universität wien

MASTERARBEIT

Product Differentiation vs. Product Commonality

Deciding about component commonality in an activity based costing environment

Verfasst von

Hirschvogl Thomas, Bakk.phil. Bakk.rer.soc.oec.

angestrebter akademischer Grad

Master of Science (MSc)

Wien, 2014

Studienkennzahl lt. Studienblatt:	A 066 915
Studienrichtung lt. Studienblatt:	Masterstudium Betriebswirtschaft
Betreuer / Betreuerin:	Univ.-Prof. Dr. Thomas Pfeiffer

1 Introduction 3
2 Reasons for component commonality 4
2.1 Marketing 5
2.1.1 The individual consumer 5
2.1.2 The individual firm 6
2.1.3 Market equilibrium 7
2.1.4 Optimal variety 8
2.2 Production costs 8
2.3 Component commonality 10
2.4 Effects of component commonality 11
3 Activity Based Costing 12
3.1 Definition 12
3.2 ABC versus traditional costing systems 13
3.3 Activity Based Management 17
3.4 Conditions for suitable application of ABC 18
4 Component commonality in an activity based costing environment 21
4.1 Cost effects identified in literature 23
5 Trade-off between revenue and cost 24
5.1 Determinants of the model 24
5.1.1 Consumers 24
5.1.2 Products 25
5.1.3 Product configuration 26
5.1.4 Manufacturing and design costs 27
5.2 Analysis 28
5.2.1 Unique configuration 28
5.2.2 Premium-common configuration 29
5.2.3 Basic-common configuration 31
6 The combined model 33
6.1 Reasons for the selected models 33
6.2 Adjustments 34
7 Example 38
7.1 Assumption of the example. 38
7.2 Numbers 39
7.3 Trade-off revenue and cost 40

7.3.1 Unique configuration 40
7.3.2 Premium-common configuration 42
7.3.3 Basic-common configuration 44
7.3.4 Comparison of results 46
7.4 The combined model. 48
7.4.1 Unique configuration 49
7.4.2 Premium-common configuration 51
7.4.3 Basic-common configuration 53
7.5 Comparison of results 55
8 Discussion 58
9 Further research 61
10 Conclusion 63
References 64
Appendix 66
Abstract 66
Example 68
Model of Desai et al.(2001) 68
Combined model 69
Curriculum Vitae 71

1 Introduction

This paper deals with the impact of component commonality on production costs and revenue. There has been a lot of research done in this area and many models are provided to show trade-offs for the revenue side as well as for the cost side.

The aim of this paper is to analyse two models and to assemble a new model, which combines the strengths of both. While one model considers the trade-off between revenue and cost when using a common component, the other provides an objective function with the ambition to minimize total cost within an activity based costing system.

Initially the reasons for component commonality regarding marketing and costs will be discussed. Also activity based costing will be introduced and relevant aspects will be highlighted.

The main model considers revenue and cost aspects. It uses market information to determine the number of sold units and realizable prices, which is done in a monopolistic environment. Additional it considers the cost side and mentions the impact of design effort. These information's are displayed with an objective function and related constraints.

The model with activity based costing simply provides an objective function without additional constraints and therefore lacks of revenue information. As a main aspect it deals with activity based costing and so provides a lot of information about the overhead distribution and the impact of the realized activities on the cost structure.

Compared to a volume based costing system, activity based costing is a pretty complex and it cannot be applied to any case. There are some conditions for activity based costing to be able to provide valid information, which will be considered.

In this paper both models will be assembled. The model considering revenue and cost will be the main model and will receive additional information for the objective function originating from model with activity based costing. This will enable the new model to be applied in an activity based costing system environment. As the main model considers already a lot of market information, the focus will be on the cost side and at the overall profit.

Subsequent to these results, the models will be discussed and some thoughts for further research will be mentioned.

2 Reasons for component commonality

Component commonality developed because of the requirements of the markets. In the markets there is a need for product variety in order to satisfy different consumer segments and to cope with competition.

According to Labro (2004:358) for firms it is necessary to offer more product variety due to increased competition and more demanding customers.

By providing more product variants in the market place, firms seek to increase revenues by serving different market segments. While more variety in the marketplace increases the revenues, costs will also increase.

"While product variety enables the firm to charge higher prices, there is always the risk that product design, development, and manufacturing costs may significantly escalate, thereby eroding profits." Desai et al. (2001:37)

This statement reveals that the revenue and the cost side have to be considered when product variety is in discussion. Therefore main aspects of component commonality are marketing and costs.

The practice of component commonality raised because of the need to match the requirements of the markets with the aims of the cost side keep costs down. Heese and Swaminathan (2006:206) mention that customers increasing demand for product variety at lower costs are a dilemma for the manufacturers.

To deal with this issue, Labro (2004:358) explains, that component commonality is increasingly considered as a way to offer high variety with low variety in operations and accordingly low costs.

This paper will investigate if component commonality can achieve this goals and how this can be done. Although Labro (2004) mentions competition as reason for increased component commonality, this paper will deal only with the customers and competition will be ignored. Subsequent the marketing and the cost aspects of component commonality will be introduced separately.

2.1 Marketing

In economic research it is commonly acknowledged that consumers are willing to buy a price for a product as long as they get a positive utility from the product. For a higher utility they are willing to pay a higher price. To take advantage of this, firms will provide different products for different consumer segments.

Lancaster (1990:190) mentions that variety within a product group will persist only if one or more of the following is true:

- each individual consumer seeks variety in his own consumption.
- different consumers want different variants because tastes vary.
- individual firms can increase profits by producing a variety of models.
- firms can increase profits by differentiating their products from those of their competitors

So either the consumers, the manufacturer or both have to benefit from variety. In addition to these basic conditions there have to be considered more aspects. For the degree of product variety, Lancaster (1990:190) considers four contexts:

1. The individual consumer
2. The individual firm
3. Market equilibrium
4. The social optimum

Each of these contexts will influence the product variety in the marketplace. These contexts are described subsequent.

2.1.1 The individual consumer

For the individual consumer many models exist that consider their preferences. In case of component commonality specific aspects have to be considered.

Lancaster (1990:190) explains that for the individual consumer the economist's traditional model of consumer choice is not applicable, because it was developed to describe broad choices between product groups rather than within groups.

As component commonality deals with similar products within a family, a more suitable approach has to be applied. Choices within a group are still determined by the preferences.

Lancaster (1990:190) describes, that strict convexity implies an inherent preference of variety. He concludes that for some range of prices, there is a combination of n goods that is preferred to any combination of fewer goods which cost no more. So broad choices over bundles of aggregate goods can be described. This means, an individual which can choose between a group of similar but differentiated goods, would consume every offered product in the group or variant for some range of relative prices.

So within a product group there are several possible choices, depending on the provided products, consumer preference and demanded price. Therefore the consumer will benefit from a broader choice in order to choose the bundle which matches his preferences best. Consumers are important determinants in the market, the other big part in the market are the firms which provide their products.

2.1.2 The individual firm

Firms can benefit from consumer behaviour when they provide products that match consumer preferences in a good manner. So for different consumer segments they could offer diverse products. Lancaster (1990:190) mentions that serious analysis of product variety in multiproduct firms, which attempt to explain the motives for producing a particular number of products, was quite recent in the economics literature. He divides the approaches into three types:

1. centred on the production side, emphasizing cost advantages from joint production or economies of scope
2. centred on the demand side, emphasizing the balance between the increased revenue possible from a more varied product line and the loss of scale economies in the production of each variant.
3. centred on the strategic considerations, especially pre-emption in the product space as a deterrent to entry

The points 1 and 2 are notably relevant for the model in this paper. This is caused by the fact that the model considers both, the demand side and also the production side.

By taking a look on the production side, Browning and Zupan (2006:229) explain,

"Economies of scope are present if it is cheaper for one firm to produce products jointly than it is for separate firms to produce the same products independently."

So economies of scope are a possible consequence when a company produces more than one product. To discover if economies of scope appear, the output of a single firm has to be compared against separate production, Pindyck and Rubinfeld (2005:241) explain:

"In general, economies of scope are present when the joint output of a single firm is greater than the output that could be achieved by two different firms each producing a single product(with equivalent production inputs allocated between them)."

So economies of scope take place, when multiple products are produced in firm with less resources, than it could be done by separate firms.

Also on production side, economies of scale can appear, Pindyck and Rubinfeld (2005:237) defines, that economies of scale appear, when a firm can double its output for less than twice the cost.

More general Browning and Zupan (2006:220) explain, that economies of scale mean a case, where a firm can increase its output more than in proportion to its total input cost.

Concluding, at economies of scale a firm benefits from an increased number of produced units with reduced marginal costs for the additional produced units.

Thereby the considerations of product variety for the individual firm are derived. Firms could benefit from larger production amounts with economies of scale and when producing multiple products from economies of scope.

2.1.3 Market equilibrium

The market equilibrium limits the degree of product variety. Lancaster (1990:191) explains that product variety is limited to the smaller of

1. maximum number of variants which consumers in the aggregate are willing to buy or
2. number of variants which the suppliers in the aggregate are willing and able to produce

So product variety can be limited on demand or on the supply side of the market. Respective to consumers, Lancaster (1990:191) mentions that marketing literature assumes a finite number of market segments, while most economists' models assume the potential demand for variety as unlimited. Product variety has been perceived as limited only on the supply side.

This aspect has to be considered when a model is applied.

2.1.4 Optimal variety

The optimal variety depends on the already mentioned aspects. Lancaster (1990:192) explains that the fundamental structure of all optimal variety problems is the interplay of two elements in the economy. The existence of a gain from variety interplays with the existence of scale of economies of some kind. For cases that involve a balance of variety against scale economies, the solution depends on the preference properties of consumers, the scale properties in production and distribution.

This interplay from these two elements will be a major part of the model in the subsequent chapters. Consumer preferences and production properties will be involved and handled accordingly.

Regarding the production side, Lancaster (1990:192) mentions that a lack of economies of scale associated with individual product variants would mean that it is optimal to produce everyone's chosen specification. In absence of gains from variety and appearing economies of scale, it would be optimal to produce only a single variant or only such variety as uses scale economies to the limit.

To sum up, the paper of Lancaster revealed the determinants for product variety. Variety in market place exists, if customers seek for variety and firms can increase profits by producing this variety. The degree of variety is influenced by the individual consumer, the individual firm and the market equilibrium. On production side, firms possibly could benefit from economies of scope and economies of scale.

2.2 Production costs

Accounting literature delivers a broad spectrum of production costs. Hussey (1995:262-264) defines production cost as the total of all costs incurred in producing a product or cost unit. In accounting the production cost is represented by the total of all direct material, direct labour, direct expenses and the manufacturing overhead.

So the production costs consist of direct manufacturing cost and overhead cost. The direct costs are already mentioned, in addition to that, Hussey (1995:246) defines overhead cost as the indirect cost of an organization, usually classified as manufacturing overhead, administration overheads, selling overhead, distribution overhead, and research and development cost.

With direct costs and overhead costs, the basic cost structure is revealed. These production costs can be influenced in many ways. Regarding product costs, Banker et al. (1990:269) mentions that product designers play an important role in influencing total life cycle costs of a product. Traditional accounting systems monitored and controlled costs incurred subsequent to the design process. When costs are influenced by product complexity, many costs are determined in the design stage. So it is important to develop systems to inform the designer of the cost implications of alternative design choices. Such systems should display the factors that are affected by design engineers and influence manufacturing costs.

This adds an additional dimension to the situation. Not only costs must be considered, also the timeline is important. Managers are aware of the challenge to take care of the total lifecycle costs of a product and especially overhead costs, Miller and Vollman (1985:142) explain:

"high manufacturing overhead has a dramatic effect on profit and competitiveness, and manufacturing managers believe themselves to be poorly equipped to manage these costs well."

So managers seek for tools that help them to cope with all relevant costs. Costs can be influenced already in the design stage and not only in current production. Therefore the complexity of a product is an important aspect. Banker et al. (1990:270) explain that complex products result in high manufacturing overhead costs consisting of activities as quality control, inspection, machine and tool maintenance, and production control. Typical cost accounting systems group overhead costs together and allocate them to the products on basis of direct labour or machine-hours. But these distribution bases do not express the demand on resources by products that are difficult to manufacture. Therefore product costs become distorted resulting in biased analysis of product profitability.

So complex products will increase the overhead due to their increased demand for attention. Additionally the distribution of costs can be distorted by the costing system, when they are distributed by volume. This issue has to be considered when production costs are calculated.

Scales of economies are a considerable aspect at production costs. Heese and Swaminathan (2006:206) mention that matching products to heterogeneous consumer needs have serious negative implications on manufacturing efficiency due to increased product and process complexities and reduced scale economies

This is obvious, due to the fact, that a bigger number of parts in smaller numbers will miss the advantages from economies of scale. Therefore a smaller number of components in larger amounts probably save costs.

So it is revealed that manufacturing costs probably are distorted by the costing system. As the manufacturing costs are influenced in the design stage, there is a need for a costing system that captures the impact of design decisions on later manufacturing costs.

2.3 Component commonality

Now that the roots of component commonality are revealed, the impact of this knowledge into the product has to be specified. The need for product variety in certain environments is obvious, so the term has to be defined. Lancaster (1990:189) uses the term product variety as the number of variants within a specific product group.

So not the whole market is considered, instead only a specific product group is mentioned, which is valid for the research purpose of this paper. As there was a lot of research in this area there are additional definitions, which are more specific.

"Product variety can be defined on two dimensions: the breadth of products that a firm offers at a given time and the rate at which the firm replaces existing products." Fisher et al. (1999:297)

From this statement it is evident that there is more than one possibility to receive product variety. The first part of the definition means that a firm provides a great variety of products at a specific time point, whereas the second part counts the number of different products within a time period. This is an extension compared to Lancaster (1990), who didn't include timeline in his definition.

In order to provide a great variety and keep costs at a reasonable level, Fisher et al. (1999:297) explains, that companies coped with that challenges and tackled it with process based or product based approaches. The process-based strategies seek to provide flexible production and distribution processes to enable them to accommodate a high level of variety at reasonable cost. On the other hand, product based strategies look for product design that show high variety in the marketplace while requiring a low level of component variety and assembly complexity from the production and distribution system.

