4 Calculations

4.1 Introduction

The job of a calculation

Calculations serve many different purposes, but all have in common that they determine costs related to a certain job. Based on this principle, this chapter will deal with a very important job within a given firm, i.e. to establish or approach the cost function for the production activities in a firm where:

- More than one good is produced
- The time horizon is realistic
- Going concern is a main point of view (if not necessarily the only one).
  Going concern means that the company is expected to continue its activities in the near future.
- The production is carried out on a more or less know facility with more or less known technology etc.

Calculations on costs etc. are used in many different places within the financial system of the firm, therefore it is no surprise that the calculations can solve many different jobs. Some of these include:

- **Control:** For instance concerning pre and post calculations, controlling that a given production has the expected financial consequences. At the same time, a basis for future calculations is built upon these experiences. Examples of this relational dynamic are calculations concerning public capital investments such as: bridges, roads, metros, or calculations involved in building a house, or sewing clothes.
- **Inspiration:** Major cost entries could be investigated in order to rationalize, whereas major cost divergence, in a seemingly constant production flow, would generate extreme decision-maker curiosity.
- **Production:** Knowledge and understanding of the costs of several different alternatives is necessary, before it is possible to assess how a product is to be produced at the lowest possible cost.
- **Decisions:** Cost calculations are, for instance, used in relation to pricing and choice of product mix.

In short, the calculation tasks are everyday workings aspects of a firm.

To solve this complicated calculation task requires knowledge about a huge number of methods and terms, some of which are introduced in this chapter. In this text, it is naturally impossible to go in depth with all of the issues, but a number of the most important chains of reasoning will be discussed. The final part of the chapter presents some concrete methods of dividing costs, each method representing an approach to dealing with the calculation task.

Definition of a calculation

In the most traditional sense a calculation can be defined as follows:

”A calculation is a financial estimate of the costs attributed to the purchasing, manufacturing and sales of a company’s goods.” [13]

Or “A calculation is an estimate of the financial consequences of a given action, ex-ante or ex-post. It could be for a single product unit or a comprehensive alternative action (e.g. construction of a new factory). It can be a pure cost calculation or a calculation that incorporates (expected) future earnings.”
The tool “a calculation” adapts, to a large extent, to this job.

Pre-calculation is a way of drawing up the expected costs per product unit. The pre-calculation focuses on production that has yet to take place (ex-ante).
Post-calculation seeks to establish the costs that were actually involved in a completed production (ex-post).

By combining a pre- and post-calculation for the same product unit, it is possible to control whether or not the production has proceeded as expected, as well as identifying locations of cost deviations.

Costs vary with the purpose and the job.

Due to a number of factors costs can not be determined unambiguously, but have to be defined with relation to the issue at hand.

Costs and marketing/sales:

- Principally speaking, costs and marketing-conditions have to treated independently. They are not to be connected before optimization of the job has taken place. In practice however, a correlation may occur between the two disciplines, for instance, sales knowledge and marketing could inspire possibilities as to the size of a realistic production. As such, it is superfluous to calculate on the basis of output levels that are impossible to market and sell. At the same time, the time horizon should be established with regard to both cost and marketing conditions.

Costs and dependency on quantity:

- The classic cost definition states that costs are a function of the consumed factors of production, multiplied with the price for production factors. The consumption of production factors is directly connected to the produced lot.
- Jumps in capacity are either "hard" or "soft," reversible or irreversible, and can thus result in different cost related considerations, including both expansion and reduction in production. In this way, uncertainty or fluctuations in production levels is a cost factor.
- Temporary reductions in capacity produce great difficulties using or integrating the use of factors of production, including individuals possessing key knowledge and technological set-up, which could result in overly optimistic assessments.
- Because of gradual adaptations, the marginal costs and average costs have both a tendency to avoid listing the so-called sneaking costs, whereby the dependency on quantity is underestimated. Examples of this are petty theft, power, and having ½ an extra employee.
- Production risks are not typically included in cost calculations, e.g. competitive tendering in major public works.

Costs and time dependency:

- Short-term and long-term defined as technology choice. In the short-term, existing facilities are employed. While in the long-term, it is possible to adjust to the most appropriate configuration of production and technology.
- Short-term as basis for operations decisions mean that relatively few of the fixed costs are variable. Concerning a long-term perspective, it is possible to adjust the costs, including various reversible, and irreversible cost developments.
- Learning curves, efficiency development, etc. are also included.

Costs and situation dependency:

- Costs can vary with the degree of capacity utilization. In a situation with over capacity in a business sector, businesses are inclined to assess the overhead fixed costs as being higher than in a situation with a shortage of capacity, as the variable costs are lower.
- Costs vary in accordance with the competitive situation found in a business sector. If the competition is fierce, the businesses will, when listing the calculations, assess the overhead fixed costs to be higher than if the competitive situation makes room for more long-term calculations.
- Non-going concern is a perspective where the assets are realized/sold as a result of crisis or normal phasing out, e.g. because of expectations that the firm will not exist in the near future.
- Opportunity costs, depreciation vs. real loss of value caused by wear and tear, financial life-span, alternative usage of capital, or new technology.
- Subcontracting and outsourcing both nationally and internationally, international division of labor, etc.
- Conditions inherent to returns to scale, rationalizing, management effort, technology level, etc.
- The firm's strategic situation, ownership, the industrial competitive situation, capacity of profit, and loss, etc.

