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Dynamic Costing

Troels Troelsen

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Dynamic Costing
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Dynamic Costing[1]

Costs defined in a dynamic perspective with decision making as objective

"You cannot formulate one universal cost term, you have to establish different cost terms and measures for different purposes"

John Maurice Clark 1923[2]

"Producing a good requires an effort of resources that usually has a price. This consumption of resources is called costs. To produce a specific good with the lowest possible cost is a decisive factor for the long-term success of a business. Therefore, it is important to be able to establish costs in order to obtain the relevant management information necessary to achieve the lowest possible production costs.

Achieving the lowest possible costs is a holistic job, involving management, business culture, optimal technology, optimal internationalization, optimal size of production, etc. And costs vary with the relevant decision occasion. This is the dynamic perspective."

Troels Troelsen 2003

"By definition, a cost is considered to be relevant if it is affected by a management decision. Any cost not affected by a decision is considered irrelevant."

Paul G. Keat and Philip K.Y. Young 2000[3]

Author of the book is Troels Troelsen, Course Coordinator Department of Operations Management Copenhagen Business School, 2003

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Preface

The objective of operations management is to organize the production and sales/marketing efforts in the most appropriate way for the business.

The purpose of a business is to produce a series of goods or services (from this point on, these terms are considered the same and are referred to as goods). It is a deciding factor that this process is achieved as cheaply as possible.

- Private business products: A Harboe non alcoholic beer, a box of Legos, a newspaper, a car repair.
- Public business products: A full year's work for a pupil in 7th grade, a hip operation, administration of fines.

The challenge and problem of costs can be described as:

1. Production of a good requires an effort or consumption of resources that in most cases have a price, i.e. a minimal consumption of resources, at the lowest possible price, is essential.
2. This consumption of resources is called costs
3. Producing a specific good at the lowest possible cost is often decisive for the long-term success of a business.
4. Therefore it is important to be able to establish costs in order to obtain the necessary management information, required for achieving lowest possible production costs.
5. Achieving as low costs as possible is a very holistic job, involving management, business culture, the right technology, the right internationalisation, the optimal size of production etc.
6. The cost of producing a good vary in terms of the relevant decision-making occasion, **which is the content of a dynamic perspective**.

A business can, among other things, be described as a string of contracts (nexus, nodes), which combined comprise the fundamental base, the production, and the liquidity access (sales or grants/appropriations).

Such contracts (to buy, sell, establish a production facility, hire staff etc.) are commonly agreed upon with contracting entities outside the group of owners and decision makers. It is therefore essential to understand a number of models which place the firm in the context of its environment.

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Concerning the course of and decision-making situations in operations management, there are three central problem areas relating to a firm's decision analysis, each of which is described in compendiums, paving the way for the possibility of a future book.

- The firm in context (available in English)
- Dynamic Costing, costs in a dynamic perspective
- Dynamic Pricing, pricing in a dynamic perspective

These fields will all be described based on known and solid operations management models and theories. An extension will though be directed towards structuring decision-making in terms of the decision-making circumstances and conditions relevant to the specific occasion.

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1 Introduction to Costs

1.1 Introduction

Cost theory

The term "theory" is a Greek derivative and means: "seen from above." That is to say that a theory is an overall discussion of a subject, taken out of the concrete decision-making situations, while focusing on the general aspects, and not the specifics.

But in order to understand the general aspects, you have to understand the specifics, and the theory cannot be so general that it does not apply to the specific decision-making situation.

The defining of a cost theory, focusing on separating different decision-making occasions, and thereby allowing for the understanding and description of the differences these factors present in cost-theory, is a problem we hope to solve with this text.

Decisions have to be indivi-dualized

Some of the conditions that require the individualizing of cost decisions include:

- Different time perspectives
  - Short-term, including planning of tomorrow's assignments and decisions
  - Long-term, including planning of future assignments and production

- Different products
  - Perishability, e.g. Legos vs. fresh vegetables; Legos maintain their value in a warehouse, whereas fresh vegetables quickly lose value.
  - Alternate values, e.g. milk not sold at supermarkets could be used in the production of milk-powder. A hotel room vacant for the night, on the other hand, has no value the following day.

- Different forms of production
  - Automated production, e.g. production of Legos; i.e. if there are economies of scale or diseconomies of scale.
  - Manual production, e.g. food in a restaurant.
  - Service production, where knowledge is a decisive factor for production.

- Different levels of competition intensity in a market
  - Low levels of competition allow for long-term planning.
  - High levels of competition require short-term planning.

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- Different future expectations
  - Is an increase in production temporary or permanent?
  - Is a decrease in production temporary or permanent?

- Different dependencies on external conditions, such as market conditions.
  - Dependence on consumer confidence indexes, which influence long lasting consumer goods such as cars, as well as both small and large kitchen appliances.
  - Dependence on business confidence indexes, which influence investments, production lines, automating initiatives, expansion/reduction in warehouse capabilities, the "Bull whip"/Forrester effect, i.e. when changes in consumption-level is multiplied up through the supply chain.

- Different seasonal dependencies
  - Some businesses are influenced by high and low seasons, e.g. camping sites have high season in vacations, and clubs have high season during weekends.
  - Some businesses, on the other hand, are not affected by seasonal deviations, e.g. cigarettes, milk, furniture etc. are sold independently of season.

- Random factors
  - Weather-based production (agriculture)
  - Affects of war/terror/disease (travel agencies)

Achieving the lowest possible costs

For firm's long-term success, it is essential to produce a certain amount of goods or services at the lowest possible cost. Producing at the lowest possible cost is a holistic management job, contingent on the following points:

- **The optimal production design:** The production design is a combination of machines, technology, employees, IT, etc., together comprising the production machinery.
- **The optimal production design:** The production design is a combination of machines, technology, employees, IT, etc., comprising the production machinery of the firm.
  - At the Harboe breweries the production machinery consists of fermentation containers, bottling machinery, bottle cleaning machinery, malting machinery, grain reception, IT systems, production leaders, employees, etc.