Both of these approaches can be applied on the two dimensions of product variety. For the definition below, the term component sharing is similar to the term component commonality.

"*Component sharing is a product-based strategy that depends on the fact that families of similar products have similar components."* Fischer et al. (1999:297)

So Fisher et al.(1999) determine that component commonality is product based. Additionally they reason this with the fact that related products are using similar components.

As the paper deals with component commonality it has to be defined which approach it follows. Concluding from the previous definitions, for this paper the definition will be valid:
Component commonality is a product based strategy to provide product variety within a specific product group at a specific time point.

2.4 Effects of component commonality

The previous chapters revealed the reasons for component commonality and how it could be applied. The usage of a component for multiple products has an impact at many levels.
An important aspect in this context is the effect on the realizable selling price.

"While manufacturing costs always decline with the use of commonality, the firm's overall profits may decline because of reduced differentiation." Desai et al. (2001:38)

Similar to that Heese and Swaminathan (2006:206) mention that increased component commonality limits a firm's potential to extract price premiums through product differentiation.
So the reduced differentiation at component commonality is a considerable effect and the advantages of reduced production costs have to be weighed against the reduced revenues.
Component commonality affects the cost side, Fisher et al. (1999:299) consider economies of scale, and mentions that a shared component will be produced in higher volumes and so economies of scale in the production process may lead to lower unit variable costs.
So economies of scale are an important and often considered factor for the production cost. Besides economies of scale, the cost advantage in production costs is not that obvious as it seems, the effect can go both ways, upwards and downwards.

"Component sharing involves factors that may both increase and decrease the variable costs of production" Fisher et al. (1999:299)

This can be confirmed when comparing an individual component in relation to total cost. Even if the specific component is produced at lower costs there are more aspects to be considered. Fisher et al. (1999:299) mentions, that a shared component must be designed to perform adequately in all product applications. Thereby, often the most stringent performance requirements are substantially greater than those for the least stringent application in which the component will be used. This excess capability may incur a unit variable cost penalty relative to the variable costs of unique components designed for each unique product application.

This excess capability and the attendant cost potentially result in higher total production costs, even if economies of scales appear. So far with direct production costs, on the cost side there are overhead costs that have to be considered. Fisher et al. (1999:299) explain that firms incur "system costs" of production, distribution and after-sale support. Activities that influence these costs can be quality assurance, procurement and spar-parts inventory. The number of unique parts drives these costs and so component commonality may lead to reduced system costs.

So the possible effects of component commonality for the revenue side, as well as for direct production costs and production overhead are indicated. With this knowledge all relevant aspects of component commonality are mentioned and subsequent this will be applied in the models.

3 Activity Based Costing

3.1 Definition

ABC stands for <u>A</u>ctivity <u>B</u>ased <u>C</u>osting and is a powerful tool that supports the management to make accurate decisions. This is done by accounting changes in the overhead costs to activities instead of volume.

"ABC reveals the links between performing particular activities and the demands those activities make on the organization's resources, it can give managers a clear picture of how products, brands, customers, facilities, regions, or distribution channels both generate revenues and consume resources." Cooper (1991:130)

A more concentrated definition is made by Noreen (1991:160)

"ABC systems are based on the notion that products incur costs by giving rise to activities[...] which generate costs"

From these statements it is visible, that ABC analyzes activities and reveals how they are linked with resource consumption and provides these information to the management. The information displays the influence of these activities on revenues and resource consumption.

With few words Hussey (1995:12) explains that ABC is aware that costs are incurred by the activities within an organization and that products should cover the costs for their activities they use. The cost drivers are identified, together with their cost pools, which are used to charge costs to products.

Summed up, the definitions agree that activity based costing reveals the relationship between activities and changes in costs. With this information, the behaviour of overhead costs can be considered in decision making, so that products truly will cover their costs.

Furthermore to the previous definition, Cooper (1991:130) explains, that ABC leads the managers to focus on improving activities that have the biggest impact on the bottom line.

This focus on activities with big impact on the bottom line is important for the research of this paper. It will be shown that it is an important choice for the management to perform specific activities in order to control costs.

With this definition and the revealed objective, a general overview above the topic is made. Subsequent, the relevant parts of activity based costing will be highlighted.

3.2 ABC versus traditional costing systems

Activity based costing can be an important tool to control costs, especially overhead costs. Regarding overhead costs, Miller and Vollman (1985:143) explain, that developing a model that relates overhead costs to the forces behind them is an important step to control them. Many costing systems allocate overhead costs to the products, but they don't explain them.

The explanation of overhead costs is important to understand how they develop and why they behaviour in their ways, Miller and Vollman (1985:143) mention that

"the driving force behind most overhead costs is not unit output or direct labor. Overhead costs do usually correlate with unit outputs, but that does not mean that unit outputs 'cause' overhead costs."

This statement supports the idea that while overhead is correlated to production output, the production output does not determine overhead costs. They may are driven by other indicators. Miller and Vollmann (1985:144) conclude that overhead costs are driven by transactions and not by products. Such transactions can be exchanges in the material or production to move production along, which are not directly resulting in physical products.

These transactions can be displayed with activity based costing. In order to use ABC as a guide to profitability, Cooper (1991:130) mentions, that it is important to leave traditional costing systems and to act on the insights ABC analysis provides. Managers must neglect to

allocate all expenses to individual units. At ABC they must be separated and matched with the activities that consume the resources.
While Cooper(1991) is confident that traditional costing systems have to be put aside, Noreen (1991:160) clarifies that activity based costing systems technically subsume the more traditional methods of determining product costs.
So the costs will be separated according to activities which consume resources. This separation is valid, because the overhead costs are not driven by volume, but by transactions.

Allocation of costs

Activity based costing can be an important tool to provide useful product costs.

"If overhead costs are generated by transactions not directly proportional to production volume but these costs are assigned to products based on measures of volume, then product costs may be distorted." Banker et al. (1995:116)

Similar to that, Noreen (1991:160) supposes that the practice to allocate overhead based on direct labour distorts the product costs and overstates the savings that would result from reducing direct labour.
So ABC provides more accurate product costs than traditional costing systems. The overhead costs are assigned to the products in a more careful way and enable more accurate decisions. In this way, a distortion of product costs is avoided or at least reduced.
For the implementation there is a need to allocate the costs in a specific manner.
"Managers must refrain from allocating all expenses to individual units and instead separate the expenses and match them to the level of activity that consumes the resources." Cooper (1991:130)
So the costs are not directly distributed to an individual unit, but to separate cost pools and there they are matched with the level of activity.

"managers should separate the expenses incurred to produce individual units of a particular product from the expenses needed to produce different products or to serve different customers, independent of how many units are produced or sold." Banker et al. (1995:116)

After the costs are separated, Cooper (1991:130) explains, that managers have to search for options to reduce the resources required to perform various activities. To transform those reductions into profits, they must reduce spending on those resources or increase their output. The actions allow the insights from ABC to be translated into increased profits at the bottom line.

Later it will be shown in the model that an increase of some activities leads to reduction in manufacturing costs and the model deals with the trade-off between design effort and unit manufacturing costs

Cooper (1991:131) mentions that traditional cost accounting systems allocate overhead costs like support activities on the base of machine hours, direct labour or similar. Otherwise, activity based costing separates these costs by activities. Then those expenses are assigned based on the drivers of the activity. By doing this, hierarchies emerge. These hierarchies are built on where the performance is executed. This can be on unit level, batch level or somewhere else, depending on the production process.

So ABC accounts costs in a very specific way. The costs are separated in a more detailed way and therefore hierarchies appear. Costs can behave in different ways and therefore Noreen (1991:159) mention that activity based cost systems assign overhead to products using multiple allocation bases, whereof some are related to unit volume and some are not.

So allocation costs based on volume is not out of mind, but only if they behave in that way and not because of lack of better information. With this fact it is demonstrated an activity based costing system also subsumes methods of traditional costing systems.

Continuing with the hierarchies, Cooper (1991:131) mentions that with these hierarchies the management has a better idea about the relationship between activities and there resource consumption. The managers have to distinguish between the different hierarchies.

When the costs are separated successfully, the basis for reasonable decisions is prepared.

Decisions with activity based costing

With this picture, that shows the activities and their effect on the corresponding hierarchy, the management has a base to make decisions.

> *"Interestingly, ABC analysis often points managers in the direction of the advanced manufacturing and design philosophies some companies have begun to pursue."*

Cooper (1991:133)

This statement means that managers expand their view from direct manufacturing costs and they consider more aspects of production like investment in design. As ABC can show the effect on the current product mix, due to its structure with hierarchies and activities, it can give a preview for changes in the product mix. This is supported by Cooper (1991:133) who mentions that ABC can not only help managers modify existing product mixes, it could also help managers anticipate the effects of planned changes.

So activity based costing provides a broader cost picture and decisions' based on this information will balance between several prospects.
Cooper (1991:134f) concludes that ABC shows managers which actions are going to have the greatest impact on their profits. After an ABC analysis, they should reprise products and alter the price based on their demand for resources. This should lead them to a product mix that demands fewer resources or generates more revenues at the same level of resource consumption.
That means to raise efficiency and would result in producing the same amount with fewer resource consumption. Subsequent Cooper (1991:134f) mentions that managers should seek to reduce resource consumption. This can be achieved by reducing the number of performed activities required for the same output. To do so, products can be designed with fewer parts or with more common parts. Moreover an improvement program can be established to increase quality or improve factory layouts.
From this insight the most relevant part is the incentive to use common parts. To use common parts in a product, this topic has to be addressed in the design stage.

So activity based costing not only gives a clear picture of overhead costs, it also has an impact on product costs and avoid to distort them. Instead of distributing the overhead costs based on volume, they get separated into cost pools and distributed because of performed activities. Based on this information, ABC gives a preview on changes in product mix and helps the management to identify which changes would have the biggest impact on the bottom line.

Taking care of costs in the design process

An important aspect of costs is when they are approached. Costs of operation can be approached at any time. But unit costs have to be approached in the design stage. Cooper (1996:88) revealed that after the design of a product is finished, about 70% to 80% of a product's costs can't be changed any more.
So in the design process it is important, to take care of costs which will appear in the future, approach them at the design decision and consider their future effect on the overhead costs and manufacturing costs.

3.3 Activity Based Management

As the activity based costing system provides a great insight into the cost structure, managers have to take care of these information's. Kaplan and Cooper (1998:4) explain that ABC systems lead naturally to activity based management (ABM), a set of actions that can be taken on a better informed basis. This enables the organization to accomplish its outcomes with fewer demands on organizational resources and so the same outcome is produced at lower total cost. Activity based management achieves this with operational ABM and strategic ABM.

So activity based management appears subsequent to activity based costing. This management type can be separated into a operational and strategic part. Kaplan and Cooper (1998:4f) assert that operational activity based management means to do things right and gains to enhance efficiency, lower cost and enhance asset utilization. It can increase the capacity of resources by improving or eliminating faulty activities and processes and therefore increasing the efficiency of the organizations resources. The realized benefits show off as reduced costs, higher revenues and cost avoidance.

So operational ABM cares about the actual part of production. Kaplan and Cooper (1998:5) declare that strategic activity based management means to do the right things. It gains to alter the demand for activities to increase profitability while assuming, that activity efficiency remains constant. Additionally strategic activity based management influences design decisions about product design and development perhaps the biggest opportunity for cost reduction. Inadequate cost systems send faulty signals about the economics of their products to product designers and engineers. They make decisions that ignore the costs of using unique versus common parts, new versus existing vendors and simple versus complex production processes.

So operational ABM optimizes the short term of production by doing things right, whereas strategic ABM looks more forward and ensures that the right things are done.

At activity based management, the operational and the strategic part are not strictly separated, when they are applied together they will deliver the best results

"Obviously, operational and strategic decisions are not mutually exclusive. Organizations will get the greatest impact when they reduce both the resources required to perform a given quantity of activities and, simultaneously, shift the activity mix to more profitable processes, products, services, and customers." Kaplan and Cooper (1998:5f)

This means that managers will gain from applying both, operational and strategic ABM. To emphasize this, Kaplan and Cooper (1998:219) report an example of a company which spent more money on product development and launch expenses than on direct labour costs. With their direct labour cost system, all attention had been focused on reducing direct labour costs. Product development and launch costs were blended into the factory overhead rate, applied to products based on direct labour. With activity based costing, the managers realized the opportunity for major cost reduction by attacking the product launch cost directly.
This example greatly shows the benefits which emerge when ABC and ABM is applied.

So activity based management is a step subsequent to the implementation of and activity based costing system. It is based on the provided information's, gains to improve efficiency and can be split into an operational and a strategic part, which are not independent of each other. For this paper out of the strategic ABM the influence on design decisions is the most relevant part and this aspect will be covered later with an example.

3.4 Conditions for suitable application of ABC

As the previous passage revealed, activity based costing has a lot of advantages compared to traditional volume based systems. These advantages alone would be a clear reason to prefer activity based costing. When considering application of this system, some issues appear which have to be handled.

Necessary and sufficient conditions by Noreen

In his research about activity based costing, Noreen (1991:162) established conditions under which ABC product costs represent avoidable product costs and ABC overhead rates represent incremental activity costs.
Out of these conditions, for the research purpose of the paper on the hand, especially the conditions for the ABC overhead rates to represent incremental activity costs are relevant. For the purpose that the conditions are understood in the right manner, the relevant terms got defined in the paper. These terms are "avoidable costs", "incremental cost" and "ABC system".

The definition starts with avoidable costs.

"The avoidable cost of a product is defined to be the change in total cost if the product were dropped, keeping the volumes of all other products the same."

Noreen (1991:163)

So avoidable costs can be observed when the production volume of a product changes, while the production volume for all other products remains the same. The changes in total costs are the avoidable costs.

Regarding the overhead rates, incremental cost means:

"the incremental cost of changing the level of an activity is the change in total cost that would be incurred."

Noreen (1991:163)

So incremental cost in ABC meanings is similar to the literal meaning of the word. Even ABC was already defined in the previous chapter, the definition of Noreen is stated:

"a well-specified ABC system is simply an allocation scheme in which the cost drivers, or activity measures, are correctly identified and measured on at least the aggregate level."