The sum of all these issues influences cost estimations.

Collection of data and calculations

All these factors that influence the conception of costs also imply that data collection is not limited to measurement and registration of the firm's own production. It is necessary to access a large number of information bases for the different calculations, some of which are listed below:

Historic, internal data:

- All accounting data in the financial transaction system
- The contributing margin from a number of relevant divisions within the company, its customers, products, etc.
- Prices, price developments, key figure indexes, the "Dupont key-figure pyramid" development, etc.
- Technical data such as material consumption, time consumption, waste, degree of exploitation, etc.

Historic, external data:

- Price indexes, wage indexes, rates of exchange, interest rates, etc.
- Technical achievements, norm data, etc. for production, machinery, employees, etc.
- Industry data, macro economic data, statistical data, etc.
- Competitive data, more or less exposed.

Non-financial data, both internal and external:

- Consumer satisfaction polls, consumer attitudes
- Quality measurements, societal optimism/pessimism, expectations for business cycles/market conditions. This data is often applied when doing different kinds of bench-marking, balanced scorecards, etc.

Typical cost divisions

In a calculation task a number of the earlier mentioned cost divisions are normally applied. The most important are:

- **Fixed and variable costs.** A number of factors are crucial when costs are arranged in fixed and variable costs.

- **Direct and indirect costs.** Direct costs can be attributed to an action, a production, product line, a production facility, or a cost bearer. Furthermore, these factors are applicable on different levels, such as unit, product line, or section.

  It may be necessary to categorize costs in different forms depending on the decision that is to be made. This categorization process can go a bit against the grain of the registration assignment.
  Indirect costs then, are the costs that are not direct.
  In some cost model plans of distribution, the purpose is to divide the different indirect costs into various cost bearers/products (e.g. see the full cost model at the end of this chapter).
  In other models, such a distinction is not made (e.g. the contribution margin model).

- **Sales and administrative costs** are a special kind of costs. They are not directly variable with regards to production, but are indispensable in both the short-term and in the long-term. On the other hand, these costs are often adjusted for activity level as well as sales effort aspirations, service level, control level, etc. But these costs are dependent on the specific business, its strategy, and management. Understanding the relevant time horizon is crucial here. For instance, the size of the sales force in the perfume department of Magasin is determined according to the expected sales, but on a rainy morning there could be over capacity because the sales force in the very short term is a fixed cost, due to scheduling.

Remark: the categorization of a cost as direct or indirect depends on which cost bearer is defined, i.e. the purpose of the calculation (e.g. the production price of one working hour for an accountant, or 1 liter of milk, or a Sony CD-player). In the same way, the division into variable and fixed costs is dependent on the chosen time horizon. For instance, if a single product units is chosen as a cost bearer (e.g. a liter of milk), many costs become indirect. On the other hand, if product lines are focus units, (e.g. the milk packing line) then more costs are direct.

Optimization

When calculations are applied to the optimization purposes (optimal price, optimal product mix), some of the central terms in the previous chapter on costs must be revised, starting with the calculation task, i.e. they have to be "re-interpreted in terms of the calculation perspective:"

- **Marginal costs, MC**
  According to the calculation perspective, a narrow production view can often result in a similar situation to that described in the following metaphor: the camel that eventually broke its back because the loaders kept saying: "If it can carry this, it can also carry that." A production can typically manage to manufacture one unit more or less without any consequences for the costs other than the direct product costs, such as materials and direct wages. Therefore, MC is often underestimated significantly, as so-called "sneaking costs" (such as decreasing efficiency) are rarely incorporated, even though they are significant for most production processes. Other important factors in this context include: management, repairs, internal transport, etc.

- **Average Variable Costs, AVC**
  From the calculation perspective, "half-variables" (e.g. sales and administrative costs, machinery, production management, etc.) represent a difficult problem, as they are extremely time horizon dependent. Moreover, precision is lost when it is necessary to apply many, more or less dubious distribution plans in order to achieve a calculated AVC.

- **Average Total Costs, ATC**
  ATC equals AVC + AFC. AFC is only marginally related to the actual production. AFC may be comprised of depreciation on historic goodwill, development costs, and other sunk costs.

- **ABC – costs per cost-object, CCO**
  CCO estimates the costs attributed to a cost-object as having applied the ABC cost classification, and subsequently the division on cost-objects using the cost-drivers as tool. This relationship will be explained later in greater depth.

American economists often use the ATC, suggesting that in this way a long-term optimization is achieved, combined with a safeguard against the liability to compete recklessly, and not cover the fixed costs.

European calculation traditions are more devious, maybe because there is not the same tradition of tough competition between companies, as is found in the USA.

The calculation problem

When calculations are used in optimization (e.g. pricing and optimal product mix), it is important that costs are attributed to the relevant decision. Whether or not a product, a product line, or an activity is profitable depends on which costs are included in the action.

As not every cost can be attributed directly to the specific product unit (e.g. sales and administrative costs), one of the central problems involved in the calculation task is to deal with costs that are common to several products, product lines, and/or business sections. Should such joined costs be distributed to specific product units? And if yes, then how? It is also up to the calculations to solve the issue of how theoretical correct, meaningful, and objectively accurate, this distribution of the joined costs is executed.