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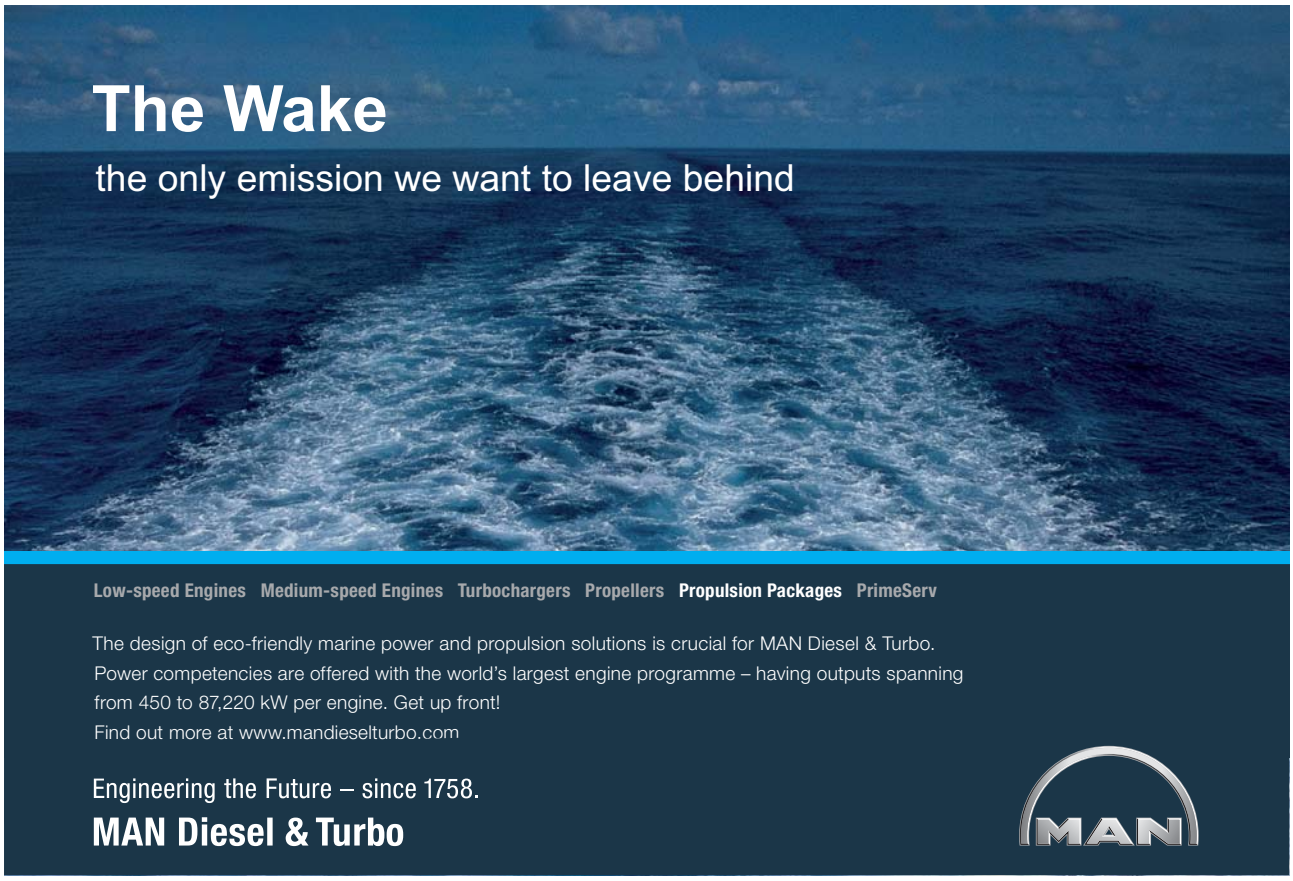
- **The optimal combination of production factors:** The production factors are all the factors applied when producing a good or a service. Production factors include:
  - Natural resources, e.g. the sites of Harboe's factories
  - Workforce, i.e. the knowledge and skills of e.g. master brewers, metal workers, bottling staff, etc.
  - Physical capital, i.e. bottling machinery and storage tanks.
  - Liquid physical capital, e.g. power for machinery, hops, and malt, at Harboe.
- **Optimal technology:** The firm can continuously renew the production machinery because of the technological development. However, technological improvements have to be assessed on the basis of cost-benefit analyses. Investments are to be made if the increased value exceeds the costs.
- **Good, motivated employees:** It is the competencies and motivation of the employees that determine whether or not the firm can produce at the lowest possible cost. In other words, it is futile to make the production machinery more effective if the benefits are neutralized by demoralized employees.



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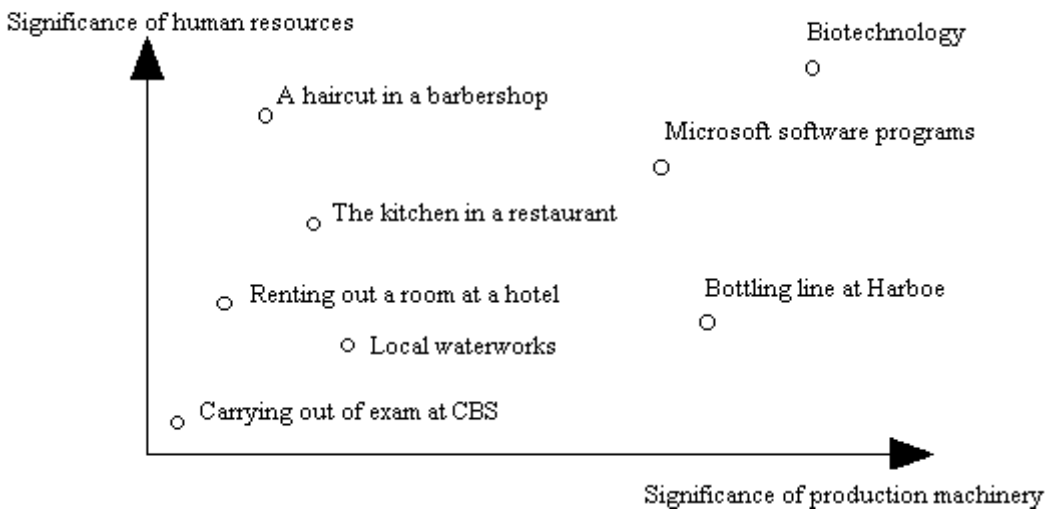
- **Optimal outsourcing:** The managers have to compare the production costs of the firm with the costs of buying from a supplier. In case the firm cannot produce the good at the lowest costs, the firm should outsource the production – and apply the effort elsewhere. Furthermore outsourcing has the advantage that part of the risk of the firm is transferred to the supplier. E.g. if the demand is lower than expected, some of the costs of a surplus production are assumed by the supplier.
- **Optimal internationalization:** The firm's degree of internationalization influences, among other things, the possibilities for outsourcing production to low-wage countries. The size of the production is also influenced by the degree of internationalization, which is important in terms of relation discounts, economies of scale, etc.

The significance of the above factors is dependent on the business sector, as well as distinctive features of the firm. For example, the production design, the combination of the factors of production and the technology are central management issues at the Harboe breweries. On the other hand, in an architect firm, a central issue will be attracting good employees – and making sure that they are constantly being motivated

Production type significance

The factors described above comprise different values in conjunction with different production forms. Some forms of production are mostly dependent on production design, i.e. machinery, employees, technology, IT, etc., while other production forms are more dependent on competencies and employee motivation. See figure 5.1.

Figure 5.1 Human resources versus the production machinery



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Decisions and costs

The basis for the future existence of almost any firm, is the ability to make the right decisions at the right time.

The most important cost-related decisions include:

- To produce a good at the lowest possible cost, i.e. to understand the origin of costs in a firm and to understand and manage the process, which leads to the lowest possible costs.
- To expand the product portfolio to include new products – or to reduce it.
- To invest in production facilities
- Whether to have in-house production or to outsource to a supplier
- To relate to and participate in the competition in the market place.

The decision outcome is dependent on multiple factors, such as costs. E.g. the decision of whether to produce or outsource will depend on the costs of in-house production compared to the costs of outsourcing. The time horizon of the specific decision can be quite decisive. Also, the costs of re-establishing production could also be a relevant consideration.

Even though it may be difficult to comprehend that the costs of producing a specific good can differ based on the decision-making occasion, this reality is at the core of a dynamic cost theory. Which is also the motivation for this book.