Noreen (1991:163)

This definition goes along with the definitions which were mentioned before.

Conditions

In total there are 3 conditions where 2 of them must be satisfied.

Basically, Noreen (1991:164) states that an ABC system must be well-specified and the underlying cost function must be able to partition the total cost into cost pools, where each depends solely upon one activity. Additionally for each activity it must be possible to partition it into elements that depend solely upon each product.

So the system has to be handled accurate and adapted to the correct cost function. It has to be possible to distribute the costs clearly to a product.

For the first necessary condition, Noreen (1991:164) defines, that total cost must be able to be partitioned into cost pools, while each of them depends solely upon one activity. This condition is built on the fact that every cost is the product of a price and a quantity of something and this could be considered as the activity. Virtually it is supposed that the number of different activities in an cost system is limited. It is sufficient when an activity measure is a satisfactory proxy, when it is highly correlated with an activity.

So costs must be partitioned precisely into cost pools which depend on one activity. The increase in an activity not necessarily must lead to a similar increase in costs, but a proper relationship between them is compulsory. For the degree of correlation, there is no specific number mentioned.

There is another necessary condition, respective to this condition Noreen (1991:164) mentions that each activity can be partitioned into elements that depend solely upon each product. So by summing up the activity measures of the individual product should make up the total activity.

So for activities it must be possible to separate them into elements corresponding to a product. When they are summed up, they have to result in the total activity.

These conditions ensure that all activities are considered and there is no shortfall or excess of activity in calculation.

Additional to these two necessary conditions, there is another condition which has not to be met exactly. The last condition of Noreen (1991:164) implies that the cost in each cost pool must be strictly proportional to the level of activity in that cost pool. When this condition is not met and costs are not strictly variable at the level of the cost pool, they should be excluded from the allocations and handled in some other manner.

This condition is not a must be met condition and therefore allows exceptions. When the cost in the cost pool is not proportional to the level of activity it could be handled in another costing system

So there are 3 conditions, whereof two must be fulfilled and one which permits alternatives if not met.

"In sum, the conditions required for ABC systems to accurately reflect avoidable product costs and incremental activity cost are quite strong. Only those costs whose behavior more or less conform to the necessary and sufficient conditions should be allocated using ABC methods."

Noreen (1991:164)

This compendium of the conditions confirms that these conditions are hard to met. Only the costs which meet these conditions should be allocated in the ABC system. The costs that don't match these conditions should be handled in other ways.

j

4 Component commonality in an activity based costing environment

Component commonality probably benefits from activity based costing, as costs are displayed more precisely. Labro (2004) provides a model which is based on activity based costing. The aim is to minimize total cost of production and overhead costs. Therefore the production costs and the overhead costs are considered.

The paper builds up in big parts on other papers, Labro (2004:359) explains that the paper reviews component commonality literature with focus on the cost effects of using the same version of a component at multiple products. This is done through a management-accounting lens and most of the considered literature is theoretical. While most papers express that with component commonality the costs will decrease, a review of the literature using an ABC framework concludes that the cost picture is more subtle. For specific costs there may be conflicting views on the sign of the effect.

So the referenced paper uses the knowledge of other papers and assembles their findings. The impact of component commonality is complex and results of the papers come to conflicting results. First an ABC framework is introduced and afterwards the ABC-hierarchies and the specific items are named.

The model

The paper doesn't provide a complete model. Instead, Labro (2004:360) provides the objective function for an optimization model with using an ABC-system. The model determines the optimal level of component commonality. The objective function is written as a summation of cost-rates multiplied by cost-driver use over all ABC hierarchical levels.

Objective function: $\min_N \sum_{j \in N} q_j * q_j + \sum_{l \in H} \sum_{c \in C_l} a_{cj} * d_{cj}$

Notation:

N set of components, index j

H set of hierarchical levels, index l

C_l set of activities performed on ABC hierarchical level l, index c

p_j price per unit of component j

q_j quantity of component j purchased in units

a_{cj} cost rate per activity c, which may depend on the choice of component j

d_{cj} cost-driver use expressed in units of activity c driver performed, which may depend on the choice of component j

So the objective function covers the direct production cost, displayed in the first term. The second term represents the impact of several activities on the overhead cost. The costs alter according to the chosen product configuration. The costs originate from different hierarchical levels. To show the cost effects, Labro (2004:360) defines an ABC-system with 5 levels: supplier (s), component (i), order (o), batch (b), and unit (u) level. When cost becomes variable can be derived from the hierarchical level at which a cost is classified.

The variation in cost for a specific level is explained with examples, so Labro (2004:360) mentions, that the selection of a supplier results in a cost-driver use on supplier level. Cost on supplier level may include negotiating and managing costs. These costs do not occur when no supplier is selected. Related to the hierarchy of ABC, costs for selecting a supplier are variable on the supplier level.

For each of the mentioned level in the ABC hierarchy Labro (2004:360) provides examples:

Level	**Cost driver**	**Example**
Supplier	Selection of a supplier,	managing cost, negotiation cost
Component	Selection of a component	Component specific R&D, component specification, component testing
Order	Placing an order	Ordering and invoicing costs
Batch	Batch is delivered	Inspection and setup costs
Unit	Unit	Price, inventory holding costs

Built up on this table it is visible how costs behaviour. Labro (2004:360f) explains, that several activities on each level are performed. The costs occurred each are derived by multiplying the cost-driver usage with the cost rate. At the batch level, total setup costs are derived by multiplying the number of setups with the cost rate for setups.

Nevertheless that there is a lot of critics to activity based costing, Labro (2004:361) argues that using ABC is a leap forward, because the linearity of the cost function delivered better approximations compared to volume-related approaches. ABC requires the assumption of linearity to hold on each hierarchical level. So costs should behave in a linear way accordingly to the cost driver for the specific level.

So the model is introduced and the background is described. The characteristics of the model are highlighted and the ABC hierarchies are established and explained.

4.1 Cost effects identified in literature

Additionally to providing an objective function which minimizes the costs of production at component commonality and defining an ABC hierarchy, Labro (2004) did some research what are the effect of increasing component commonality to the specific levels.
Labro (2004:361) summarized the results in a table and within each hierarchical level distinguished between the effects on cost rate a_{cj} and on cost driver use d_{cj}.

Commonality increase	**Driver**	**Cost-rate** a_{cj}	**Driver use** d_{cj}
Supplier level(s)	Number of suppliers	Increase	Decrease
Component level (i)	Number of components	Increase	Decrease
Order level (o)	Number of orders	Constant	Decrease
Batch level (b)	Number of batches	Increase or decrease	Decrease
Unit level (u)			
Price	Number of units bought	Increase or decrease	Constant or increase
Inventory holding	Number of units held in inventory	Increase or decrease	Decrease
Backlog	Number of backlog orders	Constant	Decrease

Labro (2004:360)

This table expands the former mentioned ABC hierarchies and adds additional information. The cost driver is explicit mentioned and the effect of component commonality on the cost-rate and on the driver use is announced. The results show that the impact on total costs can go several ways. Most cost rates will increase and most driver usages will decrease. On some hierarchical levels the effect is ambiguous. As the result of cost-rate and driver use make up the resulting costs, the changes in the costs will depend on how much the specific values increase or decrease.

5 Trade-off between revenue and cost

When considering component commonality, the impact on revenue and cost will determine the decision to use a common component. In their paper, Desai et al. (2001) developed a model that considers revenue side as well as cost side. The model cares about product differentiation, prices which could be charged to the consumers and the optimal design effort. Some assumptions are made in the model, so it rests on the assumption that the quality of the components is predetermined. Desai et al. (2001:39) mention this assumption and explain that the main decision is about making a component common between different products. If there is a favour for a common component the model has to support the selection of the component.
In order to make a valid decision the model covers plenty aspects of marketing and production view. Therefore it takes care of the consumers, the products, the product configuration and the manufacturing and design costs. All of them are represented in the model.

5.1 Determinants of the model

5.1.1 Consumers

The behaviours of the consumers determine the demand side of the market. The amounts sold in the market and the charged prices determine the revenues of the manufacturer. In their model Desai et al. (2001:40) assume two market segments, a high-valuation(H) and a low-valuation(L) market-segment. The utility of a consumer is derived with the equation $U_i = \theta_i * q - p$. The consumer utility from a product is represented by U_i. The subscript i is an index for the segment i, which can be the high- or low-valuation segment (i=H,L). As commonly used, p represents the price and q stands for the quality. The variable $\theta_i (\theta_H > \theta_L)$ stands for the consumers marginal valuation per unit quality. $\theta_i * p$ represents the reservation price of the consumers. The utility function reveals that the price for the product has to be below this reservation price, so that the consumer will have an utility from purchasing the product.
So the utility function of the consumers determines the price the consumers are willing to pay for a specific product quality. As the variable θ_i is determined by the consumer, the

manufacturer can influence the other relative variables. Desai et al. (2001:40) mention that the price p is determined by the manufacturer and individual for each product. As there are two segments, their utility functions differ and so the consumers of the high-valuation segment are willing to pay $\theta_H * p$ for a high-quality product with the relevant quality q. For this mentioned product with a high-quality, consumers of the low-valuation segment are willing to pay $\theta_L * q(\theta_L > \theta_H)$.

When the numbers of the market segments are summed up, they make up the total market size. Desai et al (2001:40) specifies that the number of consumers is represented by n. The fraction of consumers in a market segment(i) is represented by r_i. Both segments summed-up have to represent the total market, $r_H + r_L = 1$. For each segment the manufacturer provides a specific product with an appropriate quality. As the consumers can self-select which product they purchase, they can buy both products and not only the product designed for their segment. For the manufacturer this raises the challenge to choose a product configuration and equivalent prices, so that the consumers will buy the product aimed for their own segment.

The consumer section reveals that there are a lot of challenges for the manufacturer on the consumer-side. Consumer segments and their utility function, product configuration and prices have to be considered, so that the consumers will buy the product aimed for them.

5.1.2 Products

The former section showed that there are two market segments and for each specific segment there has to be a product with an appropriate quality. Desai et al. (2001:40) determines that each product consists of two components, named A and B. The quality q of the product is determined by the quality of those components. The quality of the components is predetermined and they can be premium(p) or basic(b) level. The quality of a product depends also on the importance weight w_i of the relevant component A or B. The overall product quality is derived with the equation $q = \omega_A * q_A + \omega_B * q_B$. q_A and q_B represent the quality of the component and is either premium or basic.
As it is the aim of the model to deal with the trade-off between making a component common or not, there is an additional assumption in the model. Desai et al. (2001:40) explain that there are attributes, which are easier to be adapted to be common than others. For the model they

raise the assumption that component A can be made common across two products while this doesn't hold for component B which has to be unique.

This section showed that the quality of a product is derived from the specific quality of the two assembled components and their importance weight. Quality of the components is predetermined. For further processing it is assumed that only component A can be made common across different products.

5.1.3 Product configuration

As the product quality is determined by the assembled components and each component can be premium or basic quality, there are some feasible product configurations. Desai et al. (2001:40f) mentions that four overall quality levels are possible. These qualities are denoted by the component quality as $q^{i,i}$, where superscript i=p(premium) or b(basic). So the possible product qualities are $q^{b,b}, q^{b,p}, q^{p,b}, q^{p,p}$. As previous mentioned, component B can't be made common and the premium quality component is offered only to the high-valuation segment and the basic quality component is offered only to the low-valuation segment. This leads to the fact that there are only three possible configurations.

1. Unique configuration: The products are assembled with the components designed for the specific segment. So the configuration can be $q^{b,b}$ or $q^{p,p}$. The product aimed for the high-valuation segment is assembled only with premium components, while the product aimed for the low-valuation segment is assembled only with basic components.
2. Premium common: Component A is in every configuration the premium component. Component B is different for each product. This holds for the product aimed for the high-valuation segments, as well as for the product aimed for the low-valuation segment. The respective configurations are $q^{p,p}$ or $q^{p,b}$.
3. Basic common. Component A is in every configuration the basic component. Component B is different for each product. This holds for the product aimed for the high-valuation segments, as well as for the product aimed for the low-valuation segment. The respective configurations are $q^{b,b}$ or. $q^{b,p}$

Table 1 Details of Configurations

Product Details		Unique	Premium-Common	Basic-Common
Product for *H* segment	Component A	Premium (q_A^p)	Premium (q_A^p)	Basic (q_A^b)
	Component B	Premium (q_B^p)	Premium (q_B^p)	Premium (q_B^p)
	Overall Quality	$q^{p,p}$	$q^{p,p}$	$q^{b,p}$
	Optimal Price	$\dot{p}^{p,p}$	$\ddot{p}^{p,p}$	$\dddot{p}^{b,p}$
Product for *L* segment	Component A	Basic (q_A^b)	Premium (q_A^p)	Basic (q_A^b)
	Component B	Basic (q_B^b)	Basic (q_B^b)	Basic (q_B^b)
	Quality	$q^{b,b}$	$q^{p,b}$	$q^{b,b}$
	Optimal Price	$\dot{p}^{b,b}$	$\ddot{p}^{p,b}$	$\dddot{p}^{b,b}$

figure 1 Desai et al. (2001:41)

The product configuration gives an idea how component commonality could appear and provides the basis for further analysis.

5.1.4 Manufacturing and design costs

The market for the products and the requirements of the customers are already mentioned. Subsequent manufacturing and design costs are described.

As it is the aim to handle the trade-offs of component commonality, the costs of manufacturing have to be revealed. In this context, design effort has the power to change unit cost. Desai et al. (2001:41) considers the costs to be associated at the component level. They use the notation q_j^i, where subscript j(j=A or B) means the component and the superscript i (i= p or b) means the quality level of the component. The costs are assumed to be convex which is consistent with a large literature in economics. The cost coefficient is noted as k_j and recognizes differences in cost of producing unit quality across components. They assume the manufacturing costs for one unit of a component j(j= A or B) with quality i as $k_j\left(q_j^j\right)^2$. It is possible to reduce manufacturing cost with some investment in design effort. The design investment improves process efficiency and causes a proportional reduction in unit manufacturing cost. The design investment affects only manufacturing costs and has no influence on component quality. The design effort for a component j is noted as e_j. A design effort of e_j leads to a reduction of the manufacturing costs of $\sqrt{e_j}$. The manufacturing costs of component j with design effort of e_{jj} is stated as $c_j = k_j\left(q_j^i\right)^2 - \sqrt{e_j}$. The marginal cost to produce a product is the sum of the marginal costs of its components. The fixed costs are noted by F.