Costs centers and cost bearers

The following terms are central for establishing a calculation:

- **Cost centers** focus on organizational work, process oriented, or production oriented elements in a business. A number of costs can be measured, attributed, or applied to these respective foci.
  In order to determine the focus, the reporting system and the account plans of the firm must be adequate and approachable in their arrangement.
  A number of cost centers are presented below. These cost centers are described within the framework of a firm HKP, a woodworking factory with 5 employees, producing windows and doors with different measurements.

  - Depreciation of the machinery value
  - Cost of cleaning, service, and power for the woodworking section.
  - Repairs, sharpening of cutting edges etc. for different machine sections.
  - Wage costs for different tasks
  - Total costs for office and accounting tasks

- **Cost bearers** are the production elements whose costs are to be analyzed and calculated. Typically, these are the firm's products, groups of products, and/or services. Often these elements include many costs that cannot be measured directly (unlike the cost centers). Cost bearers can also be semi-manufactured goods, or internal services aiming to establish cost prices between the sections. Using the HKP case, cost bearers could include:

  - The price of a window or an established number of windows of a specific type.
  - The price for one woodworker's hour of labor, including wages attached to the estimation of special assignments
  - The price of dip-impregnating a batch of wood.
  - The price for installing a typical window in a typical house.

Distribution plans

- **Plans of distribution** are applied in order to distribute costs from cost centers to cost bearers. When distributing a number of costs from cost centers to cost bearers, the distribution keys aim at finding the most objectively correct connection between the costs of the cost center, and the cost bearer's use of the same. As a rule, this process occurs in such a fashion that a variation in the cost bearer's production causes the same variation in the costs of the cost center. The better the distribution key is at executing this task, the more objective it is. Likewise, the worse the distribution key is to execute the task, the more arbitrary (random) it becomes.

An example of a bad distribution key could be when wood consumption for producing a window is included in the work hours. "Experiences tell us that it takes an hour to produce a window, and that in one hour, 9.3 meters of wood are processed." Such a distribution key would not be able to manage shorter or longer series in production, or different types of windows, with different numbers of panes, etc.

A number of typical distribution keys are presented below. The calculation task defines based on, among other things, precision and decision task requirements. The more precise, the more costs are included in the calculation task:

Activity based:

- Wages or time worked
- Production size, consumption of raw materials etc.
- Turnover
- Number of customer visits and number of offers made.

Process based:

- Number of machines
- Process turnaround time
- Number of processes or number of m2 occupied by the process
- Number of customer visits, number of products or product lines.

One of the main tasks implicit in the calculation task is the distribution of costs, placed in cost centers, to cost bearers.

ABC terms

During the '90s an American calculation model called Activity Based Costing, won increasing recognition.[14] This model operates with cost divisions that are somewhat different from those described above. The ABC model is explained fully later in this paper, but its terms are introduced here.

Fundamentally, the same chains of reasoning are applied in the ABC:

- **Cost pools** are more or less the same as cost centers. In the same way the term cost pools deals with the firm's activities as attributed to a source of resources.
- **Cost objects** are the ABC term for cost bearers. In this way ABC seeks to establish a sensible connection between cost pools and cost objects (which in ABC can be processes).

ABC sets out to distribute a single cost pool over several cost objects. It is not necessary for each cost pool to have a cost object.

Even though the ABC calculation is reminiscent of the full cost calculation mentioned earlier, there is a difference between the basic philosophies behind full cost and ABC.

Possible cost attribution

The calculation task is often focused on establishing the costs of a given activity. This activity will typically be established by analyzing the costs of producing one unit of a given product. A concrete example referring to the HKP company context mentioned earlier: **"producing a Dannebrog-window measuring 82 × 128 cm with thermal panes."**

In this case, a downward-moving tendency of possible cost attributing would be typical, where an objective distribution key is necessary between phases.

Cost type:	Definition:	Examples :	Possible distribution key:
Direct product unit costs	Costs directly attributed to the producing entity.	Number working hours used Helping materials Direct wood consumption	None, as the costs are direct
Direct product costs	Costs directly attributed to the specific production	Estimated training Illness Holiday allowance Petty theft/shrinkage	A 22% wage supplement. Experienced shrinkage/petty theft totalling 8%
Direct product line costs	Costs that are directly attributed to the specific product line	Special machinery for window production Tests Approvals Quality control	Distribution based on working/machine hours Distribution as a fixed supplement per window
Direct sectional or departmental costs	Costs attributed to the section /department	Operation of buildings Cleaning Insurance Other machinery etc.	Supplement per working hour Supplement per machine hour
Additional indirect costs	Costs that cannot be attributed to the items above.	Offices Sales and marketing effort Generating estimates	Supplement per order Supplement per DKK in turnover Supplement per order created

As only the direct variable costs that are tied to the specific product units, can be distributed without complications, principally will all other costs be distributed using a distribution key, see above matrix.

When or if a cost center is to be distributed to cost bearers, this is accomplished with the most suitable distribution key, being as correct or as simple as possible. Thus a distribution key is a statement of the criteria by which the costs are to be distributed. The table below shows how a distribution key could be used to distribute both indirect costs to direct costs, and fixed costs to variable cost. Variations occur depending on the "cost school."