Case 1a:
When Avis car rental planned the purchase of new cars for 2001, they of course had to assess the total costs of owning a rental car for the planned time horizon, presumably two years. Including interest, and depreciation costs, also included in the rental. For a medium class car the result was that the total costs at a 12,000 km rental was 2.68 DKK per kilometer. When September 11th drastically changed the way many perceived the world, travel-activity diminished dramatically, prices on used cars fell unexpectedly, etc. AVIS and the other car rental companies ended up with huge, idle car fleets , only capable of making money in one way: by being leased. But in this new and more short-term oriented competition, the short-term costs were only 1.24 DKK per kilometer when leased. This new situation meant that AVIS had to understand the changes created by dramatic and unexpected external causes.

Registration and decision-making

This paper/book is concentrating on cost theory from a decision-making perspective. There are other perspectives, such as the registration oriented perspective, known from presentation of accounts, periodic accounts, annual accounts etc.

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The fundamental difference here, is that while registration provides a picture of the historic activities of the firm (ex post), decisions are centered on the future of the firm (ex ante), which can still be influenced. Of course the historic experience will mostly provide a solid database for setting up future costs, but still there are a number of fundamental differences, shown in table 1.1.

	Registration	Decision-making
Purpose	The purpose is to give a true and fair presentation of the financial position of the firm, which can for example provide for external stakeholders' reaching an accurate financial evaluation of the firm.	Oriented towards decision-making so that the firm can make the most efficient use of its means of production. *i.e. the expectation of a more rational production is composed here.*
Aspect of time	Historic perspective – ex post	Future perspective – ex ante
Target group	The accounts provide information for external as well as internal stakeholders.	Mainly internally in the firm providing basis for decision-making.
Legal obligations	The companies are obliged to present annual accounts bound by legal criteria regarding how the costs are specified and presented.	It is up to the specific firm whether to apply economic theory in managing the firm.
Scope	The accounts, in most cases, cover the entire firm.	Economic analyses are often carried out for single investments and single problems.
Frequency	Accounts are mostly presented monthly, biannually, or annually.	Carried out on an ad-hoc basis, when the situation demands it.
Cost definition	Costs of consumption/usage, which are the costs that sooner or later will be financially realized. In other words, costs that are to be paid or realized through losses in value.	Both costs of consumption/usage and opportunity costs (treated later), which are loss in income that emerge in case the factors of production have a possible alternative usage, which cannot be realized as a consequence of the activities.

Table 1.1: Fundamental differences between registration and decision-making

1.2 Different Cost Definitions

Cost case based on the costs of driving a car.

Different cost related problems are treated later in this chapter in relation to a simple car case (My Uncle's Car, case 1.6). Why the description of cost functions, cost types, and other costs are relevant to decision-making is based on the determination of the costs of owning and driving a car.

The case is simple but contains many of the issues that appear in when determining the costs of a specific activity.

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Expenses, payment, and costs

When determining costs, one has to differentiate between the following terms:

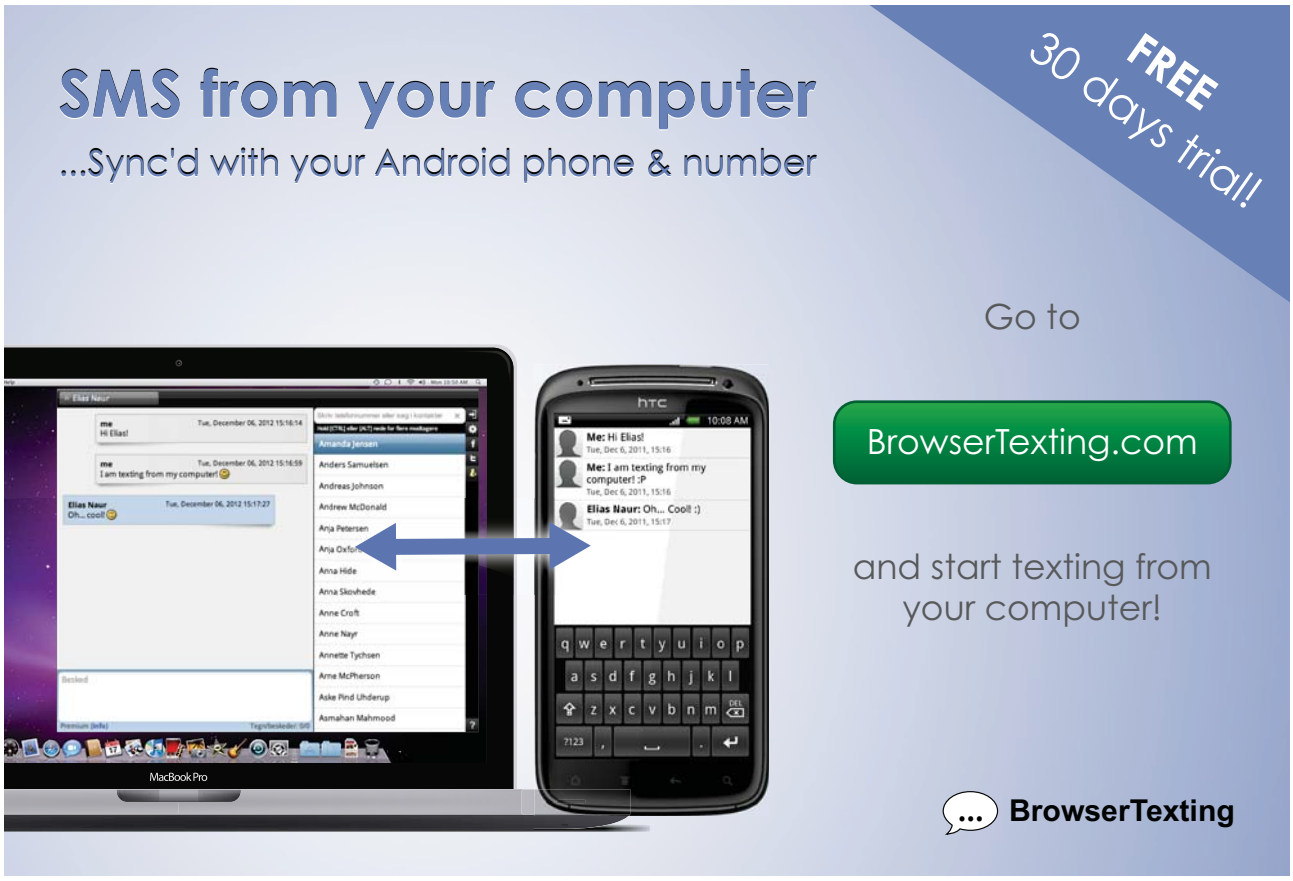
- *Expenses, which are implicit in the making of a deal, purchasing factors, and production.*
- *Payments, which are the cash flow resulting from expenses.*
- *Costs, which appear when the specific factors of production are utilized in relation to a given activity.*

Based on the car case:

- Fuelling up is an expense
- If cash is the method of payment, then the expense generation and payment occurs simultaneously. Whereas when a creditcard/membership card is the means payment, then the actual payment experiences a time delay, i.e. when the debt to the creditcard or membership card is cleared.
- The cost of a given trip appears as the fuel is consumed.

Generally speaking:

- An expense and a payment are separated when buying on credit.
- Costs usually have to be spread over many usage periods, i.e. if the factor of production endures in many years: e.g. the buying of the car (the depreciation is spread over several years).