With manufacturing costs per component, the knowledge to calculate the costs for a product is revealed.

5.2 Analysis

With the information of the previous chapters, all necessary information about market information, product configuration and manufacturing costs are revealed. Based on this, subsequent the analysis of the trade-off for different configurations will be discussed.
For the analysis, Desai et al. (2001) stated an objective function which aims to maximize the profit under the consideration of some constraints.
Desai et al. (2001:40) analyzes the relative profitability of the 3 mentioned configurations. In order to do this, the manufacturers' maximization problem is characterized and the optimal solution is derived. After the optimal profit under each configuration is calculated, the profitability of each configuration is compared with the unique solution.
For the analysis the notation mentioned in the previous chapters is used. It starts with the unique configuration case, continued with the premium common case and finished with the basic common case.

5.2.1 Unique configuration

In the first case, at unique configuration no component commonality appears. This case is analysed in order to have a reference case to discover if component commonality results in benefits for the manufacturer. Desai et al. (2001:42) repeats that the products do not share a common component. Product qualities are derived with the provided formula: $q = \omega_A * q_A + \omega_B * q_B$. So the maximization problem is derived with:

max: $n * r_H \left(p^{p,p,} - c^{p,p} \right) + n * r_L \left(p^{b,b} - c^{b,b} \right) - e_A^p - e_B^p - e_A^b - e_B^b - F$ (1)

s.t. $\theta_H q^{p,p} - p^{p,p} \geq \theta_H q^{b,b} - p^{b,b}$ (2)

$\theta_L * q^{b,b} - p^{b,b} \geq \theta_L q^{p,p} - p^{p,p}$ (3)

$\theta_H q^{p,p} - p^{p,p} \geq 0$ (4)

$\theta_L * q^{b,b} - p^{b,b} \geq 0$ (5)

Each of the equations contributes to the consistency of the model.

"The firm's profit function is as given in (1). Constraints (2) and (3) ensure each segment prefers to buy the product meant for it rather than the product meant for the other segment. Constraints (4) and (5) ensure that each consumer gets nonnegative utility from his or her purchase." Desai et al. (2001:42)

Subsequent the consistency of the model is discussed and therefore Desai et al. (2001:42) explains, that there is no incentive for the low-valuation segment to purchase the high-quality product. So the manufacturer should price the product equal to the product valuation of the low-valuation segment. $\dot{p}^{b,b} = \theta_L q^{b,b} = \theta_L(\omega_A * q_A + \omega_B * q_B)$

Furthermore, Desai et al. (2001:42) states, that the high-valuation segment receives a utility of $(\theta_H - \theta_L)\dot{p}^{b,b} \geq 0$ from the low-quality product. When the price for the high-quality product is $\dot{p}^{p,p} = \theta_H * \dot{q}^{p,p}$, there is zero utility for the high-valuation segment from purchasing the premium product, but a positive utility from low-quality product. So they would purchase the low-quality product. To avoid cannibalization, the manufacturer sets the price $\dot{p}^{p,p}$ so that the high-valuation segment gets the equal utility from purchasing either of the products.

$$\theta_H q^{p,p} - p^{p,p} = \theta_H q^{b,b} - p^{b,b}$$

$$p^{p,p} = \theta_H\left(\omega_A * \left(q_A^p - q_A^b\right) + \omega_B * \left(q_B^p - q_B^b\right)\right) + \theta_L\left(\omega_A * q_A^b + \omega_B * q_B^b\right)$$

The first order condition solved for the design effort derives:

$\dot{e}_j^p = \left(\frac{n r_H}{2}\right)^2$ and $\dot{e}_j^b = \left(\frac{n r_L}{2}\right)^2$ for j=A,B

So these are the results for the unique configuration. The constraints for price-setting were investigated and the optimal design effort for the components is portrayed.

The chapter product configuration showed that there are 3 possible configurations. As the unique configuration is deconstructed already, both other configurations which use component commonality will be deconstructed subsequent.

5.2.2 Premium-common configuration

Now the model deals with component commonality, starting with a premium-common configuration. Desai et al. (2001:42) repeats that in this case component A is common for both products and furthermore the common component is the premium component.

Component B is specific to the customer segment, so for the product for high-valuation it is the premium level component and for the low-valuation segment product it is the basic level component. This lead to the following product qualities:

high-valuation product: $q^{p,p} = \omega_A * q_A^p + \omega_B * q_B^p$

low-valuation product: $q^{p,b} = \omega_A * q_A^p + \omega_B * q_B^b$

These equations show that both products use for component A the premium component. Therefore the quality of the product for the low-valuation segment increases. This has an impact on the perception of the customers.

Desai et al. (2001:43) writes the maximization problem as follows:

max: $n * r_H \left(p^{p,p,} - c^{p,p} \right) + n * r_L \left(p^{p,b,} - c^{p,b} \right) - e_A^p - e_B^p - e_B^b - F$

s.t. $\theta_H q^{p,p} - p^{p,p} \geq \theta_H q^{p,b} - p^{p,b}$

$\theta_L * q^{p,b} - p^{p,b} \geq \theta_L q^{p,p} - p^{p,p}$

$\theta_H q^{p,p} - p^{p,p} \geq 0$

$\theta_L * q^{p,b} - p^{p,b} \geq 0$

It is visible, that the impact of the component commonality on the maximization problem is a change in the cost function, because there is only a need for design effort for three components. The change in quality of the product for the low-valuation segment can be seen in the constraints and also in the maximization problem in the cost for this product.

Desai et al. (2001:43) recalls that the price of the low quality product is set to make the low-valuation segment indifferent between buying the low-quality product and not buying any product. $\ddot{p}^{p,b} = \theta_L q^{p,b} = \theta_L \left(\omega_A * q_A^p + \omega_B * q_B^b \right)$

Now that the price for the low-valuation segment is clarified, the price for the high-valuation segments has to be arranged. Desai et al. (2001:43) recall that an incentive for the high-valuation segment is needed so that they buy the premium product. This is achieved, by setting the price for their product so that they are indifferent between purchasing the high- and the low-quality products.

$$\ddot{p}^{p,p} = \theta_H \left(q^{p,p} - q^{p,b} \right) + \theta_L q^{p,b}$$

$$\ddot{p}^{p,p} = \theta_H \left(\omega_B * q_B^p - \omega_B * q_B^b \right) + \theta_L \left(\omega_A * q_A^p + \omega_B * q_B^b \right)$$

The first order condition solved for the design effort derives:

$\ddot{e}_A^p = \left(\frac{n}{2}\right)^2$, $\ddot{e}_B^p = \left(\frac{n r_H}{2}\right)^2$ and $\ddot{e}_B^b = \left(\frac{n r_L}{2}\right)^2$

This common component case revealed that the design effort for the common component will be higher, compared to a case when the products are constructed with unique components. Total sum of design effort will remain the same, but the distribution is different.

The price set for the low-quality segment will increase compared to the common case, because the provided quality is higher and therefore the utility of the customers enables to charge higher prices.

So the case for the premium common configuration is derived. The differences to the unique case are obvious and influence the prices for the products, as well as their costs, design effort and qualities.

5.2.3 Basic-common configuration

Now the common component is located on the basic level. Desai et al. (2001:43) state that component A is the common component and being basic quality level. Component B is premium quality for the high-valuation segment and basic quality for the low-valuation segment. This lead to the following product qualities:

high-valuation product: $q^{b,p} = \omega_A * q_A^b + \omega_B * q_B^p$

low-valuation product: $q^{b,b} = \omega_A * q_A^b + \omega_B * q_B^b$

Desai et al. (2001:43) writes the maximization problem as follows:

max: $n * r_H\left(p^{b,p,} - c^{b,p}\right) + n * r_L\left(p^{b,b,} - c^{b,b}\right) - e_A^b - e_B^p - e_B^b - F$

s.t. $\theta_H q^{b,p} - p^{b,p} \geq \theta_H q^{b,b} - p^{b,b}$

$\theta_L * q^{b,b} - p^{b,b} \geq \theta_L q^{b,p} - p^{b,p}$

$\theta_H q^{b,p} - p^{b,p} \geq 0$

$\theta_L * q^{b,b} - p^{b,b} \geq 0$

The configuration with basic common compared to premium common leads to changes in the whole model. The objective function as well as all constraints differs due to the different configuration.

According to Desai et al. (2001:43) the price for the low valuation segment will be set to $\dddot{p}^{b,b} = \theta_L q^{b,b} = \theta_L \left(\omega_A * q_A^b + \omega_B * q_B^b \right)$

As the quality in this configuration is equal to the unique case, the price will be the same.

Regarding the product for the high-valuation segment, Desai et al. (2001:43) recalls that the customers have to be indifferent between purchasing the high- and the low-quality product. This leads to a price setting equation:

$$\dddot{p}^{b,p} = \theta_H \left(q^{b,p} - q^{b,b} \right) + \theta_L q^{b,b}$$

$$\dddot{p}^{b,p} = \theta_H \left(\omega_B * q_B^p - \omega_B * q_B^b \right) + \theta_L \left(\omega_A * q_A^b + \omega_B * q_B^b \right)$$

The first order condition solved for the design effort derives:

$\dddot{e}_A^b = \left(\frac{n}{2} \right)^2$, $\ddot{e}_B^p = \left(\frac{n r_H}{2} \right)^2$ and $\ddot{e}_B^b = \left(\frac{n r_L}{2} \right)^2$

Again we see that for the common component the optimal design effort is different than in the unique case. Similar to the premium common case, the design effort for the common component is $\dddot{e}_A^b = \left(\frac{n}{2} \right)^2$. The price for the low-valuation product will be equal to the unique case, but the price for the premium product will be lower, due to the reduced quality.

In both common component configurations, the design effort for the common component is higher than in the unique case. Prices for the products change similar to the changes in product quality. So the use of a common component will clearly influence the revenue of the firm. Manufacturing costs will differ according to the used components

6 The combined model

Both models provide valuable information regarding component commonality. Desai et al. (2001) provide a complete and consistent model that enables to calculate an optimal solution. However, cost side deals only with design effort and direct manufacturing cost. All other costs are considered as fixed costs. The model of Labro (2004) provides an objective function which aims to minimize costs. Under assumption of activity based costing, cost data is provided more accurate and enables to control costs more detailed.

Based on the previous chapters which revealed how the models work, this chapter will bring them together in order to benefit from their advantages. The model of Desai et al. (2001) builds the main part of the combined model. The representation of the costs benefit from Labros (2004) model and will be handled more detailed.

6.1 Reasons for the selected models

Desai et al.(2001)

The selection of this model results from the fact that it delivers an operating model without unnecessary complexity. The model focuses on the trade-off between revenue and costs.

It covers many topics, so cost and revenues are considered, market size and market segmentation are involved. The quality of the components influence production costs, product quality and consequential achievable prices. Many aspects of the model like product qualities are predetermined in order to keep it as simple as possible. All this is done within a monopolistic setting.

Additionally there are many papers referring to the mentioned model. For instance Heese and Swaminathan (2006:207f) allude to Desai et al. (2001) and mention many analogies between both models regarding handling of valuation changes or research focus.

So by using the respective model of Desai et al. (2001) there are many possibilities for further development based upon the combined model.

Labro (2004)

The selection of the model of Labro (2004) is mainly influenced by the selection of the model of Desai et al. (2001). With the provided objective function Labro (2004) delivers a fundamental expansion to the reference model. It integrates the model of Desai et al. (2001)

into an activity based costing environment and therefore upgrades the ability to balance revenue and cost drivers.

So both models benefit from each other. While Desai et al. (2001) deliver an operating model, it benefits from Labro (2004) because it adds more information to the cost side.

6.2 Adjustments

In order to integrate the result from Labro (2004) into the model of Desai et al. (2001), there are some necessary alignments and notation has to be reviewed. The aim is to make Desai et al.'s (2001) model consistent with ABC costing.

Objective functions:

Labro (2004): $\min_{N} \sum_{j \in N} q_j * q_j + \sum_{l \in H} \sum_{c \in C_l} a_{cj} * d_{cj}$

Desai et al. (2001): $n * r_H \left(p^{p,p,} - c^{p,p} \right) + n * r_L \left(p^{b,b,} - c^{b,b} \right) - e_A^p - e_B^p - e_A^b - e_B^b - F$

The objective function of Labro (2004) has to be implemented into the model of Desai et al.(2001). They seek to maximize profit, whereas Labro (2004) aims to minimize costs. The structure of the model of Desai et al. (2001) is to calculate profit by computation the revenues and subtracting the costs, the costs for the hierarchical levels at Labro (2004) $\sum_{l \in H} \sum_{c \in C_l} a_{cj} * d_{cj}$ will substitute the design effort Desai et al.'s (2001) model. This is valid, because design effort will be represented as an ABC hierarchy.

The costs to produce the products and their sold quantity is displayed at Labro (2004) as $\sum_{j \in N} q_j * q_j$. Desai et al. (2001) consider this information in the objective function by $n * r_H \left(p^{p,p,} - c^{p,p} \right) + n * r_L \left(p^{b,b,} - c^{b,b} \right)$. Here the information of the costs to produce the goods is integrated. For a better view it could be separated into $n * r_H * p^{p,p,} - n * r_H * c^{p,p,} + n * r_L * p^{b,b,} - n * r_L * c^{b,b,}$ and with further rearrangement $n * r_H * p^{p,p,} + n * r_L * p^{b,b,} - n * r_H * c^{p,p,} - n * r_L * c^{b,b,}$.

So to increase profit the costs have to be minimized, or the revenues have to be increased.

Number of customers/ market size

At the function of Desai et al. (2001) it is obvious, that the total number of customers' n only appears in combination with the fraction for a specific segment n^*r_H and n^*r_L.