Great skill and experience are required in order to establish good and simple distribution keys. Furthermore, simplicity is crucial, as the necessary calculation information should be obtainable, but also measurable through an appropriate organization of the firm's accounting and financial controlling.

4.2 Different Calculation Models

Cost models

Several methods of solving the calculation problem exist. The most common procedures are split into the following three models, each with its own "cost school."

- **Full cost model – absorption cost model:** This model is used by many companies as a method of measuring the lowest price the product could be sold for. This model distributes both fixed and variable costs to the cost bearer; i.e. both direct as indirect variable and fixed costs are distributed. Often the distribution key for the fixed costs becomes quite arbitrary, i.e. random. The issue here is that the indirect fixed costs cannot be logically distributed, and should not be included in the optimization considerations, at least not in the short-term.

- **Contribution margin model – Cost-volume-profit-model:** This model is the most classic and applied model in Denmark. Among those who use or have used this model are Danish professors: Palle Hansen and Zakken Worre, both from CBS. This method distributes the variable costs to the cost bearers; i.e. both the direct and indirect variable costs are distributed. To some extent the model distributes variable costs to the cost bearers by using distribution keys. The distribution keys are usually sufficiently objective, but the adjustment of the time horizon to the calculation task is the great concern of this model. Here, the problem is that the sales and administration costs are partially variable within a certain time horizon; how far should this time horizon go?

- **Activity Based Costing (ABC):** Is represented by R. Cooper and Rober Kaplan[15]. This method distributes the direct costs on cost objects; i.e. the method distributed both direct variable and the direct fixed costs of a given activity, but does not attempt to distribute the indirect cost. The ABC model is increasingly applied by many companies. The model distributes all the costs caused by a given action, which is quite logical but has a downside in that the cost definition obtained is not coherent with an optimization model, neither the "total model" nor the MC model.

The differences between the three models are shown in figure 4.1. A brief verbal sketch of the model's illustrated points:

- The contribution margin model only distributes the direct and indirect variable costs
- The ABC model distributes the direct variable costs and the direct fixed costs. The indirect variable costs are to a certain extent distributed using of cost drivers.
- The full cost model distributes all costs

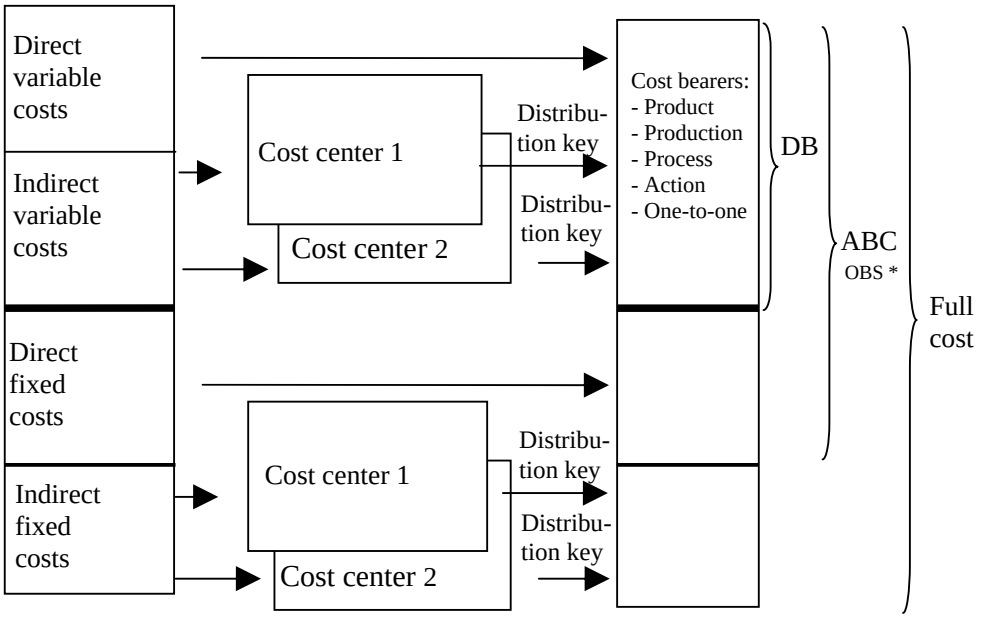


Figure 4.1

** The ABC model does not distribute all indirect variable costs*

Advantages and drawbacks of the different models are discussed later, although such a discussion is similar to standing in the eye of the storm. Experts and researchers, also at CBS, disagree on the different models, and especially about which one of them is the best. It may be sensible to argue that it depends on which type of calculation task is to be performed.

Variable costs and capacity costs

All the models have in common that they represent a trade-off between living up to sound economic reasoning and being practically applicable. It is for instance a theoretical weakness that the models, only to a very limited extent, include a time perspective (short-term, long-term).[16] This time factor, though not present in all models, is fixed, and cannot adapted to the specific decision-making task. Resultingly, the models generally use differing definitions of variable and fixed costs (also called capacity costs).

Here are the definitions professor Zakken Worre, applied in the marginal contribution model[17]:

- **Variable costs** are costs that in a any situation are given by the amount of activity and type of activity.
- The firm's capacities are the number of factors (in the widest sense), that are not in any situation controlled by the amount of the activity and the type of activity. We define **capacity cost**s as the costs caused by a (red. production) capacity.