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In certain circumstances:

- The opportunity costs can exist even though there is no matching expense or payment, which is the case when your own factors of production are used; e.g. a farmer who himself is working on the farm, or a grocer who has tied his own money up in the inventory. When using own factors of production the opportunity costs are of great significance (see below).
- An expense can exist without any payment, which is the case if the supplier accidentally does not send the bill, or if the firm goes bankrupt and is not able to pay the bill.
- An expense can exist without a matching cost; i.e. if the expense does not concern the specific activity; e.g. the purchase of inoperative software or the hiring of a person that does not show up at work.

Different cost definitions

It is important to understand there are many differences and similarities concerning costs, which is why different definitions and examples of cost types are listed below.

Costs of consumption/ usage

In terms of the consumption/usage definition, costs are defined as: *"The, in money, assessed consumption/usage of production assets, included in the completion of a given product and sales procedure."*[4]

In other words, it is about costs that are paid or realized through loss in value.

Based on car case 1.6 the costs of consumption/usage are the, in money, assessed consumption/usage of factors of production concerning the owning and driving of a car. Examples of costs of consumption/usage are:

- Fuel, tires, maintenance, wear and tear etc. All of which are consumed/used during the driving of the car, i.e. mileage-dependent costs.
- Insurance, vehicle excise duty, interest etc. All of which are consumed/used by letting the car stand still, i.e. time dependent costs.
- And then some costs that are difficult to manage: e.g. the risk of damaging the car while driving (damage typically results in the payment of own risk and in some cases a higher premium), or a flat tire, an act of vandalism on the car, a deficiency in the alarm system etc.

Depending on what the decision-making situation demands, consumption/usage costs can be stated in terms of mileage, trip, period of time, driver, or as situation-dependent.

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Opportunity costs

Opportunity costs are defined as the indirect loss in income, occurring if the factors of production have alternative uses that are excluded by the activity.

In this situation, we see an expansion of the consumption perspective as the use of own factors of production, such as workforce and equity, are embraced. Here the exclusion of alternative activity is also embraced.

If carrying out activity X inhibits the possibility of carrying out activity Y, then the value of carrying out activity Y is the opportunity cost of activity X. Opportunity costs are also called implicit costs.

To an owner of a car the opportunity costs are equal to the value of the best alternative, in the case that having the car rules out other activities. Some examples:

- Alternate rate of return possibilities on the capital that is tied up in the car. This example is determined by the fact that if the car were sold or not bought in the first place, yield could be obtained by buying stocks or bonds.
- Alternate leasing of the car, which means that if driving in the car excludes the possibility of leasing it, the lost income is an opportunity cost.

Grocer case 1.2:
A minor grocery store is owned by a 35 year-old man and has an annual turnover of 2,100,000 DKK and annual costs of 1,750,000 DKK which, without taking opportunity costs into consideration, makes a profit of 350,000 DKK a year. He has tied up 500,000 DKK in the inventory and he has, if he is willing to sell, been offered 500,000 DKK in goodwill for the business, money that could produce a 4% yield on the bond market. Moreover he has been offered a job at a major retailer offering a yearly salary of 320,000 DKK -and possibly better working conditions.

The profit of the grocer is presented with and without opportunity costs in table 1.2:

Profit excluding opportunity costs:	Profit including opportunity costs:
Turnover 2,100,000 kr. – Costs of usage 1,750,000 kr.	Turnover 2,100,000 kr. - Costs of usage 1,750,000 kr. - Opportunity costs (yield) 40,000 kr. - Opportunity costs (alternative salary) 320,000 kr.
Profit 350,000 kr.	Profit - 10,000 kr.

Table 1.2: The profit of the grocer, excluding and including opportunity costs.

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According to table 1.2 the grocer achieves a profit of 350,000 DKK but it excludes other alternative activities (yield and salary if employed), which results in a direct loss of income of 360,000 DKK. According to this, the grocer would achieve an additional income of 10,000 DKK a year by closing down business, taking the job at the retailer, and investing the released capital from the inventory in bonds.

1.3 Fixed Costs vs. Variable Costs

Fixed costs

Fixed cost are defined as those which do not vary with the level of output.[5]

Fixed costs are the costs that do not increase and decrease with the size of the production.

The fixed costs are the costs of having a given production capacity. In the car case, these are examples of fixed costs

- insurance
- vehicle excise duty
- value loss of car because of age

Insurance and vehicle excise duty are fixed costs because they do not vary with the mileage.

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Variable costs

Variable costs changes as the level of output changes.[6]

Variable costs are the costs that increase and decrease with the production. In the car case these are examples of variable costs:

- Fuel
- Maintenance
- Value lost on the car because of mileage

Fuel and maintenance are variable costs as they vary with the mileage

But there are also some problems. If the product is "one driven kilometer," then its obvious that the use of fuel is not the same if you drive economically or fast, in the city or on a highway, or are stuck in traffic during rush-hour. With a midsize class car it may mean a difference between a car driving 15 km/liter or driving 4 km/liter. The wear and tear on brakes, clutch etc. is also very different.

If a cab driver in northern Jutland is to sell his cab, based on the above stated reasoning, then he will promote it as a country-cab; i.e. a "northern-Jutland-Mercedes-cab" despite it having driven the same amount of miles as a "Copenhagen-city-Mercedes-cab," it has experienced significantly less wear and tear. Once again, it is not that simple to present an unambiguous coherence between product and costs.

The problematic classic treatment of variable costs

The problem of the classic cost-theory is that variable costs are treated exclusively, as variables compared to the determined unit, e.g. size of production, mileage, etc.

Other factors can equally influence the variable costs:

- Motivation for work among the employees, i.e. efficiency.
- Employee treatment of materials, machinery, equipment etc. i.e. use of resources.
- Organization of the work, i.e. the management solution.
- The more complex the production is the greater the role played by education, communication, understanding of the firm's culture etc. which is why these factors have to be optimized as well.

Only by focusing on all the influencing factors is the achievement of the lowest possible cost assured.

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Costs of owning and driving a car

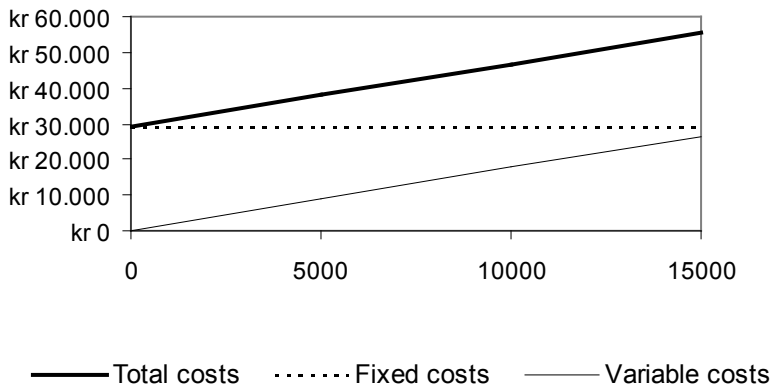
In the following section, fixed and variable costs are explained on the basis of the costs of owning and driving a car. The annual costs of owning and driving a car are, for the sake of simplicity, illustrated in figure 1.3, where the mileage (Q = quantity) is depicted along the horizontal x-axis and the costs measured in DKK are shown along the vertical y-axis.

The costs are communicated as variable, fixed, and total cost functions. As seen in figure 1.3 the variable costs increase with mileage, while the fixed costs remain at the same level, independently of the mileage. Furthermore, it is clear that the total costs are the sum of the fixed and variable costs.