In order to simplify the model without loss of any information this can be also written as $m_H = n^*r_H$ for the high valuation segment and $m_L = n^*r_L$ for the low-valuation segment, with m_i representing the number of customers in a market segment and i is the index for the market segment. Total market size is represented with m .

Consumers, products and product configuration remain the same.

Cost/ Design effort

The display of the cost side has to differ in order to be consistent with the notation of the combined model.

The cost in the model of Desai et al. (2001) consists of design effort noted with e_j and leads to a reduction in the unit costs: $c_j = k_j\left(q_j^i\right)^2 - \sqrt{e_j}$. The design effort of Desai et al. (2001) can be modelled as a cost driver in Labro's (2004) model. The design effort will be located on the component level of the ABC hierarchy. As mentioned in the Labro (2004) chapter, component specific R&D is located on component level. While the design effort at Desai et al. (2001) is represented with e_j, in the combined model it will be displayed as cost driver usage d_{cj}. Subsequent the new function for the unit costs is written as : $c_j = k_j\left(q_j^i\right)^2 - \sqrt{d_{cj}}$

The assumption that design effort doesn't influence product quality is still valid and therefore it won't be any influence on the revenues. However, the profit will be affected by the manufacturing costs and the overhead costs.

Design effort will continue as a hierarchy in the ABC system. For the costs the representation in the objective function will be: $\sum_{l \in H} \sum_{c \in C_l} a_{cj} * d_{cj}$

Fixed costs

Desai et al. (2001) note the Fixed costs as F. The new model provides more accurate cost information and so this notation has be differed. Now that more detailed information of the cost side is available some of these costs will be manipulable and represented in the ABC hierarchies. The new notation for the remaining fixed costs will be Fx.

New objective function:

For the analysis this would result in a new objective function:

Unique configuration case:

$$\max m_H\left(p^{p,p,}-c^{p,p}\right)+m_L\left(p^{b,b,}-c^{b,b}\right)-\sum_{l\in H}\sum_{c\in C_l}a_{cj}*d_{cj}-Fx$$

Premium-common configuration case:

$$\max m_H\left(p^{p,p,}-c^{p,p}\right)+m_L\left(p^{p,b,}-c^{p,b}\right)-\sum_{l\in H}\sum_{c\in C_l}a_{cj}*d_{cj}-Fx$$

Basic-common configuration case:

$$\max m_H\left(p^{b,p,}-c^{b,p}\right)+m_L\left(p^{b,b,}-c^{b,b}\right)-\sum_{l\in H}\sum_{c\in C_l}a_{cj}*d_{cj}-Fx$$

Design effort

The optimal design effort is derived by solving the first order condition of the objective function for the design effort.

Unique configuration:

$\dot{d}_{cj}^{p}=\left(\frac{m_H}{2}\right)^2$ and $\dot{d}_{cj}^{b}=\left(\frac{m_L}{2}\right)^2$ for j=A,B

Premium-common configuration:

$\ddot{d}_{cA}^{p}=\left(\frac{m}{2}\right)^2$, $\ddot{d}_{cB}^{p}=\left(\frac{m_H}{2}\right)^2$ and $\ddot{d}_{cB}^{b}=\left(\frac{m_L}{2}\right)^2$

Basic-common configuration:

$\dddot{d}_{cA}^{b}=\left(\frac{m}{2}\right)^2$, $\ddot{d}_{cB}^{p}=\left(\frac{m_H}{2}\right)^2$ and $\ddot{d}_{cB}^{b}=\left(\frac{m_L}{2}\right)^2$

ABC hierarchies

All costs which are not considered as fixed costs are located on an ABC hierarchy.

Design effort:

As mentioned before, design effort is located on component level, due to the fact that design effort is clearly related to the components.

Setup-costs

Setup-costs are located on batch-level, as Labro (2004:364) locates it also on batch-level.

Expectations for the behaviour of cost-rate and driver-use:

Formerly the results of Labro's (2004) research were displayed in a table, which revealed the ABC-hierarchy and corresponding cost-driver, cost-rate and driver-use. It showed how cost-rate and driver use will behaviour if component commonality is applied.

Therefore according to Labro (2004:362) the following is expected:

- Design effort: As design effort is located on component level, the cost-rate is expected to increase, while the driver use will decrease.
- Setup-costs: For the batch-level, the behaviour of the cost rate is ambiguous and could increase or decrease. For the driver-use, it is expected to decrease.

So it is shown, that both original models fit together. The combined model is introduced with the relevant notation and functions are derived. The corresponding ABC-hierarchies are mentioned and the expected behaviour of them is stated.

7 Example

While the previous chapter revealed the theoretical function of the model, in this chapter an example will be presented, in order to prove that it performs well. Based on the results of the model, the manufacturer has to make a design decision. This decision is located at the strategic level of activity based management, as design decisions are made on this level. The developed model provides more relevant information for decision making. This example will show that the additional information in the new model can make a difference at the decision to prefer unique components or component commonality.

As it is a model, it is only a pre-calculation of planned actions. So it is possible that in reality the whole thing works out differently than expected by the model. To avoid deviances between model and reality, the calculation should include as much information as possible.

In the first stage the example is calculated according to the rules of Desai et al.'s (2001) model dealing with revenue and cost. The calculation will be performed for the unique case, so to have a basis of comparison. Afterwards a premium common case and basic common case are calculated. Both cases are considered, in order to show which is more beneficial.

In the second stage, the identical numbers will be applied to the new combined model. The results will show how the information's added by the activity based costing system can lead to a different decision.

7.1 Assumption of the example.

The major assumption in the example concerns the fixed costs. In the model dealing with the trade-off between revenue and cost they are assumed to be fixed costs. In lack of an adequate costing system there is no detailed information about them and they seem to be truly fixed.

For the new combined model things are different. The activity based costing system permits to see more aspects of the costs and that some costs turn out to be variable. These costs can have the power to alter the decision of the manufacturer.

The change in cost would also occur at the model of Desai et al. (2001). In their model it would not be considered for the decision and therefore could lead to an inappropriate decision. The cost reduction would become visible earliest after the decision is made and implemented.

Parts of the fixed costs can become variable if the number of components alters. This happens for set up costs. Supposed the manufacturer always used 2 unique components to produce the 2 products, so in total 4 components. These costs are not related to volume, they occur when the production switches from one component to another, so these costs develop based on activities. When the manufacturer never altered the number of components, he probably doesn't have the information that these costs are variable. This information would be revealed with an activity based costing system.

By introducing the paper of Labro (2004), it was mentioned, that in case of component commonality most cost-rates increase and most driver usages will decrease. In this example the cost-rate for Setup-costs are assumed to be constant, while the driver usage will decrease in case of component commonality.

7.2 Numbers

This section shows the number used for the calculation of the models. The meaning of the variables was already explained in the Chapter "Trade-off between revenue and cost ". The numbers applied in the example are:

n=100

r_H=0,7

r_L=0,3

k_A^b	2	q_A^b	8	ϖ_A	0,3
k_B^b	3	q_B^b	8	ϖ_B	0,7
k_A^p	3	q_A^p	16	θ_b	400
k_B^p	4	q_B^p	16	θ_p	800

With all mentioned assumptions and populated numbers the calculation for the models can start.

7.3 Trade-off revenue and cost

In the first stage the numbers are applied to the model considering revenue and cost. Therefore the fixed costs are assumed to be 400.000.

7.3.1 Unique configuration

Calculation starts with the unique configuration, in order to have a basis for comparison. Product quality is derived with the quality of the components multiplied with the importance weight of the components. $q = \omega_A * q_A + \omega_B * q_B$

So the model receives a quality of $q^{b,b}$ =0,3*8+0,7*8=8 for the basic product and a quality of $q^{p,p}$ =0,3*16+0,7*16=16 for the premium product.

With the product quality it is possible to calculate the price for the product. For that purpose, Desai et al. (2001:42) provide the formula $\dot{p}^{b,b} = \theta_L q^{b,b} = \theta_L(\omega_A * q_A + \omega_B * q_B)$. So for the basic product the optimal price is received with $\dot{p}^{b,b}$ = 400*8=3.200.

To prevent the high-valuation segment from buying the basic product, the price must be set accordingly. They must receive a positive utility from the premium product. Therefore, Desai et al. (2001:42) provides the formula: $p^{p,p} = \theta_H\left(\omega_A * \left(q_A^p - q_A^b\right) + \omega_B * \left(q_B^p - q_B^b\right)\right) + \theta_L\left(\omega_A * q_A^b + \omega_B * q_B^b\right)$.

By inserting the numbers of the example in this formula the price for the premium product is derived with $p^{p,p}$ =800*(0,3*(16-8)+0,7(16-8))+400*(0,3*8+0,7*8)=9.600.

So the price for the product is set with the given numbers. Therefore on the revenue side all relevant numbers are derived. On the cost side the costs of the products have to be balanced with the design effort. For the optimal design effort, Desai et al. (2001:42) solved the first order condition for the design effort and received for the components j=A,B $\dot{e}_j^b = \left(\frac{n r_L}{2}\right)^2$ for the basic product and $\dot{e}_j^p = \left(\frac{n r_H}{2}\right)^2$ for the components of the premium product. Merged with the numbers of this example, the optimal design effort for the components of the basic product is

$\dot{e}_j^b = \left(\frac{100*0,7}{2}\right)^2 = \dot{e}_j^b$ =1.225 and for the components of the premium product $\dot{e}_j^p = \left(\frac{100*0,3}{2}\right)^2 = \dot{e}_j^p =$ 225.

The unit costs are derived with $c_j = k_j\left(q_j^i\right)^2 - \sqrt{e_j}$ (Desai et. al., 2001:41).

So the model delivers $c_b = 2*(8)^2 - \sqrt{1.225} + 3*(8)^2 - \sqrt{1.225} = 250$ for the basic product and $c_b = 3*(16)^2 - \sqrt{225} + 4*(16)^2 - \sqrt{225} = 1.762$ for the premium product.

The table below gives a brief overview over the results

	Basic	Premium
product quality	$q^{b,b}$=8	$q^{p,p}$ =16
product price	$\dot{p}^{b,b}$= 3.200	$p^{p,p}$ =9.600
design effort	$\dot{e}_j^b$=1.225	$\dot{e}_j^p =$ 225
costs per product	c_b= 250	c_p =1.762

With the objective function provided by Desai et al. (2001:42): $n*r_H\left(p^{p,p,} - c^{p,p}\right) + n*r_L\left(p^{b,b,} - c^{b,b}\right) - e_A^p - e_B^p - e_A^b - e_B^b - F$ the profit is received. With the numbers of this example the profit is derived with 100*0,3*(9.600-1.762)+100*0,7*(3.200-250)-225-225-1.225-1.225-400.000=38.740

The results split up into details:

Revenue=$n*r_H*p^{p,p,} + n*r_L*p^{b,b,}$ =100*0,3*9.600+100*0,7*3.200=512.000

Manufacturing costs=$-n*r_H*c^{p,p} - n*r_L*c^{p,p}$ =-100*0,3*1.762-100*0,7*250=-70.360

Design effort: $-e_A^p - e_B^p - e_A^b - e_B^b$=-225-225-1.225-1.225=-2.900

Fixed Costs:-400.000

So the results for the unique configuration case are derived. To reveal if component commonality is an advantageous strategy the result for a common component scenario has to be calculated.

7.3.2 Premium-common configuration

The results of the unique configuration will be compared to a premium-common configuration. The numbers stay the same, the main difference is in the configuration of the products. This has an impact on every aspect of the model.

Product quality is still derived with the quality of the components multiplied with the importance weight of the components. At this point of the model the main difference occurs and has impact on every value which is based on the product or component quality. The premium component is used in both products and therefore leads to changes in the product quality of the low-valuation product.

Desai et al. (2001:42) mentions the formulas for the product quality

low-valuation product: $q^{p,b} = \omega_A * q_A^p + \omega_B * q_B^b$

high-valuation product: $q^{p,p} = \omega_A * q_A^p + \omega_B * q_B^p$

These formulas show clearly that the quality of the low-valuation product differs compared to the unique configuration. By inserting the numbers of the example, the derived values for the product quality are:

$q^{p,b} = \omega_A * q_A^p + \omega_B * q_B^b = 0{,}3 * 16 + 0{,}7 * 8 = 10{,}4$

$q^{p,p} = \omega_A * q_A^p + \omega_B * q_B^p = 0{,}3 * 16 + 0{,}7 * 16 = 16$

The overall product quality of the low-valuation product increased. This has an impact on many other parts of the model.

With the derived product quality the price for both products can be calculated. Desai et al. (2001:43) mentions for the low-valuation product $\ddot{p}^{p,b} = \theta_L q^{p,b} = \theta_L \left(\omega_A * q_A^p + \omega_B * q_B^b \right)$.

By inserting the numbers, the product price is $\ddot{p}^{p,b} = 400 * 10{,}4 = 4.160$

Even if the product quality of the high-valuation product remains the same in this premium common case, the price changes, because the trade-off with the low-valuation product is considered. Desai et al. (2001:43) provides the formula for the high-valuation product:

$\ddot{p}^{p,p} = \theta_H\left(q^{p,p} - q^{p,b}\right) + \theta_L q^{p,b}$, respectively $\ddot{p}^{p,p} = \theta_H\left(\omega_B * q_B^p - \omega_B * q_B^b\right) + \theta_L\left(\omega_A * p_A^p + \omega_B * p_B^b\right)$

The product price emerges to $p^{p,p}$ =800*0,7*(16-8)+400*(0,3*16+0,7*8)=8.640.
So the price for the high-valuation product decreases, despite the quality stays at the same level. The price is lower in order to prevent the high-valuation customers from buying the low-valuation product.

Now the revenue side is covered. Continuing with the cost side, some differences for the design effort will appear originating from the common component. Desai et al. (2001:43), solved the first order condition for the design effort:

$\ddot{e}_A^p = \left(\frac{n}{2}\right)^2$, $\ddot{e}_B^p = \left(\frac{n r_H}{2}\right)^2$ and $\ddot{e}_B^b = \left(\frac{n r_L}{2}\right)^2$

With inserted numbers the design effort for the components are:

common component: $\ddot{e}_A^p = \left(\frac{100}{2}\right)^2 = 2.500$

premium component: $\ddot{e}_B^p = \left(\frac{100*0,3}{2}\right)^2 = 225$

basic component: $\ddot{e}_B^b = \left(\frac{100*0,7}{2}\right)^2 = 1.225$

Now the unit cost for the products can be calculated similar to the unique configuration case, resulting in $c_b = 3*(16)^2 - \sqrt{2500} + 3*(8)^2 - \sqrt{1.225} = 875$ for the low-valuation product and $c_b = 3*(16)^2 - \sqrt{2500} + 4*(16)^2 - \sqrt{225} = 1.727$ for the high-valuation product:.