Worre's definition of variable costs may be criticized as too narrow, it only embraces costs that are directly tied to the specific product unit, and furthermore, there is no implied time variability.
But the definition illustrates the difference between the polished cost theory and the more pragmatic calculation discipline. The contribution margin model has thus been constructed based upon the firm's accounting system, which does not traditionally include any aspects of time.

All the models contain more than just the principles of how to handle the joint costs, but in this chapter the models are presented focusing on that topic. Later, the full cost model and the contribution margin model are shortly introduced, while the ABC model is presented more thoroughly.

The full cost model

The philosophy of the full cost model (also called the cost absorption model) is that all the firm's costs at one time or another have to be attributed to or distributed between the cost bearers (typically products). That is to say, a part of the overhead fixed (capacity) costs is assigned to each specific cost bearer, and added to the variable costs of the good. In this manner, the good's own price is found.

All capacity costs are distributed to the cost bearers, according to distribution keys. The distribution keys in the full cost model are often considered arbitrary (random) in the sense that the distribution of the costs has nothing to do with how much the specific cost bearer use of the company resources.

In the figure below illustrates the emergence of the sales price of a good as the sum of the variable costs of the good, the good's share of the over head fixed (capacity) costs, and the net profit.

Sales price	Net profit	Own price + net profit
Own price	Part of the overhead fixed (capacity) costs	Distributed through distribution keys = distributed fixed costs + the variable costs below
Cost price	Variable costs	Distributed over a fixed time horizon to each unit, possibly through a distribution key.

The contribution margin model

The contribution margin model is based on the idea that the capacity costs are not to be distributed on to the cost bearers at all. The only costs that are attributed to a product are the ones that are directly connected to the product (i.e. variable costs). It is based on this information that financial control and decisions are to be carried out.

In this sense, the contribution margin model is as true to the economic marginal theory's marginal reasoning as possible. As mentioned earlier, the weakness is that the established time horizon must be extremely secure. The precision of the measurements are dependent on the complexity of the production, i.e. the number of processes, products, etc. Moreover MC is easily confused with the AVC, i.e. linear cost functions.

Sales price	Net profit	Own price + net profit
Own price	Part of the overhead fixed (capacity) costs	Distributed through distribution keys = distributed fixed costs + the variable costs below
Cost price	Variable costs	Distributed over a fixed time horizon to each unit, possibly through a distribution key.

4.3 Activity Based costing

ABC

Even though ABC[18] employs a slightly different terminology and another set of thoughts in distributing the costs than does the contribution margin model, the issues at hand are similar: relating the firm's costs to earnings-producing activities.

When a decision concerning pricing or product mix is about to be made, it is essential to know which costs belong to which earnings. If the costs are not in one way or the other contributing to the production of earnings, they may in an economic sense be superfluous. For instance, surplus capacity is a superfluous cost. The purpose of ABC is among other things to identify superfluous activities (=superfluous costs).

It may appear to be a very narrow economic perspective, but ABC is not constructed to stand alone or to be the sole basis for decision making. It is a tool for inspirational analysis, contributing with an estimate of the cost related consequences of the firm's activities.

Cost pools / Cost centers

Resources are divided into **cost pools** (some writers[19] use the term **cost center**s). Cost pools are for the specific firm defined so that every cost defrayed can be attributed to a cost pool. Examples of costs pools are employees, locations and information systems. Cost pools are always defined in DKK, which emphasize the direct connection to the firm's costs. A cost pool is typically controlled by a decision maker, responsible for the size and progress of the costs.

Cost objects

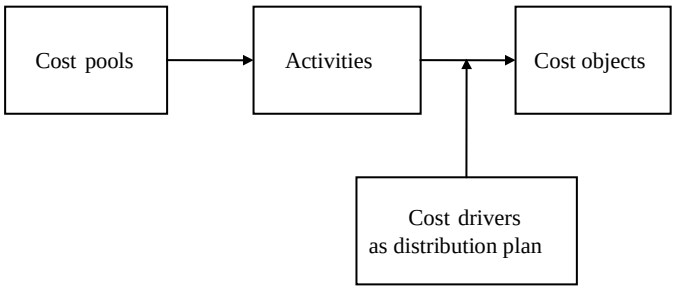
Cost bearers are in the ABC terminology called **cost objects**. Examples of cost objects are customers, groups of customers, product groups, and orders. Thus the term is closely aligned to what is traditionally referred to as division of purpose. Like cost bearers, the cost objects can be half-manufactured products and products that are traded internally in the firm.

A prudent connection between the cost centers and cost bearers corresponds to the creation of a rational linkage between cost pools and cost objects. However, it is not meaning that the cost pools and cost objects are to be combined one by one, the cost pools are too broad for that. The specific cost pool is to be distributed to several cost objects, and thus ABC can be conceived through a refined distribution key, supposedly less arbitrary than the traditional models.

Cost drivers/ Activities

The coherence between cost pools and cost objects is created by a link called a **cost driver / activity**. An activity is an action that draws on one or more resources, i.e. cost pools. This joining must not be confused with the activity term in the contribution margin model, where activity is an expression of the firm's output level.