Some Implicit assumptions are made:

- Time horizon is a one year.
- Getting rid of the car during this year is not an option.
- Driving needs are stable, and the manner of driving remains unchanged (the mix of city and countryside, aggressive and careful driving) etc.
- Accidental costs are said to be estimable and calculable; e.g. repairs, tires etc.

Figure 1.3: Annual costs of owning and driving a car as a function of the number of kilometers driven



Determining unit of activity

Based on the car case, there are no obvious difficulties connected to defining the car's activity level as the kilometers driven. This unit seems to be both a natural and operational calculation unit. Concerning truck driving, bus driving and other machine-based services, "hours" are frequently the unit of measure, no matter if the machine works more or less. In each situation both measures can be more or less right or wrong. The costs vary in proportion to both variables, hours or kilometers, depending on the activity. But this variation is not identical in different situations.

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For production firms, the number of units produced, denoted as Q for quantity, is most often the unit of determination. But for other industries such as restaurants, architectural firms, and law firms, there are no comparable measurement units. In these cases the number of hours, turnover, or even amount of costs, can be the product; as assignments differ greatly, this may be the only common denominator.

This variability means that the decision maker has exert themselves to find suitable measurement units See examples below:

- Concerning restaurants, the number of customers or the turnover typically will work as a measurement unit for the level of activity. The problem with the number of guests being used as the measurement unit is that there is a great difference in activity level, from guests who only order one course and a glass of wine, to those that order the full 5-course dinner with the accompanying wine menu. Turnover is also problematic, as the measurement of the activity level is affected by the price level, the earnings on the different products (drinks versus food), as well as price promotions. So, turnover is not without problems when applied as measurement unit

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- In regards to architectural firms and law firms, the number of working hours is a natural unit of measurement for level of activity. However, when applied as measurement unit, the number of working hours involves a great deal of uncertainty. Both concerning time and finances, there is a great difference between hours worked by a newly educated (working slowly at a low wage) individual as compared to a more experienced (working fast at a high wage) architect/lawyer. Furthermore, more hours are not necessarily equal to a better job done. The total work load may also affect both work speed and work effort. Both professions tend to let the number of hours decide the magnitude of a given assignment.

1.4 Separation of Fixed and Variable Costs

Time horizon

The time horizon is decisive when separating costs into fixed and variable costs. Costs vary in conjunction with the time horizon. This fact is suitably explained by the costs of materials, workforce, machines, and rent employed in a production firm:

- In the extreme short-term, the materials employed in the production may be the only variable costs, as this employment increases and decreases with the slightest change in production. Worker salaries, depreciation of machinery, and rent are, in the span of a few days, fixed costs, as they do not adapt to the size of production. Even workers in production companies have a few weeks notice, although day laborers do exist. The short-term production planning is also dependent on whether the goods used are storable.
- In the medium-short-term the materials employed and the production-workers' salaries are both variable costs, as long as the workers can hired or laid off with relative ease. Depreciation of machines and rent are fixed costs. These are for the most components of the minimum costs that have to be covered by the sales price – unless the product has no value if it is not sold. A product that has no value if it is not sold, has a cost of 0 DKK when it is to be sold. The late owner of the travel agency Spies said: "Even if we only get 1 DKK for the last seat to Mallorca, it's better than an empty seat."
- In the medium-term, materials employed, production-workers' salaries, some administrative workers' salaries, and depreciation are considered variable. This is the case, as long as the machines can be sold at the depreciated value. Rent is a fixed cost.
- In the long-term all production factors are variable, e.g. interest is variable to the extent that the rent can be adapted to the size of production by simply moving the production to either larger or smaller facilities, depending on the production level. Fixed costs turn into opportunity costs, i.e. the cost of alternatively employing production factors, such as rent and equity.

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The time horizons listed above are dependent on the firm and the business sector; thus they are relative.

E.g. companies can change all factors of production in conjunction with different time horizons. This flexibility means that the long-term is relative:

- For a window cleaning firm, possibly under one year
- For a taxi firm, possibly 1–2 years
- For a bus haulage contractor, possibly 2–3 years
- For pizza shop, possibly 3–4 years
- For a food product firm, possibly 8–10 years
- For a sugar factory, possibly within 15 years
- For a car manufacturer, possibly within 15 years

The other time horizons: extremely short-term, medium-short term, and medium-term, will then adapt to the long-term definition.

As will be apparent from cost theory later on, costs are traditionally and fundamentally, without regard to the decision issue to be solved, divided into short-term and long-term, which are defined as follows:

- *Short term, where at least one factor of production is considered a fixed cost.* This could be rent or office employees' (white collar) salaries, that cannot be changed within the time horizon because of giving notice requirements.
- *Long-term, where all factors of production (workforce, capital etc.) are variable, which means that they can be phased out within the time horizon.*

One of the motivations for text is the facilitation of understanding that such a separation always has to be seen in relation to the relevant decision-making situation. No matter how crystal clear this separation is, the reasons for decision-making must be analyzed before this distinction can be realized.

There exists a group of theories which are only applicable to the short-term, and another set of theories that only apply in the long-term. Of course there are a number of terms and techniques that apply in both long-term and short-term cases. Consequently, the time horizon is a decisive determinant for the specific decision-making occasion and it is fundamental that the time horizon is applied consistently.

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Furthermore, it is important to be aware that mostly firms decide on the short-term and long-term simultaneously; e.g. if the management in a minor retail chain plans the pricing strategy for the next year, while simultaneously a reaction to the competitors' "birthday-promotion" has to be laid out for the following week.

Regarding the time horizon, the main point is that it is necessary to remain focused and constantly attentive to the applicable time horizon.

Different time horizons and decision-making situations result in different costs for the same production. No wonder costs theory is difficult.

Permanent vs. temporary changes in production

Costs will typically react differently under production increases, production decreases, permanent changes, and temporary variations. Costs are also product dependent.

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Case 1.4:
Rank Xerox has a number of issues worth contemplation concerning the number of service mechanics involved in different situations:

a) Under a permanent change in number of copiers
   - If the number increases, training of new service mechanics will be initiated, so that they after 6–9 months the level will be appropriately adjusted to what is equally as efficient as the current level of mechanics.
   - If the number decreases, the least efficient surplus mechanics will be laid off, which can take 3–6 months.

b) A temporary change in the number of copiers
- If the number increases, the most likely outcome is the use of overtime for a period, combined with the anticipation of hiring new people. There might be re-deployment within the organization of people who can easily be trained for the job.
- If the number decreases, there will be no laying off of workers, because of the time it takes to re-educate workers and the insecurity involved in rehiring the same level of qualified workers. These workers will typically be employed elsewhere during this period. As laying off workers is quite costly, the solution will most often be an attempt to sell more copiers. This argumentation seemingly applies to all copier-manufacturers, and a tactical progress will have to be analyzed.
  i.e. the difficulties of re-establishing an important knowledge capacity or production is crucial in the adaptation flexibility.

Discussion of fixed and variable costs

The classification of fixed and variable costs makes room for difficult discussions, especially between decision makers (managerial economics) and accountants (financial control/management accounting), as the decision-making occasion in a control-situation is not as variable as in a decision-situation.