The table below gives a brief overview over the results

	Basic	Premium
product quality	$q^{p,b}$ =10,4	$q^{p,p}$ =16
product price	$\dot{p}^{p,b}$ = 4.160	$p^{p,p}$ =8.640
design effort	$\dot{e}_A^p =$ 2.500 $\dot{e}_B^b$=1.225	$\dot{e}_A^p =$ 2.500 $\dot{e}_B^p =$ 225
costs per product	c_b = 875	c_p =1.727

With the objective function provided by Desai et al. (2001:42): $n*r_H\left(p^{p,p,}-c^{p,p}\right)+n*r_L\left(p^{p,b,}-c^{p,b}\right)-e_A^p-e_B^p-e_B^b-F$ the profit is received. With the numbers of this example the profit is derived with 100*0,3*(8.640-1.727)+100*0,7*(4.160-875)-225-225-1.225-1.225-400.000=33.390

The results split up into details:

Revenue= $n*r_H*p^{p,p,}+n*r_L*p^{p,b,}$ ==100*0,3*8.640+100*0,7*4.160=550.400

Manufacturing costs= $-n*r_H*c^{p,p}-n*r_L*c^{p,b}$ =-100*0,3*1.727-100*0,7*875= -113.060

Design effort: $-e_A^p-e_B^p-e_A^b-e_B^b$=-2.500-225-1.225=-3.950

Fixed Costs:-400.000

7.3.3 Basic-common configuration

The calculation of the basic-common configuration is comparable to the premium-common case, with some differences in the formulas. The calculation is done in order to show differences to the unique configuration case and also to the premium-configuration case. Numbers for the calculation retain the same as in the unique-configuration case. The difference appears in the configuration, because the common component is the low-quality component. Component A remains as common component.

In the current case, the product quality is determined with the formula provided by Desai et al. (2001:43):

low-valuation product: $q^{b,b}=\omega_A*q_A^b+\omega_B*q_B^b$

high-valuation product: $q^{b,p}=\omega_A*q_A^b+\omega_B*q_B^p$

It appears that the low-valuation product is the same as in the unique configuration case, while the high-valuation product now uses the basic quality version of component A. This shows off in the calculation of overall product quality.

$$q^{b,b}=\omega_A*q_A^b+\omega_B*q_B^b=0{,}3*8+0{,}7*8=8$$

$$q^{b,p}=\omega_A*q_A^b+\omega_B*q_B^p=0{,}3*8+0{,}7*16=13{,}6$$

With the derived product quality the price for both products can be calculated.
Desai et al. (2001:43) mentions for the low-valuation product

$\dddot{p}^{b,b} = \theta_L q^{b,b} = \theta_L\left(\omega_A * q_A^b + \omega_B * q_B^b\right)$. By inserting the numbers the product price is $\dddot{p}^{b,b} = 40*8 = 3.200$

For the high-valuation product, Desai et al. (2001:43) provides the formula: $\ddot{p}^{b,p} = \theta_H\left(\dot{q}^{b,p} - q^{b,b}\right) + \theta_L q^{b,b}$, respectively $\dddot{p}^{b,p} = \theta_H\left(\omega_B * q_B^p - \omega_B * q_B^b\right) + \theta_L\left(\omega_A * p_A^b + \omega_B * p_B^b\right)$. The product price emerges to $p^{p,p}$ =800*0,7*(16-8)+400*(0,3*8+0,7*8)= 7.680

These are the results for the price calculation. The analysis continues with the cost side and starts with the design effort, where Desai et al. (2001:43), solved the first order condition for the design effort:

$\dddot{e}_A^b = \left(\frac{n}{2}\right)^2$, $\dddot{e}_B^p = \left(\frac{n r_H}{2}\right)^2$ and $\ddot{e}_B^b = \left(\frac{n r_L}{2}\right)^2$

These equations show the results:

common component: $\dddot{e}_A^b = \left(\frac{100}{2}\right)^2 = 2.500$

premium component: $\dddot{e}_B^p = \left(\frac{100*0,3}{2}\right)^2 = 225$

basic component: $\ddot{e}_B^b = \left(\frac{100*0,7}{2}\right)^2 = 1.225$

With the results for design effort, the unit cost for the products can be calculated, resulting in $c_b = 2*(8)^2 - \sqrt{2.500} + 3*(8)^2 - \sqrt{1.225} = 235$ for the low-valuation product and $c_b = 2*(8)^2 - \sqrt{2.500} + 4*(16)^2 - \sqrt{225} = 1.087$ for the high-valuation product.

The table below gives a brief overview over the results

	Basic	Premium
product quality	$q^{b,b}$=8	$q^{b,p}$=13,6
product price	$\dot{p}^{b,b}$=3.200	$p^{b,p}$=7.680
design effort	$\dot{e}_A^b$= 2.500 $\dot{e}_B^b$=1.225	$\dot{e}_A^b$= 2.500 $\dot{e}_B^p$= 225
costs per product	c_b=235	c_p=1.087

With the objective function provided by Desai et al. (2001:43): $n*r_H\left(p^{b,p,}-c^{b,p}\right)+n*r_L\left(p^{b,b,}-c^{b,b}\right)-e_A^b-e_B^p-e_B^b-F$ the profit is received. With the numbers of this example the profit is derived with 1.390.

100*0,3*(7.680-1.087)+100*0,7*(3.200-235)-225-225-1.225-1.225-400.000=1.390

The results split up into details:

Revenue= $n*r_H*p^{b,p,}+n*r_L*p^{b,b,}$ =100*0,3*7.680+100*0,7*3.200=454.400

manufacturing costs= $-n*r_H*c^{b,p}-n*r_L*c^{b,p}$ =-100*0,3*1.087-100*0,7*235= -49.060.

design effort: $-e_A^b-e_B^p-e_B^b$ =-2.500-225-1.225=-3.950

Fixed costs:-400.000

7.3.4 Comparison of results

Now that a unique configuration case and both common-component configuration case are calculated their results can be compared

	Unique configuration	Premium-common configuration	Basic-common configuration
Revenue	512.000	550.400	454.400
manufacturing costs	-70.360	-113.060	-49.060
design effort	-2.900	-3.950	-3.950
Fixed costs	-400.000	-400.000	-400.000
profit	38.740	33.390	1.390

<u>Revenue</u>

In the premium-common configuration case, the revenue increased, due to the price increase for the low-valuation product. This price increase is feasible, because the common component is the premium component and therefore the overall product quality is increased. The price for the high-valuation product is below the unique configuration case, in order to prevent the high-valuation customers from buying the low-valuation product. Because the low-valuation segment is much larger than the high-valuation segment, total revenue increases.

In the basic-common case, the revenue is below the unique- and the premium common case, due to the reduced quality of the high-valuation product. The reduced quality forces the manufacturer to reduce the price for this product, so to avoid that high-valuation customer's change to the low-valuation segment. So the decrease in revenue is caused by the lower product quality.

Manufacturing costs

The manufacturing costs in the premium common configuration is above the unique configuration case, due to the fact, that the common component is a premium component, where the quality is higher, the cost coefficient is higher. This leads to increasing manufacturing costs for the low-valuation product. Costs for the high-valuation product decreases slightly, originating from the cost function which rewards design effort. The design effort for the common component is higher because it is used in both products.

In the basic-common case, the manufacturing costs decrease, compared to both other cases, due to the fact that the common component is basic quality. This reduces the manufacturing costs for the high-valuation product. The individual unit costs are superior to both other cases. The manufacturing costs for the low-valuation product benefits from the increased design effort. While compared to the premium-common case the costs decline due to reduced overall quality.

Design effort

The total design effort increases in both cases of common configuration. For the product specific component B the design effort remains the same, while for the common component the design effort increased, because the cost function of both products benefit from this aspect.

Profit

Between unique configuration and premium-common case, the balance between gains in revenue and increase in costs is negative, resulting in a profit of 33.390 in the premium-common case, compared to 38.740 in the unique configuration.

Similar appears for the comparison of unique configuration and basic-common case, the balance between gains in revenue and increase in costs is negative, resulting in a profit of 1.390 in the basic-common case, compared to 38.740 in the unique configuration.

If component commonality must be applied, the premium-common configuration is preferred over the basic-common configuration

This example gives a clear picture of how component commonality works. The trade-offs at the revenue side and at the cost side have to be considered. The effect of component commonality can go both ways, and maybe result in an increase or decrease in profit. The impact of the component commonality depends on the numbers of the model parts. Therefore the numbers have to be calculated as precise as possible in order to stay close to the reality. By calculating the basic-common and the premium-common configuration, the differences in the bottom-line of these cases are revealed.

7.4 The combined model.

To show the benefits of the combined model, the numbers are applied to it. For all relevant cases the results will be derived and finally compared against the model considering only revenue and cost. As already mentioned, their model considers only direct manufacturing costs and design effort. All other costs are considered to be fixed. The model dealing with component commonality within an ABC environment was integrated into the model considering revenue and cost in order to benefit from a more detailed view on the costs.

The resulting objective function for the unique configuration was:

$$\max m_H\left(p^{p,p,}-c^{p,p}\right)+m_L\left(p^{b,b,}-c^{b,b}\right)-\sum_{l \text{€} H}\ \sum_{c \text{€} C_l} a_{cj} * d_{cj} - Fx$$

Setup costs

Basic assumptions for the numbers of the model remain the same. An additional assumption is made at the fixed costs. Because of the activity based costing system the information about the costs are more granular. The activity based costing system reveals that some parts of the fixed costs are variable and differ based on the number of setups executed.

Therefore out of the former fixed costs of 400.000, the amount of 200.000 is a now variable.

For these 200.00 the ABC hierarchy "Setup cost" is established

As the unique configuration case considered 4 components the Setup Costs are split up by this number.

To be consistent with the notation of the ABC framework of Labro (2004), the number of cost-drivers is 4. Total cost in the ABC hierarchy "Setup cost" is 200.000. The cost rate per setup is derived by dividing the total cost of the hierarchical level by the number of cost drivers. So the equation: 200.000/4=50.000 results in a cost rate per Set Up of 50.000.

So the numbers used to calculate the model is:
Fixed costs(Fx): 200.000

cost-rate per Setup(a_{cj}): 50.000

cost-driver d_{cj} = number of used components

Regarding the conditions of Noreen (1991) mentioned in a former chapter for ABC systems to provide relevant data for decision making, Setup costs greatly satisfy them. Setup costs can easily be separated into a particular cost pool and clearly distinguished from other costs. The performed activity can be partitioned into elements depending on a performed setup. So they easily can be summed up and certainly will make up total activity. Also the cost in that cost pool will be strictly proportional to the level of activity in that cost pool. Labro (2004:362) mentions that in case of component commonality the cost-rate for setups either increase or decreases.
For the example it is assumed that the cost-rate remains constant. Therefore Setup costs are a valid choice to prove the advantages of an ABC-system as in Labro's (2004) model and in the combined model.

Design effort
For the design effort the assumption is that one unit of the cost driver has a cost-rate of 1

cost-rate per Design effort(a_{cj}): 1

cost-driver d_{cj} = amount of design effort

7.4.1 Unique configuration

In the unique configuration case, the additional assumption that setup costs are variable has no impact on the bottom line. This originates from the fact, that 4 components are used and so the costs of the ABC hierarchy "Setup cost" will remain the same. The impact will appear in the distribution of the costs.
The values for market size, customer segments, quality of components, importance weight of the components, cost coefficient and marginal valuation of the consumer per unit of quality remain the same.

Accordingly, the results which are based on these factors are equal to the model considering revenue and cost calculated in the previous chapter. The cost function differs in notation and is written with $c_j = k_j (q_j^i)^2 - \sqrt{d_{cj}}$, but results remain the same.

So they are not calculated a second time, but mentioned again:

The table below gives a brief overview over the results

	Basic	Premium
product quality	$q^{p,b}$ =8	$q^{p,p}$ =16
product price	$p^{b,b}$ = 3.200	$p^{p,p}$ =9.600
design effort	e_j^b =1.225	e_j^p =225
costs per product	c_b = 250	c_p =1.762

Revenue is not influenced by the new objective function and again shows 512.000

Costs are calculated differently as they are now applied with an activity based costing system. Design effort is derived with Design effort will continue as a hierarchy in the ABC system. For the costs the representation in the objective function will be: $\sum_{l \in H} \sum_{c \in C_l} a_{cj} * d_{cj}$.

For the calculation this means that it is written as

Design effort: $-a * d_A^b - a * d_B^b - a * d_A^p - a * d_B^p$ =-1.225*1-1.225-1-225*1-225*1=-2.900

As manufacturing costs of the products remain the same, also total manufacturing costs remain the same and are derived with -70.360.

As in the model considering revenue and cost the fixed costs were assumed with 400.000, in the combined model the picture is more accurate.

The fixed costs are now 200.000.

The Setup costs are calculated separately. As there are 4 components in use, the total costs stay the same, but the distribution of the costs alters. The cost-driver is equal to the number of components and so used 4 times. As the cost-rate is 50.000 per Setup, the Setup costs result in 4*50.000 = 200.000

For the Profit this means that it will remain the same at 38.740, but calculation is more detailed:

100*0,3*(9.600-1.762)+100*0,7(3.200-250)-1*225-1*225-1*1.225-1*1.225-200.000-4*50.000=38.740

Unique configuration. "Trade-off between revenue and cost" vs combined model

	Desai et al. (2001)	combined model
Revenue	512.000	512.000
manufacturing costs	-70.360	-70.360
design effort	-2.900	-2.900
Fixed costs	-400.000	-200.000
Setup costs	Not displayed	-200.000
profit	38.740	38.740

In the unique case, the results of the model dealing with the trade-off between revenue and cost matches with the combined model. The result at the bottom line is exactly the same, but in the calculation the cost picture in the combined model is more accurate.