The coherence between the central terms mentioned above is shown in the figure below:



As is the case of cost pools and cost objects, the activities have to be categorized in sensible way, if the coherence of the different terms is to be found in practice. Johnson and Kaplan, who introduced ABC in the end of the 80s, are very specific when it comes to categorizing the activities. They suggest four main groups of activities:

- **Unit determined activities:** These are directly determined by the production of a specific product unit. A product unit is typically a good or a service, and examples of the corresponding activities are consumption of raw materials, consumption of power, and the working process, that is directly related to the specific unit.

- **Activity series:** i.e. activities that are directly determined by the production of the particular product series. Costs that are caused by activity series do in principle not vary with the number of units produced in each series. Typical activity series are: reorganization of machinery for a new series, or quality control of a given existing series.

- **Product preserving activities:** This group of activities is tied to the particular product types and models. Thus the activity is independent of how many product series the specific product type is produced in, and the quantity of units produced. Examples: product development and product design.

- **Business preserving activities:** *ABC* operates with "the rule of one": Some activities, such as top level management and auditing are necessary no matter how much is produced in the company. Broadly speaking, these activities do not vary with the number of units, series, and products that are produced in the company, and as such they are irrelevant to distribute.

It is reasonable to consider the unit determined activities in the ABC equal to the variable costs from the contribution margin model (not to be confused with variable costs from the cost theory). In both circumstances, the terms vary wholly with the particular product. However one should be aware of the differences of activities in the ABC and costs in the contribution margin model. Activities are actions that can not be fully determined financially, whereas costs are always listed in kroner and øre. Herein lies ABC requirement for some kind of distribution key in order to distribute the activities between the cost pools that represent the costs.

More long-term oriented

The four activity terms above can be seen in relation to the more static contribution margin model, that only operates with two levels: Either the costs are variable or not.

Variable costs are in the contribution margin model exclusively defined with outset in the specific product unit, where ABC operates with series, product types and company specific levels, meaning that more costs can be distributed and fewer costs are classified as capacity costs. Business preserving activities are the ABC equivalent to capacity costs:

More true and fair

The positive idea is that the distribution carried out in ABC is somewhat more true and fair than the one carried out through, for example, the full cost model. Product costs that are independent of the production volume (product development and design for instance) will be distributed onto the particular products in the full cost model. This process gives the impression that the cost is dependent on the amount produced. In ABC, these costs, would on the other hand, be distributed onto the series, product type, or company levels.

Cost drivers

After the company has established a sound connection between the cost pools and the activities, it has to identify a linkage between the activities and the cost objects. This is found by using **cost driver**. Cost drivers can be compared to the units of use, and express how much a cost object draws on a given activity. A cost driver has a direct influence on how much a given resource is drawn upon; e.g. the number of invoices (cost drivers) has a direct connection to how much a given accounting employee (cost pool), who is in charge of billing (activity), is utilized. The cost driver for a mechanical engineer (cost pool) who re-calibrates machines (activity) for new production series, could be the complexity of the calibration for a given series.

ABC and the full distribution cost model

ABC and the full costs model differ from each other on the following points:

- ABC does not have the ambition of distributing all costs, as some activities are considered business preserving activities. This principle is in opposition to the full cost model, which seeks to distribute all costs.
- ABC operates with four different types of cost objects (units, series, product types, and company) while the full cost model only distributes costs at the unit level.
- ABC proposes a less arbitrary distribution key than the full cost model; i.e. distribution keys considered draw on real resources.
- ABC only distributes the indirect variable costs to a certain extent.

ABC and the margin contribution model

In relation to the margin contribution model, some substantial differences are worth drawing attention to:

In the margin contribution model, variable costs are defined on the unit level. Furthermore, ABC defines variable costs (by activities) on series and product levels. From the ABC perspective, this application method means that the capacity costs in the contribution margin model embrace both series, product, and company activities. In this way, ABC has the possibility of distributing more costs as (partially) variable and thereby decision-making relevant. A comparison of the ABC, the full cost model (FC), and the margin contribution model (MC) is shown in the table below:

	ABC	FC	MC
Units	V	V	V
Series	V	V	C
Product types	V	V	C
Company	C	V	C

V = Variable/distributed costs
C = Capacity costs

ABC provides certain guidelines for how the distribution keys are set up, in line with activity categorization, and cost drivers (even though there still is a great difference between the specific implementations). The contribution margin model is not that specific in comparison, meaning that from a margin contribution perspective the ABC is only one way of determining distribution keys. The ABC focus on activities means that the model is suitable for cost minimizing, where the non-value creating activities are liquidated.

As ABC treats series and product level so specifically, the model becomes more long-term oriented than the margin contribution model's focus on the particular product's margin contribution. This focus makes it difficult to handle events such as replacement of product types, which are typical long-term initiatives.

The justification of ABC

The limitations of the **margin contribution model,** concerning the fact that it only distributes the volume dependent costs, have with been criticized through the years. Increasing automation has resulted in fewer costs that vary directly with production volume, and an ever larger part of the company costs become capacity costs, applying the margin contribution terminology. As the capacity costs are considered irrelevant for decision making, the financial controlling rests on increasingly inadequate and short-term foundations in the contribution margin model.

