1**	**4**	97

Considering component level analyses, Version 2 has lower (traditionally seen as better) values, except with the number of common components. However, Version 3 has lower values measured from the subassembly and inventory item (number of subassembly-specific ID codes) perspective, the number of inventory items being a very interesting measure as regards component commonality. Version 2 requires 8 inventory items while the standardization innovation reduces the number of inventory items to 4. At the same time, the innovation enabling the change increases the production value of a motor support by 6 euros. The impact of the standardization innovation of Version 3 on the number of components and subassemblies held in the inventory is also illustrated in Figure 5.

The company management wants to start using Version 3 because the reduction in the number of subassemblies should decrease capital deployed in the inventory. However, the increased production value will override the savings in the cost of capital deployed even with a rather small volume increase [see Lyly-Yrjänäinen et al.04]. Thus, the question is, will the decrease in the number of subassemblies yield additional cost savings, for example, in project management or project sales activities, thus justifying the increased production value of Version 3?

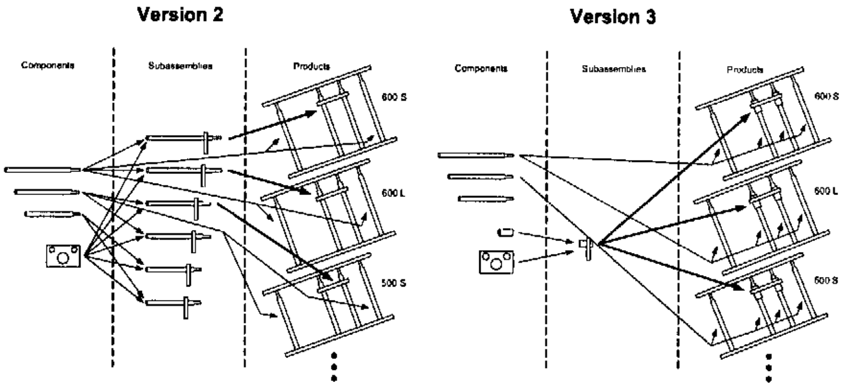


Figure 5. The reduction in number of subassemblies between Versions 2 and 3.

Analyzing the cost behavior of various indirect activities would naturally be an interesting pursuit, and activity-based costing (ABC) is a generally approved tool for that. However, the effect of component commonality on production value is not that clear-cut either. Thus, there is plenty of spadework to be done in analyzing the effect of component commonality on production value before rushing into indirect activities or various overhead recovery factors. It has been claimed that 30-40 percent of a company's expenses could be assigned using various cost drivers related to product structure [Larson & Åslund01]. However, as illustrated by the case, cost behavior is quite complex even with such a simple construction. Thus, detailed-level case examples are needed for understanding such a complex phenomenon as the cost effect of component commonality. Despite the fact that generalizations, in general, should be the reserve of various statistical survey studies [see e.g. Stake95;Yin94; Alasuutari99], the findings of this case are certainly transferable [Marshall&Rossmann99] to other companies and other case studies based on the ideas of contextual generalization [Lukka&Kasanen95].

5 Conclusions

The objective of the paper was to analyze the cost effect of component commonality and its measurement from the manufacturing cost perspective. The paper has analyzed three versions of a subassembly used for attaching motors in roll conveyors. The three versions have been analyzed from the "number of component" perspective. In addition, the number of subassemblies and thus also the number of inventory items were discussed, which gave an interesting new perspective to the case. Thus, it is not clear-cut at what level component commonality should be analyzed. With Version 3, the number of components increases, but at the same time the number of subassemblies decreases, which will have an impact on inventory holding costs. Considering manufacturing costs, Version 2 turned out to be the most cost-efficient. That, however, is no surprise, because various authors have claimed that standard solutions are always somewhat more expensive from the purchase or manufacturing cost perspective than product-specific or "unique" solutions. Lower manufacturing costs, in this case, are mainly explained by lower material costs – Version 2 is 6 euros cheaper compared to standardized Version 3.

However, this paper focuses on component commonality and its cost effect from the manufacturing cost perspective. Component commonality has a significant impact on indirect activities that were not included in the analyses. An interesting topic for future research is whether standardization innovation will in the end enable cost savings when several overhead costs such as product development, project management, and sales and logistics activities are also included in the analysis. Furthermore, when the effect of component commonality is estimated, it is necessary to include also those products or subassemblies that share components with the motor support. That, however, is the objective of a new three-year research project that is just about to start.

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