7.4.2 Premium-common configuration

At the premium-common configuration, the main advantage of the combined model will be obvious. The results of the unique configuration case of the combined model will be compared to a premium-common configuration. The numbers stay the same as in the previous chapter. The configuration of the products differs and this has an impact on every aspect of the model.

As in the model of Desai et al. (2001), product quality is derived with the quality of the components multiplied with the importance weight of the components. $q = \omega_A * q_A + \omega_B * q_B$ In case of component commonality, using the same numbers, the product qualities for the products are:

$$q^{p,b} = \omega_A * q_A^p + \omega_B * q_B^b = 0{,}3*16 + 0{,}7*8 = 10{,}4$$

$$q^{p,p} = \omega_A * q_A^p + \omega_B * q_B^p = 0{,}3*16 + 0{,}7*16 = 16$$

This influences the price setting equation and the results are equal to the model of Desai et al. (2001). For the low-valuation product the price is $p^{p,b}$ =400*10,4=4.160 and for the high-valuation segment, the price is $p^{p,p}$ =800*0,7*(16-8)+400*(0,3*16+0,7*8)=8.640

On the cost side, the values for the design effort are matching. For the components, the results are derived:

Common component: $\ddot{e}_A^p = \left(\frac{100}{2}\right)^2 = 2.500$

Premium component $\ddot{e}_B^p = \left(\frac{100*0,3}{2}\right)^2 = 225$

Basic component $\ddot{e}_B^b = \left(\frac{100*0,7}{2}\right)^2 = 1.225$

By calculating the manufacturing costs for one unit of a product the costs are derived.

For the low-valuation product $c_b = 3*(16)^2 - \sqrt{2.500} + 3*(8)^2 - \sqrt{1.225} = 875$ and for the high-valuation product: $c_b = 3*(16)^2 - \sqrt{2.500} + 4*(16)^2 - \sqrt{225} = 1.727$.

The table below gives a brief overview over the results

	Basic	Premium
product quality	$q^{p,b}$ =10,4	$q^{p,p}$ =16
product price	$\dot{p}^{b,b}$ = 4.160	$p^{p,p}$ =8.640
design effort	$\dot{e}_B^b$ =1.225	$\dot{e}_A^p =$ 2.500 $\dot{e}_B^p =$ 225
costs per product	c_b = 875	c_p =1.727

Until now, on the product level there are no differences in the numbers between the models of Desai et al. (2001) and the combined model. The differences appear on the overhead level, respectively on the ABC hierarchy "Setup costs".

Costs are calculated as in the unique configuration case with activity based costing system. For the calculation this means that with the received values for the optimal design effort, total design effort is calculated: $-a*d_A^p - a*d_B^b - a*d_B^p$=-2.500*1-1.225*1-225*1=-3.950.

Manufacturing costs for the products are calculated with $-m_H*c^{p,p} - m_L*c^{p,b}$ and result in -113.060

As expected, these values are consistent with the basic-common case in the model of Desai et al. (2001).

As at the previous cases already mentioned, in the model of Desai et al. (2001) the fixed costs were assumed with 400.000, in the combined model the picture is more accurate. The fixed costs are now 200.000.
At setup costs the combined model differs from the model dealing with Trade-off between revenue and cost. Here the differences between the unique configuration and the premium common case become visible. As there are only 3 components in use, Setup costs differ. The cost-driver is equal to the number of components and so used 3 times. As the cost-rate is 50.000 per Setup, the Setup costs result in 3*50.000 = 150.000

With the objective function of the combined model $m_H\left(p^{p,p,}-c^{p,p}\right)+m_L\left(p^{b,b,}-c^{b,b}\right)-e_A^p-e_B^p-e_B^b-Fx$ the profit is received. With the numbers of this example the profit is derived with 100*0,3*(8.640-1.727)+100*0,7(4.160-875)-1*2.500-1*225-1*1.225-200.000-3*50.000=83.390.

These are the results for the premium-common case. Some differences to the unique case are apparent. Subsequent, the results for the basic common configuration will be calculated and afterwards, the results will be compared.

7.4.3 Basic-common configuration

In contrast to the premium-common configuration in this case the common component is basic quality. In the calculation for the model dealing with the trade-off between revenue and cost some differences to the premium-common case appeared and for the combined model, similar results are likely. The numbers remain the same as in the previous chapters. Configuration is now with a basic quality common component.

In case of component commonality with a basic common component, using the same numbers, the product qualities for the products are:

Low-valuation product: $q^{b,b}=\omega_A*q_A^b+\omega_B*q_B^b=0{,}3*8+0{,}7*8=8$

High-valuation product: $q^{b,p}=\omega_A*q_A^b+\omega_B*q_B^p=0{,}3*8+0{,}7*16=13{,}6$

This influences the price setting equation and the results are equal to the model of Desai et al. (2001). For the low-valuation product the price is $p^{b,b}$ =400*8=3.200 and for the high-valuation segment, the price is $p^{b,p}$ =800*0,7*(16-8)+400*(0,3*8+0,7*8)=7.680.

On the cost side, the values for the design effort remain the same. For the components, the results are derived:

Common component: $\dddot{e}_A^b = \left(\frac{100}{2}\right)^2 = 2500$

Premium component: $\dddot{e}_B^p = \left(\frac{100*0,3}{2}\right)^2 = 225$

Basic component: $\dddot{e}_B^b = \left(\frac{100*0,7}{2}\right)^2 = 1.225$

By calculating the manufacturing costs for one unit of a product, the costs are derived. For the low-valuation product $c_b = 3*(8)^2 - \sqrt{2.500} + 3*(8)^2 - \sqrt{1.225} = 235$ and for the high-valuation product: $c_b = 3*(8)^2 - \sqrt{2.500} + 4*(16)^2 - \sqrt{225} = 1.087$.

The table below gives a brief overview over the results

	Basic	Premium
product quality	$q^{p,b}$ =8	$q^{p,p}$ =13,6
product price	$\dot{p}^{b,b}$ = 3.200	$p^{p,p}$ =7.680
design effort	$\dot{e}_A^p$ = 2.500 $\dot{e}_B^b$ =1.225	$\dot{e}_B^p$ = 225
costs per product	c_b = 275	c_p =1.087

As in the premium common case, at this point there are no differences in the numbers between the models of Desai et al. (2001) and the combined mode. The differences appear on the overhead level, respectively on the ABC hierarchy "Setup costs".

Costs are calculated as in the other configuration cases with activity based costing system. For the calculation this means that with the received values for the optimal design effort, total design effort is calculated: $-a*d_A^b - a*d_B^b - a*d_B^p$=-2.500*1-1.225*1-1*225=-3.950.

Manufacturing costs for the products are calculated with $-m_H*c^{b,p} - m*c^{b,b}$ and result in -49.060

Similar to the premium-common case, manufacturing costs remain the same as in the model of Desai et al. (2001).

As at the unique case of the combined model mentioned, in the model of Desai et al. (2001) the fixed costs were assumed with 400.000, in the combined model the picture is more accurate. The fixed costs are now 200.000. As in the premium-common case, here there are only 3 components in use and so Setup costs are reduced adverse to the unique case. The cost-driver is equal to the number of components and so used 3 times. As the cost-rate is 50.000 per Setup, the Setup costs result in 3*50.000 = 150.000

With the objective function of the combined model $m_H\left(p^{p,p,} - c^{p,p}\right) + m_L\left(p^{b,b,} - c^{b,b}\right) - e_A^p - e_B^p - e_A^b - e_B^b - Fx$ the profit is received. With the numbers of this example the profit is derived with 100*0,3*(7.680 -1.087)+100*0,7*(3.200-235)-1*2.500-1*225-1*1.225-200.000-3*50.000= 51.390

These are the results for the basic-common case. Subsequent the derived results are compared.

7.5 Comparison of results

Now that the results for the model with trade-off between revenue and cost and for the combined model are derived they can be compared.

<u>Comparison of unique configuration and common configurations</u>

Model with trade-off between revenue and cost

	Unique configuration	Premium-Common Configuration	Basic-Common Configuration
Revenue	512.000	550.400	454.400

manufacturing costs	-70.360	-113.060	-49.060
Cost of design effort	-2.900	-3.950	-3.950
Fixed costs	-400.000	-400.000	-400.000
profit	38.740	33.390	1.390

Combined model

	Unique configuration	Premium-Common Configuration	Basic-Common Configuration
Revenue	512.000	550.400	454.400
manufacturing costs	-70.360	-113.060	-49.060
Cost of design effort	-2.900	-3.950	-3.950
Fixed costs	-200.000	-200.000	-200.000
Setup costs	-200.000	-150.000	-150.000
profit	38.740	83.390	51.390

model with trade-off between revenue and cost vs combined model

The tables show that most parts are equal. The difference appears due to the fact, that the combined model adds extra information at the overhead level. So revenue, direct manufacturing costs and design effort are equal. Differences appear at fixed costs. As the model considering revenue and cost has no information about Setup costs, they are considered to be fixed. The combined model takes advantage of the other model dealing with ABC and considers Setup costs as an ABC hierarchy. Therefore the fixed costs are only 200.000 and the Setup costs are displayed with 200.000 as in the unique case, the cost driver is used 4 times. So information regarding cost improved.

unique vs. premium common configuration

In this comparison for the unique configuration case, it is visible, that the profit in both models is the same. In the model with trade-off between revenue and cost, the unique configuration is the preferred case, as the profit is higher as in the premium common case.

In the combined model, the information about setup costs and their behaviour according to the number of components is known and therefore the premium common configuration is the preferred case, as the profit is more desirable.

unique vs. basic common configuration

In the model with revenue and cost the unique configuration would be the preferred case as the profit is higher in the common configuration case. This situation changes in the results of the combined model. There the profit in the unique case is smaller than in the basic common configuration and so the common case would be preferred.

unique vs. premium common configuration vs. basic common configuration

The numbers at the bottom line for the unique case are in both models the same. In the model dealing with trade-off between revenue and cost, the unique configuration would be the best solution. In the combined model the unique configuration would be the poorest choice, because both common component configuration cases provide better results. As the premium-common case delivers a higher profit than the basic-common case, the premium-common configuration would be the preferred configuration.

activity based costing vs. traditional costing system.

The results of the example show that the model which is supported with an activity based costing system is more drawn towards using a common component. This is caused by the fact, that activity based costing reveals more information about cost and how they can be handled. These superior cost information leads to an generally higher preference for component commonality.

The Example showed in total 6 cases for 2 models. For each model a unique a premium-common and a basic-common configuration case was calculated. The comparison of these cases reveals the advantages of the combined model, namely more details in the pre-calculation of costs. Results for the cases differ when the assumptions regarding the numbers would be changed, but the fact that the combined model adds crucial information is obvious.

8 Discussion

Quality of components is fixed

In the used model of Desai et al. (2001) the quality of components is assumed to be fixed. For components no changes in component quality are possible due to design effort. The quality of the components is assumed to be predetermined. With a view on the impact of design effort $c_j = k_j \left(q_j^i\right)^2 - \sqrt{e_j}$ it is visible that the only impact is the ability to reduce the unit production costs.

By defining quality Desai et al. (2001:40) explain that it is important to understand, that the considered quality in their analysis is performance quality and specifically does not include conformance quality. In terms of a car, their definition of performance covers engine size, ride quality or audio system that determines the overall quality of a car.

So when the model is applied these limitations regarding the inability to change the quality of a component through design effort and the boundaries of the performance definition have to be considered.

Activity Based Costing

Regarding activity based costing, in a former chapter the issue of Noreen(1991) was mentioned that there are some conditions that have to be fulfilled in order to provide correct information. Two of these conditions are forcing constraints and one permits alternatives if it is not met. In reality it is hard to meet these conditions.

Noreen (1991:165) mentions that an ABC system will provide relevant data only if the cost in every cost pool is strictly proportional to its activity measure. There are costs that do not satisfy this condition. Factory rent is hardly strictly proportional to machine hours. When the cost structure for a given cost pool is assumed to be linear with a positive intercept, this will lead the activity based costing system to estimate product and activity costs too high.

So activity based costing estimates the influence able costs as too high and therefore leads to biased decisions.

"If care is not exercised in the design of an ABC system and there do indeed exist fixed costs of joint costs, then the costs generated by the ABC system will not provide reliable signals for the kinds of decisions for which ABC systems have apparently been designed."

Noreen (1991:165)

So the existence of fixed costs has to be bared in mind when an activity based costing system is used, in order to make the right decisions.

__Limitations in the model of Desai et al. (2001)__

For the model of Desai et al. (2001) there are some limitations. Depending on the numbers applied to the model, it is possible to receive negative unit costs due to enormous design effort.

This is due to the equation for the unit costs: $c_j = k_j (q_j^i)^2 - \sqrt{e_j}$. Because design effort is subtracted from the unit cost it could result in negative unit costs.

This can be proved with an example:

numbers:

n= 100000

r_H =0,7

r_L =0,3

k_A^b	2	q_A^b	8	ϖ_A	0,3
k_B^b	3	q_B^b	8	ϖ_B	0,7
k_A^p	3	q_A^p	16	θ_b	2
k_B^p	4	q_B^p	16	θ_p	4

In the case of unique configuration, the model leads to optimal design effort for the basic components of 1.225.000.000 and for the premium component 225.000.000.

According to the function of the unit costs $c_j = k_j (q_j^i)^2 - \sqrt{e_j}$, the values received for the unit costs are -34.968 for component A and -34.952 for component B of the basic product. For the premium product, for component A the model derives -14.808 and for component B -14.744.

Calculation for component A of basic product: $-34.968 = 2 * 4^2 - \sqrt{1.225.000.000}$.

As the production costs can't be negative, the system boundaries are hurt. At negative production costs, the model would result in revenues simply by producing units, no matter if they are sold or not.

This issue could be solved by applying additional constraints to the model, limiting the design effort to a reasonable number, or they could ensure that the production costs at least are positive.

Competition

The applied models do not take competition into account. The frame for the models is a monopolistic setting, but component commonality could be a relevant factor to deal with competition. Pindyck and Rubinfeld (2005:497) explain that barriers to entry are an important source of monopoly power and profits and can be created by economies of scale.