Also, the fact that outsourcing (where the supplier insist on having his ATC covered as a minimum) is becoming increasingly popular, results in the variable costs are changing fundamentally with the choices of whether to outsource or not. Moreover, the margin contribution model does not consider that MC can be either progressive or digressive with economies or diseconomies of scale as a result, and thereby differ substantially from AVC.

Opposite the contribution margin model, the **full cost model** seeks to distribute all the company's costs onto the company's products. However, this only happens through the use of distribution keys, and so the full cost model often moves far away from an economic theory where the distribution keys can be explained objectively. Thus, when the costs are attributed to products in conjunction with which they do not vary, the profitability of the products are presented in a true and fair way. [20]

As we see, there are such essential issues at hand in the case of both the margin contribution model and the full cost model, that serious alternatives are more than welcome. ABC (activity based costing) seeks to counter some of the challenges faced by the two other models, in the process of which new problems arise. No wonder cost is a difficult issue.

Criticism of ABC

One could easily get the impression that ABC places itself between the margin contribution model and the full cost model, effectively incorporating the best from both worlds. Critics, on the other hand, point to the fact that ABC more likely places itself in a void, and fails when it comes to financial stringency.

Essential critique:

- It is problematic to continue ABC calculations in optimization situations, because ABC includes different levels of cost objects. It is too restraining that ABC can only be used as a source of inspiration for cost minimizing etc.
- ABC is a comprehensive solution, making it quite difficult to do ad hoc analyses on single products without setting up a relatively considerable system.
- The ABC model does not incorporate considerations of measurement, variability, and reversibility, which are regarded as fundamental for financial control.[21] These factors are, for instance, central to the margin contribution model.

No universal recipe

For some people, the choice of calculation method is more a question of religion or politics than a rational choice. One can hardly wonder why, when considering all the choices and limitations that are tied to the particular methods. When all essential factors are to be considered in a calculation, the problem at hand becomes so immense that at this point there are no complete solutions in model form. When choosing the calculation model, the choice also falls upon advantages and disadvantages, opportunities and limitations.

When confronting the problem, it is crucial to weigh both advantages and disadvantages of the different methods and relate them to the situation at hand. Different methods are suitable means for different ends, and a model that seem appropriate in one occasion may be useless in another. The best choice is achieved by knowing the different methods well, and at the same time, be conscious of the aims and conditions of each calculation. The choice is hard, and only few have a good understanding of all methods.

Case 4.1: DK Bodywork Parts Ltd.

DK bodywork parts Ltd.

"DK bodywork parts Ltd." is a 50 year old family owned business situated outside Tønder. The company manufactures bodywork parts for both cars and trucks, and has just below 3,000 different items in its selection. DK bodywork has 70 employees, of which 10 are administrative (sales, purchasing, accounting, and diverse administration) and 60 work in production. The firm has an annual turnover of 100 million DKK, and annual fixed costs of 20 million DKK.

Working procedure on a front wing/fender

In the firm's selection the item no. F127-98, a front wing/fender for a Fiat 127. The working procedure for the production is as follows:

1. Cut out the basic unit from a 1.5 × 3.2 meter galvanised metal plate.
2. Press the cut basic unit so that it takes the right shape.
3. Prime the wing/fender (degreasing, dipping in paint, and processing in oven)
4. Apply label with barcode and item number
5. Place wing/fender on a rack
6. Internal transportation from production hall to warehouse on a truck.
7. Shipment

Choice of cost calculations

The firm applies different cost calculations in different decision-making situations.

- The contribution margin model is applied in cases of short term optimization, or if there is idle capacity in production.
- The ABC model is applied when the excessive costs, for example, for idle capacity are to be identified. Here, the model relates to the costs for the activities that create earnings, so that the redundant activities can be localized.
- The full cost model is applied when the company has to settle on a "minimum sales price" in regards to the long-term planning of the products.

In the following examples of the margin contribution model, the ABC model, and the full cost model are presented based item no. F127-98, i.e. a front wing/fender for a Fiat 127.

The margin contribution model

The margin contribution model for one unit of the front wing for a Fiat 127:

Direct variable costs:

• Materials, including paint, metal, labels, etc. as well as shrinkage (experienced)	21.50 DKK/unit.
• Wages for production workers, including supplement of 28% for training/education, illness, etc.	24.25 DKK/unit
• Transport of purchases, quality control of raw materials	3.30 DKK/unit
• Power for production machinery	12.00 DKK/unit
Total	**61.05 DKK/unit**

Indirect variable costs

• Safety equipment, work clothes, etc. for production workers	2.30 DKK/unit
• Repair and maintenance of production machines. Distributed using machine hours as distribution key	6.90 DKK/unit
• Control of finished goods	4.20 DKK/unit
• Re-calibration of machines	5.90 DKK/unit
• Insurance of production workers	1.25 DKK/unit
Total	**20.55 DKK/unit**

Total costs of a single front wing/fender for a Fiat 127 according to the margin contribution model: **81.60 DKK/unit**

The ABC model

The ABC model for a single front wing for a Fiat 127

Production unit costs:

• Materials, including paint, metal, labels, etc. and shrinkage (experienced)	21.50 DKK/unit
• Wages for production workers, including supplement of 28% for training/education, illness, etc.	24.25 DKK/unit
• Transport of purchases, quality control of raw materials	3.30 kr./unit