The basis of the discussions is the fact that they work with ex post registrations (historic) and ex ante decision-making occasions ("what-if"). Also, decision makers can be presented with many decision-making occasions for which it is unreasonable to expect that the accounting system can deliver data. Finally, decision makers are, because of the mentioned management assignments, often distinguish between fixed and variable costs, while accountants distinguish between capacity costs and unit costs, which are defined below:

- *"Capacity costs are the costs that result from capacity. Average variable costs are costs that result from a specific transaction of goods."*[7]

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This basic difference in definition of cost is rooted in the purpose of the costs.

The decision makers' distinction between fixed and variable costs is applied in calculating tasks concerning e.g. optimization of price or quantity, often with different time horizons, long-term price lists, short-term price competitions, frequent adaptations in capacity, both increases and decreases, different worker capacity for knowledge storing, and different products.

On the other hand, accountants' distinction between overhead fixed costs and average variable costs is applied in relation to external financial reporting, internal analyses, and internal control, e.g. predicting calculations and result-documenting calculations. Naturally, there are limits for the number of perspectives that can be applied in a single accounting and registration system; if these limits are not clearly delineated, then a massive information overload results.

The following is a simplified example of this discussion:

It is a common notion among decision makers that fixed costs, depending on decision situation and time horizon, can be spread on the costs-bearing products and thus be regarded as variable. This understanding relates to Robert Kaplan[8]: *"I'd say that, for most purposes, all costs should be considered variable."* Accountants on the other hand, regard the spreading of fixed costs (capacity costs) on the products as a mortal sin. The argument is that the spreading of fixed costs results in the closure of products, which within the financial period creates a positive contribution margin. Products that create a positive contribution margin should not be closed down, considering that any contribution margin that covers fixed costs is better than no contribution margin. Michael Andersen and Carsten Rohde[9] have appropriate input at this juncture: "*The difference between sales income and variable costs can be expressed by means of the contribution margin… in this way it becomes a central result-term in controlling the profitability of the firms different activities.*"

Another essential argument for not adding the fixed costs in optimization analyses is that the optimization theory (marginal costs = marginal revenue) shows that this results in solutions that are not optimal. The snake in this paradise is that MC is difficult to understand , as the time horizon can be uncertain.

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This discussion between the micro theorists and those adhering to Activity Based Costing by Robert Kaplan, is not yet concluded. There are many arguments and case-studies from both sides. It is not the objective of this paper to solve this discussion. As everybody has such a hard time agreeing, I have to accept that: "It depends on the decision situation and horizon."

1.5 Other Costs Distinctions Relevant for Decision-Making

Direct costs

Direct costs are the costs that result from a single activity, production, production facility, or cost bearer, and a direct cost can exist at different levels, such as the unit, the product line, the activity, the process or the department. Direct costs are separated into fixed and variable costs.

In a production firm, the direct costs in medium-short term are:

- ***Direct variable*** costs are materials employed, power consumed directly in production, calculated waste, salaries to production workers, etc.
- ***Direct fixed*** costs are operation of relevant buildings, technical facilities, yield of the capital tied up (opportunity cost principle), control etc.

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With regards to the car case, direct fixed costs are insurance and vehicle excise duty. The direct variable costs are fuel consumption, as the fuel consumption varies with the mileage, while it is also directly attributed to the covered kilometer.

Indirect costs

Indirect costs are the costs that cannot be attributed to the specific action, production, production facility or cost bearer. Indirect costs are separated into fixed and variable costs.

In a production firm the indirect costs in the medium-short term are:

- ***Indirect variable*** costs are repair and maintenance, cleaning, quality control, management of production/cleaning/service as well as parts of the administration.
- ***Indirect fixed*** costs are senior level management, directors, accountants, legal and strategic advisors, general types of insurance, operation of non attributable offices (directors offices, in-firm fitness facilities etc.), parts of the sales and administrative departments, IT-backbone etc.

Examples of indirect variable costs from the car case are: maintenance costs, as these costs vary with the mileage but cannot be attributed directly to specific covered kilometer. These costs appear abruptly and concern repairs that cannot be planned. Other examples of indirect costs are: a broken external rear-view mirror, repair of the wipers etc. An example of indirect fixed costs is depreciation of the car's value as it becomes an older model.

Reversible costs

Reversible costs are the costs that appear as a result of a production increase and disappear with a production decrease.

A high degree of reversible costs enhance the firm's capability to disengage from costs and thus change production level. Costs can also be partly reversible, which means that they increase more under a production increase than they decrease in conjunction with a production decrease, in which case it is only partially possible to disengage from the costs by lowering production.

In the car case, the vehicle excise duty and insurance are examples of reversible costs, as these disappear if the car is sold. Both the vehicle excise duty and the insurance premium is returned proportionally when cancelled.

A partly reversible cost is when a firm buys a car, and later wishes to sell it. In this case the car dealer's profit is lost. In most cases a car bought at a dealer's for 130,000 DKK and sold back after a short period of time, will only bring in 100,000 DKK. This partly reversible cost results in a loss of 30,000 DKK.

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Irreversible costs

Irreversible costs are costs that are not annulled upon a decrease in production.

A high degree of irreversible cost deteriorates the firm's possibilities of disengaging from costs by changing production level.

With regards to the car case the subscription to companies such as AAA, FDM, or other driving-support companies, are a short-term horizon irreversible costs, because these memberships do not stop when the car is sold.

Coming costs

Coming costs are the costs that appear when new products, activities and actions are launched.

If a car owner chooses to replace the car with a new and bigger/better version, incurring additional expenses, such as an increased insurance premium, these additional expenses are defined as coming costs. To purchase a new car is a coming cost, and to have special features installed is also a coming cost.

Going costs

Going costs are defined as cost savings connected to closing down products, sections, etc.

If a car owner chooses to sell the car, all the cost savings are going costs. Reversibility is essential to the going costs. Education of employees or installation of facilities on premises for specific production (e.g. ventilation), are typical coming costs but not going costs.

Sunk costs

Sunk costs are costs that are already paid/invested, and cannot wholly or partially be recovered. Sunk costs cannot be affected or neutralized by a new decision.

With regards to the car case, the re-registration fee is an example of a sunk cost, as this cost was paid when the car was bought and cannot under any circumstances be recovered. For this reason the cost is not to be integrated in any future decision processes.

Other typical examples of sunk costs are ad campaigns, distribution of leaflets, research costs, education of employees etc.

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Grocer case 1.5:

A grocer has decided on an advertising initiative involving distribution of a brochure to the local households. The printing will be carried out by a local printing house for 20,000 DKK and the distribution will be taken care of by the local boy scouts, who promised to distribute the brochures for 5,000 DKK. Furthermore the grocer expects an increase in earnings of 30,000 DKK as a result of the advertising campaign.

Unfortunately, as the brochures are ready, the boy scouts report that they cannot carry out the distribution. If the grocer wants the brochure distributed, the post office has to do it, which costs 15,000 DKK. Should the grocer have the brochures distributed or cancel the marketing initiative? Of course the answer depends on the profits of completing the initiative.

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In table 1.5 the profit of the initiative is calculated, both with and without the sunk costs

Profit, without sunk costs		Profit, with sunk costs	
Increase in earnings	30.000 kr.	Increase in earning	30.000 kr.
- Printing	20.000 kr.	- Distribution	15.000 kr.
- Distribution	15.000 kr.		
Profit	-5.000 kr.	Profit	15.000 kr.

Tabel 1.5: Profits of carrying out the initiative, with or without the sunk costs.