So by deriving a cost advantage by using a common component resulting in economies of scale could prevent other firms to enter the market.

Also if only component commonality enables the firm to produce differentiated products, this could result in a competitive advantage. Browning and Zupan (2006:326) mention product differentiation as a possible barrier to entry. When consumers perceive a product to be superior to another they are willing to pay more for it.

To sum up, component commonality could raise barriers to entry for the competition, if it leads to economies of scale or to increased differentiation.

Consumers

The model of Desai et al. (2001) simply assumes two market segments, a low-valuation segment and a high-valuation segment. This assumption could easily be adapted and various numbers of market segments could be established.

Excess capability at common component

In the chapter "Effects of Component Commonality" it was mentioned, that the common component probably will have excess functionality in order to satisfy the requirements of all products in which it is attached. This functionality could result in higher costs, as seen in the premium common case of the example.

9 Further research

Competition

In the field of component commonality, most papers consider an environment with monopolistic competition and therefore competition is out of scope. In research literature there are papers which deal with competition. Because competition will change market information's it would be a great progress to deal with it.

Changes in quality

The model of Desai et al. (2001) doesn't allow changes in component quality through design effort. In the referenced paper, this topic is covered. They deal with what happens when the manufacturer can change the quality of the components. As the quality has an impact on the realizable price, changes in quality would increase the ability to receive the desired price from the consumers.

Market segments

When the manufacturer would establish more than two market segments, this would probably result in more provided products or a market segment without a product targeted for it. When for each market segment a specific product is provided, the model could easily be adopted with additional constraints and some changes in the objective function. When there are more market segments than products the changes would be more substantial. Then it had to be decided which market segment should be omitted.

Resource constraints

In the model, resource constraint could be added which probably would result in a shortage in supply. Therefore the manufacturer had to decide which demand should be covered with the feasible production.

Self selection

The model assumes that consumers can self select which product they buy. If the market is a seller market and the manufacturer can choose which demand he satisfies the model should consider this fact.

Number of components

The model assumes that a product consists of 2 components. In most cases this assumption would not hold in practice. Considering a various amount of component could be done. For the components it had to be declared which are candidates for component commonality and which are not considered. When these changes would be applied to the model it would result in increasing number of calculated examples.

10 Conclusion

By discussing component commonality many relevant topics popped up. The demand for component commonality is a result of the demands of the market for product variation and from the aim of the manufacturers to keep costs down. It appears that costs are greatly influenced in the design stage. Not only direct manufacturing costs, also manufacturing overhead costs can be influenced. Therefore a costing system has to reveal the effect of a design decision on the total future manufacturing costs. As a proper costing system, activity based costing was identified and thereof relevant aspects were introduced.

To approach the challenge, two existing models were combined, so to profit from their particular advantages. The main model provides an already complete model that considers the revenue side as well as the cost side. The other model mainly deals with the cost function based on activity based costing.

With the combination of these models, the cost side can be displayed in a more detailed way. So the effect of the design decisions on manufacturing costs and overhead costs can be forecasted more precisely. Also the decision how to deal with component commonality is more accurate

To prove this works is shown with an example. For the model considering revenue and cost, as well as for the combined model, cases with several configurations of component commonality were calculated. By comparing the results it was revealed that the decision to use component commonality or not can change with more accurate information. This demonstrated the abilities of the combined model. As a main result it was stated, that an activity based costing system has a higher preference for component commonality than traditional costing systems. With component commonality it is possible to gain from economies of scale and economies of scope.

References

Banker R., Srikant D., Kekre S., Mukhopadhyay T.; 1990; Costs of Product and Process Complexity; in Kaplan R.; 1990 Measures for Manufacturing Excellence; Harvard Business School Press; Boston, Massachusetts; 269-291

Banker R., Potter G., Schroeder R.;1995; An empirical analysis of manufacturing overhead cost drivers; Journal of Accounting and Economics 19; 115-137

Browning E., Zupan M.; 2006; Microeconomics, Theory & Applications; 9th Edition, John Wiley & Sons Inc.; Hoboken

Cooper R., Chew W., 1996; Control tomorrow's cost through today's design; Harvard Business Review.; 88-98

Desai P., Kekre S., Radhakrishnan S., Srinivasan K., (2001) Product Differentiation and Commonality in Design: Balancing Revenue and Cost Drivers.; Management Science 47(1); 37-51.

Fisher M., Ramdas K., Ulrich K., 1999, Component sharing in the management of product variety: A Study of Automotive Braking Systems; Management Science 45(3), 297-315

Heese H., Swaminathan J.; 2006: Product Line Design with Component Commonality and Cost-Reduction Effort; Manufacturing & Service Operations Management; Vol.8, No.2 Spring 2006; 206-219

Hussey R.; 1995: A Dictionary of Accounting; Oxford University Press; Oxford; New York

Kaplan R., Cooper R.; 1998: Cost & Effect, Using Integrated Cost Systems to Drive Profitability and Performance; Harvard Business School Press; Boston; Massachusetts

Labro Eva; 2004: The Cost Effects of Component Commonality: A Literature Review Through a Management-Accounting Lens ,Manufacturing & Service Operations Management; Fall 2004; 6, 4; 358-367

Lancaster K. 1990: The Economics of product variety: a survey; Marketing Science, Vol 9, No3, Summer 1990, 189-206

Miller, J.G. and T.E. Vollmann, 1985: The hidden factory, Harvard Business Review, Sept.-Oct., 142-150.

Noreen E.; 1991: Conditions Under Which Activity-Based Cost Systems Provide Relevant Costs; Journal of Management Accounting Research, Fall 1991; 159-168

Pindyck R., Rubinfeld D.; 2005: Microeconomics; sixth edition; Pearson Prentice Hall; Upper Saddle River, NJ

Appendix

Abstract

English

The main topic of this master thesis is component commonality. It introduces the reasons for component commonality on the demand side and supply side. Effects of component commonality on diverse aspects of production, revenues and costs are revealed.

Another main aspect is activity based costing, which is introduced and the conditions for a successful application are provided. Furthermore management based on this costing system is discussed.

The main topic is to develop a model that supports the decision to make a component common or not in an activity based costing system. Therefore two models are introduced, a complex model that considers market segments and trade-offs at quality and prices and another one that provides an objective function for an ABC environment. Assembled from these two models a combined model is derived which includes the strength of both models.

To prove the benefits of the combined model, an example is calculated for the original model and the new one .The results of this example are compared and the advantages of the combined model are highlighted.

Deutsch

Diese Masterarbeit behandelt das Thema component commonality. Die Gründe für component commonality auf der Angebots und Nachfrageseite werden dargestellt. Ebenso .werden die Auswirkungen auf Produktion, Umsatzerlöse und Kosten erörtert.

Ein wichtiger Aspekt dieser Arbeit ist Activity Based Costing, welches vorgestellt wird und die Bedingungen für eine erfolgreiche Anwendung werden dargestellt. Zusätzlich wird ein darauf aufbauendes Management diskutiert.

Der Hauptteil besteht darin, ein Modell zu entwickeln, welches aufbauend auf ein Activity Based Costing System bei der Entscheidung helfen soll, ob eine Komponente gemeinsam verwendet werden soll. Dazu werden 2 Modelle vorgestellt, wovon eines eine Zielfunktion für ein ABC System liefert und das andere ein vollständiges Modell ist, welches aber nicht an ein ABC System angepasst ist. Aufbauend auf diesen beiden wird ein Modell entwickelt, welches die Stärken der beiden verbindet.

Um den Vorteil des neuen Modells zu beweisen wird ein Beispiel gerechnet. Dabei werden das alte Modell und das kombinierte Modell in verschiedenen Fällen vergleichen und die Vorteile des neuen Modells hervorgehoben.

Example

Model of Desai et al.(2001)

Unique configuration

n	100			F	400000		manufacturing costs	70.360				
rl	0,7											
rh	0,3	$c_j = k_j(q_j^i)^2 - \sqrt{e_j}$										
		Costs	p									ol
C(b)		250	3.200	kj	q	e		w		U(l)	0	400
	c(A,b)	93		2	8	1.225		0,3				
	c(B,b)	157		3	8	1.225		0,7				
	q	8				2.450						
												oh
C(p)		1.762	9.600							U(h)	3200	800
	c(A,p)	753		3	16	225		0,3				
	c(B,p)	1.009		4	16	225		0,7				
	q	16				450						
Profit	38.740				Price basic		3.200					
2	3.200	>=	3200		Price premium		9.600					
3	0	>=	-3200		design effort	p	225					
4	0	>=	0			b	1.225					
5	3.200	>=	0									

Abbildung 2

Premium-common configuration

n	100			F	400000		manufacturing costs	113.060				
rl	0,7											
rh	0,3	$c_j = k_j(q_j^i)^2 - \sqrt{e_j}$										
		Costs	p									ol
C(b)		875	4.160	kj	q	e		w		U(l)	0	400
	c(A,b)	718		3	16	2.500		0,3				
	c(B,b)	157		3	8	1.225		0,7				
	q	10				3.725						
												oh
C(p)		1.727	8.640							U(h)	4160	800
	c(A,p)	718						0,3				
	c(B,p)	1.009		4	16	225		0,7				
	q	16				225						
Profit	33.390				Price basic		4.160					
2	4.160	>=	4160		Price premium		8.640					
3	0	>=	-2240		design effort	p	225					
4	0	>=	0			b	1.225					
5	4.160	>=	0			common	2.500					

Abbildung 3

Basic-common configuration

n	100			F	400000		manufacturing costs	49.060				
rl	0,7											
rh	0,3	$c_j = k_j(q_j^i)^2 - \sqrt{e_j}$.										
		Costs	p									ol
C(b)		235	3.200	kj	q	e		w		U(l)	0	400
	c(A,b)	78		2	8	2.500		0,3				
	c(B,b)	157		3	8	1.225		0,7				
	q	8				3.725						
												oh
C(p)		1.087	7.680							U(h)	3200	800
	c(A,p)	78						0,3				
	c(B,p)	1.009		4	16	225		0,7				
	q	14				225						
Profit	1.390				Price basic		3.200					
2	3.200	>=	3200		Price premium		7.680					
3	0	>=	-2240		design effort	p	225					
4	0	>=	0			b	1.225					
5	3.200	>=	0			common	2.500					

Abbildung 4

Combined model

Unique configuration

												Activities	cost rate
n	100			F	200000		manufacturing costs	70.360		ABC Level	200000	4	50000
rl	0,7												
rh	0,3	$c_j = k_j(q_j^i)^2 - \sqrt{e_j}$.											
		Costs	p									ol	
C(b)		250	3.200	kj	q	e	Setup costs	w		U(l)	0	400	
	c(A,b)	93		2	8	1.225	1	0,3					
	c(B,b)	157		3	8	1.225	1	0,7					
	q	8				2.450							
												oh	
C(p)		1.762	9.600							U(h)	3200	800	
	c(A,p)	753		3	16	225	1	0,3					
	c(B,p)	1.009		4	16	225	1	0,7					
	q	16				450							
Profit	38.740				Price basic		3.200						
2	3.200	>=	3200		Price premium		9.600						
3	0	>=	-3200		design effort	p	225						
4	0	>=	0			b	1.225						
5	3.200	>=	0										

Abbildung 5

Premium-common configuration

												Activities	cost rate
n	100			F	200000		manufacturing costs	113.060		ABC Level	200000	4	50000
rl	0,7												
rh	0,3	$c_j = k_j(q_j^i)^2 - \sqrt{e_j}$.											
		Costs	p									ol	
C(b)		875	4.160	kj	q	e	Setup costs	w		U(l)	0	400	
	c(A,b)	718		3	16	2.500	1	0,3					
	c(B,b)	157		3	8	1.225	1	0,7					
	q	10				3.725							
												oh	
C(p)		1.727	8.640							U(h)	4160	800	
	c(A,p)	718					0	0,3					
	c(B,p)	1.009		4	16	225	1	0,7					
	q	16				225							
Profit	83.390				Price basic		4.160						
2	4.160	>=	4160		Price premium		8.640						
3	0	>=	-2240		design effor	p	225						
4	0	>=	0			b	1.225						
5	4.160	>=	0			common	2.500						

Abbildung 6

Basic-common configuration

												Activities	cost rate
n	100			F	200000		manufacturing costs	49.060		ABC Level	200000	4	50000
rl	0,7												
rh	0,3	$c_j = k_j(q_j^i)^2 - \sqrt{e_j}$.											
		Costs	p									ol	
C(b)		235	3.200	kj	q	e	Setup costs	w		U(l)	0	400	
	c(A,b)	78		2	8	2.500	1	0,3					
	c(B,b)	157		3	8	1.225	1	0,7					
	q	8				3.725							
												oh	
C(p)		1.087	7.680							U(h)	3200	800	
	c(A,p)	78					0	0,3					
	c(B,p)	1.009		4	16	225	1	0,7					
	q	14				225							
Profit	51.390				Price basic		3.200						
2	3.200	>=	3200		Price premium		7.680						
3	0	>=	-2240		design effort	p	225						
4	0	>=	0			b	1.225						
5	3.200	>=	0			common	2.500						

Abbildung 7

Curriculum Vitae

Name	Hirschvogl Thomas
Academic degrees	Bakk. rer. soc. oec. Bakk. phil.

Education

2013-2014	University of Vienna Master in Business Administration Specialization in Controlling and Production Management Thesis title: Deciding about Component Commonality in an Activity Based Costing environment
2009-2013	University of Vienna Bakkalaureus der Sozial- und Wirtschaftswissenschaften (Bakk. rer. soc. oec.) Thesis title: 1. Mechanismus Design 2. Analyse der Rosenbauer International AG
2008-2012	University of Vienna Bakkalaureus der Philosophie in Publizistik - und Kommunikationswissenschaft (Bakk. phil.) Thesis title: 1. Product Placement auf der großen Leinwand 2. Youtube und das Urheberrecht
2002-2007	Higher Technical Institute TGM, Vienna Electrical Engineering with focus on Information technology

Languages

German	Mother Tongue
Englisch	Fluent
Spanish	Basics