• Power for production machinery	12.00 DKK/unit
• Safety equipment, work clothes etc. for production workers Distributed using wages as cost driver	2.30 DKK/unit
• Insurance of production workers Distributed using wages as cost driver	1.25 DKK/unit
Total	**64.60 DKK/unit**

Production series costs:

• Control of finished goods	4.20 DKK/unit
• Re-callibration of machines	5.90 DKK/unit
Total	**10.10 DKK/unit**

Production type costs

• Development of tools for production of the front wing	**16.70 DKK/unit**
Costs for a single front wing for a Fiat 127 according to the ABC model	**91.40 DKK/unit**

The full cost model

The full cost model for a single front wing for a Fiat 127:

Direct variable costs:

• Materials, including paint, metal, labels etc. as well as shrinkage (experienced)	21.50 DKK/unit.
• Wages for production workers, including supplement of 28% for training/education, illness, etc.	24.25 DKK/unit
• Transport of purchases, quality control of raw materials	3.30 kr./unit
• Power for production machinery	12.00 DKK/unit
Total	**61.05 DKK/unit**

Indirect variable costs

• Safety equipment, work clothes, etc. for production workers	2.30 DKK/unit
• Repair and maintenance of production machines. Distributed using machine hours as distribution key	6.90 DKK/unit
• Control of finished goods	4.20 DKK/unit
• Re-calibration of machines	5.90 DKK/unit
• Insurance of production workers	1.25 DKK/unit
Total	**20.55 DKK/unit**

Direct fixed costs

• Depreciations of production machinery Distributed by using machine hours as distribution key	19.75 DKK/unit
• Development of tools for production of the front wing	16.70 DKK/unit
• Interests in capital tied to machinery (opportunity costs)	1.10 DKK/unit
Total	**37.55 DKK/unit**

Indirect fixed costs

• Administrative costs Distributed with turnover as distribution key	4.38 DKK/unit
• Lawyer and accountant Distributed with turnover as distribution key	0.80 DKK/unit
• Salary and car expenses (directors)	0.20 DKK/unit
• Operation of buildings (maintenance, property taxes, etc.) Distributed with turnover as distribution key	3.90 DKK/unit
• Interests of capital tied to buildings (opportunity costs)	0.20 DKK/unit
Total	**9.48 DKK/unit**

Costs of a single front wing for a Fiat 127 according to the full cost model	**128.63 DKK/unit**

4.4 Assignments for Chapter 4

Mini-case 4.1: "The Bicycle Mosquito"

The Bicycle Mosquito is a bicycle store in Østerbro. It was established in the mid 1990s by a former professional bicycle rider. Apart from the owner, the store has 2 employees: an experienced bicycle mechanic and a second-year apprentice. The bicycle store is competing fiercely with the other bicycle stores in Copenhagen, which is why the owner focuses much on attracting customers with good offers.

One of The Bicycle Mosquito's offers is tire repairs for DKK 28 not including VAT, which results in a sales price of DKK 35 (34.95) including VAT. For a period of time now, the owner has been wondering why the competitors do not follow the low mending prices offered by The Bicycle Mosquito. Therefore, he wishes to determine whether or not the offer is profitable. To that end, the following information has been listed:

- When estimated, including all bonuses, the real hourly wage is DKK 140 for the experienced bicycle mechanic and DKK 75 for the apprentice.
- The capital tied up in the business is worth DKK 1 million.
- A chain of bicycle stores establishing itself in Denmark is ready to buy The Bicycle Mosquito for DKK 2 million.

- The annual rent is DKK 60,000 – The rent can be divided between the sales/ show room (DKK 40,000) and the workshop (DKK 20,000)
- The owner has been offered a job as sports journalist for Ekstrabladet, with an annual salary of DKK 200,000 if he sells the bicycle store.
- The experienced bicycle mechanic can handle about ten mends per hour, while the apprentice can handle about 6 per hour. Because of the strict demands for versatile working conditions stipulated by apprentice legislation, the apprentice is not allowed to handle all the mending repairs, even though that would the cheaper alternative. Therefore they have to take turns doing the repairs.
- In connection with each mending, a schematic is filled out, a note to be fixed to the bike, a bill is to be written, etc. all of which take about 6 minutes.
- The costs of the mending, glue, power etc. equals DKK 2 per mending.
- Last year 6,000 mending repairs were carried out, contributing with 15% of the total turnover of the workshop.
- Maintenance of tools etc. caused by wear and tear reached DKK 30,000 last year.
- The owner can invest surplus capital at 5% annually.

Case assignment 4.1:
Make a calculation using both the margin contribution model and the full cost model. The calculations are to be made with the purpose of helping the owner to assess the profitability of the offer.

Case assignment 4.2:
Discuss the applicability of the two calculations regarding the assessment of the offer.

Case assignment 4.3:
Which other circumstances than those related to the costs/turnover of the mending repairs could influence whether the offer is profitable or not?

Question 4.1 List the most frequent decision-making situations for a pizzeria, where the pizzeria should apply calculations – and assign a useful calculation model to each of the situations.

Question 4.2 List a number of examples of distribution keys, which could be relevant for Harboe concerning the production of Harboe Pilsner.

Question 4.3 How are time horizons included in the models?

Question 4.4 Which calculation model is typically the basis of MC functions and why?
Why are MC functions so hard to define in reality?