As is obvious from table 1.5 the printing costs are sunk costs, which means that the costs, at the decision-making moment, have been defrayed and cannot be recovered. Furthermore, it is clear that if sunk costs are considered, i.e. if they are not integrated into the decision making process, carrying out the advertising initiative result in a profit of 15,000 DKK. This profit has to be considered on the basis that the only other alternative is not to complete the initiative but still pay the 20,000 DKK for the printing. For this reason, the grocer should continue with the advertising initiative.

Joined costs

Joined costs are the costs that apply to different products in combined production before they are separated in the final production.

An example: the costs of growing and harvesting pineapples that at the factory are separated into pineapple juice and canned pineapples.

Separate costs

Separate costs are costs that apply after products of joined production are separated in the production.

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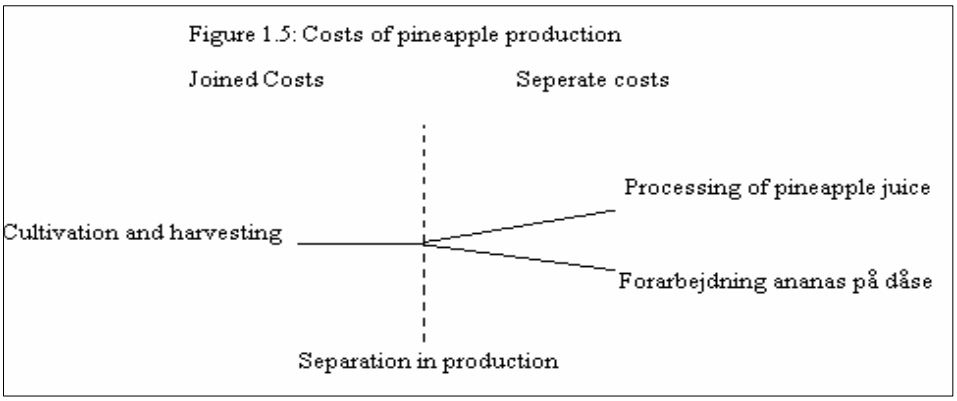
An example of this is the costs of sieving the pineapple juice and the costs of cutting the canned pineapples, which despite the fact that the costs up to that point have been joined, must be treated separately. Joined and separate costs are illustrated in figure 1.5:



Marginal costs

Marginal costs are the increase in total costs when producing one additional unit.

Marginal costs are often applied in regards to pricing. In the car case the marginal costs are applied in order to find the costs of driving an additional kilometer, or an additional trip, depending on the decision-making situation. Marginal costs are calculated as Δ costs / Δ units (in the car case kilometers replaces units), where Δ symbolizes the amount of change incurred by one unit. Marginal costs (MC) is the most used theoretical term in optimization assignments. The weakness of MC is that the entire discussion of fixed and variable costs reappears. The longer time perspective in the decision-making horizon, the more costs become variable, and thus MC increases.

Difference costs

More problems arise in this category. Sneaking costs ("Can it…"), capacity pressure as well as optimism and pessimism.

Case 1.6: The Car Case "My Uncle's Car"

The car case "My uncle's car"

Wishing to provide a basic understanding of how costs should be treated, as well as an understanding of the obligation to treat costs differently in different situations, the car case "My Uncle's Car" is introduced. A car example has been described in earlier examples, but below the case is described more thoroughly:

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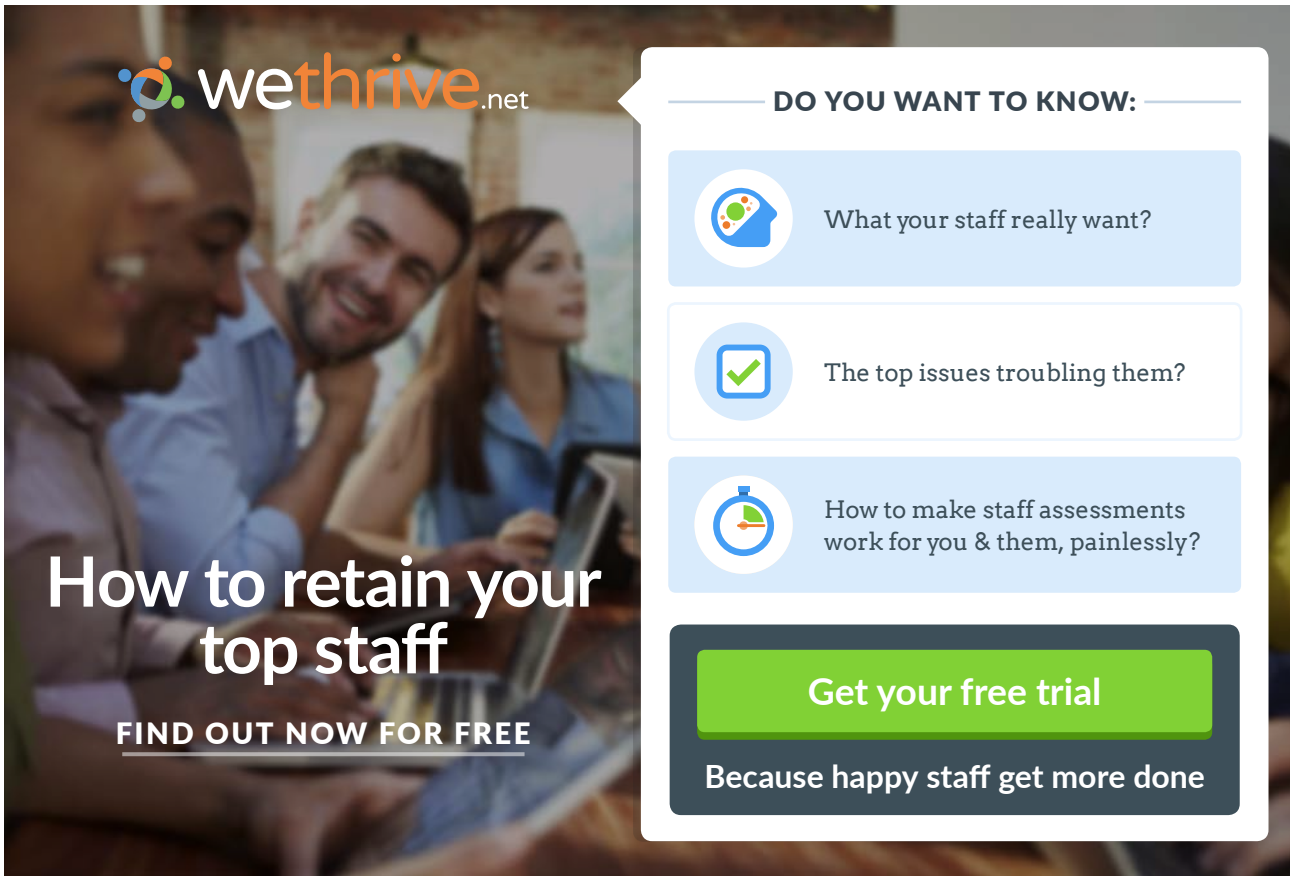
As I, Søren Hansen am an HA-student, I cannot afford my own car, which is why I now and then borrow my uncle's car. He owns a five-year-old VW Golf worth about 100,000 DKK, which I can borrow if I cover all his costs. As he is an economist and wishes to train my economic understanding, he asked me to analyze what "all costs" include. The deal is apparently crystal clear – but there is room for interpretation which can result in room for disagreement, as we will see later.

The deal was: "all costs" my uncle incurred by lending me his car. In order to clarify this term, I would like to start by drawing up my uncle's costs of owning and driving the car. The costs[10] below are calculated on basis of a yearly mileage of 15,000 km, an average fuel consumption of 10 km/liter and a fuel price of 8 DKK/liter.

My uncle's costs

Fixed costs, independent of mileage (in DKK/year):

- Insurance (liability, comprehensive, fire, accident, etc.) 12,565
  The premium depends on level at to which the car is insured, this entry will probably will change over time, based on "good customer" status or the length of time my uncle has been insured, as well as the number of accidents reported.
  My uncle is elite class driver.



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- Vehicle excise duty 2,260
- FDM and Danish Auto Help 775
- Carwash, parking etc. 2,164
- Interest 5,022
  Interest is calculated as follows:
  ((opening value 100,000 + closing value 90,500) / 2)
  multiplied by the interest rate 5,27%
- Loss of value over time 6,000
- Inspection 200
  The car is inspected every second year for 400 kr.
  which is 200 each year. It is assumed that the costs of
  repair in connection with the inspection is included in the
  maintenance costs.
- Total 29,077
- DKK per kilometer at 15,000 km pr year 1.94

Variable costs, increase and decrease with mileage (in DKK/year)

- Fuel 12,000
- Tires 1,940
  It is assumed that my uncle changes tires after 30,000 km and
  that the total costs of these is 3,880 DKK, i.e. 1,940 kr./year
  (at 15,000 km.)
- Service check-up 2,400
  It is assumed that a service check-up is carried out for after
  7,500 km and that the costs are 1,200 each time.
- Maintenance (wear and tear repairs) 6,749
- Loss of value due to mileage, at 15,000 km. 23.3 øre/km. 3,500
- Total 26,589

DKK per kilometer at 15,000 km. 1.77

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Relevant factors

With regards to the question about how much it should cost me to borrow my uncle's car, several factors must be considered, including the following:

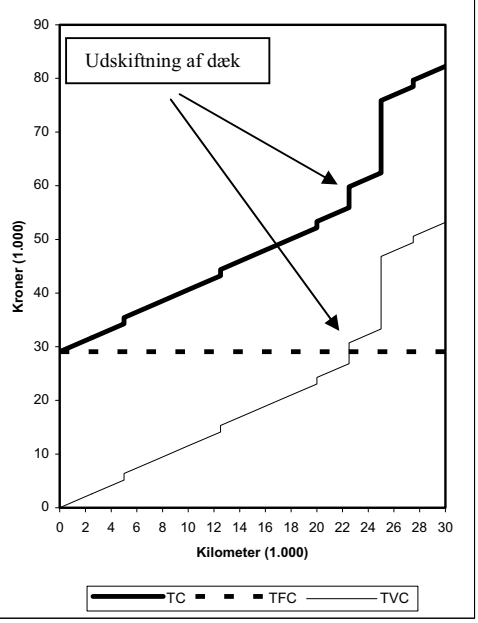
- The time horizon, owing to the fact that there is a decisive concerning fixed costs, whether I borrow the car for two hours or three months, regardless of driving.
- The mileage is of course very important as it is this factor upon which the variable costs are highly dependent.
- My uncle's situation concerning the car, as the costs are to be treated differently whether he would be using the car himself, or if he is on vacation, or can rent it out to a friend.
- "Coming costs," which are the extra costs taken on by my uncle as a consequence of my borrowing his car; e.g. a possible change in the insurance policy if I borrow the car frequently, depending on his current policy.
- Risk supplement, owing to the fact that if I borrow the car there may be greater risk of the car getting damaged than when it is in garage.
- Situations where my uncle wants the car no matter what, based on his own needs it.

Costs functions

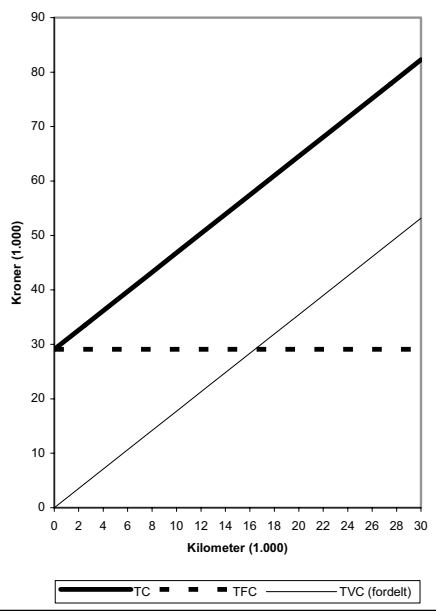
In order to give a survey of the costs, cost functions are made for the following cost types, as shown in figure 1.6.1 and 1.6.2

- *Total variable costs (TVC), which expresses the joined variable costs.*
- *Total fixed costs (TFC), which expresses the joined fixed costs*
- *Total costs (TC), which expresses the joined fixed and variable costs*

Figur 1.6.1: Samlede omkostninger i forbindelse med bilen pr. år



Figur 1.6.2: Samlede omkostninger i forbindelse med bilen pr. år



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The figures above illustrate my uncle's total costs concerning the car, as a function of the mileage. Figure 1.6.1 shows the costs concerning the loss of value due to mileage and the costs of fuel consumption as well as the costs of changing the tires, service check-ups, and maintenance. Owing to these factors, the curve "jumps," and thus illustrates the costs. Figure 1.6.2 on the other hand shows the costs after spreading the variable costs over each driven kilometer. This means that the curve is flattened, which owes to the fact that the costs of service check-up, change of tires and maintenance are treated as a cost of each driven kilometer.

The cost functions mentioned above provides a highly simplified picture of reality, as it is often necessary to make a number of more or less reasonable assumptions, before such functions can be defined.

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Explanations and assumptions

Explanations and assumptions regarding the above figures:

- *The TVC curve with "jumps" (figure 1.6.1):*
  - The even rise of the curve owes to the fact that each kilometer causes costs of 80 øre for fuel (12,000 DKK / 15,000 km) all the while the car loses 23 øre (3,500 DKK / 15,000 km.) of value per driven kilometer.
  - Service check-ups, it is assumed as mentioned earlier that these are being carried out each 7,500 kilometers and cost 1,200 DKK. Furthermore it is assumed that the last check-up was carried out 2,500 kilometers ago, which is why the curve makes a 1,200 DKK "jump" at 5,000, 12,500, 20,000 and 27,500 kilometers.
  - It is assumed that the tires were last changed 7,500 km. ago, which means that the curve makes a 3,880 DKK "jump" at 22,500 kilometers.
  - Furthermore it is assumed that all the maintenance costs are realized at one time at an expanded 10,000 km service check-up, including the necessary repairs, which is why the curve makes a 13,498 DKK "jump" at 25,000 km.

- *The TVC curve without " jumps" (figures 1.6.2):*

  - Figure 2 is a development of figure 1, and the variable costs have simply been calculated as total variable costs for 30,000 km. and then divided with 30,000 km., which yields 1.77 kr./kilometer. This method is reasonable as the indirect variable costs are spread over the cost bearing kilometers. E.g. it is reasonable to distribute the costs of changing tires on the kilometers that wore them down.

- *The TFC curve both with and without "jumps" (figures 1.6.1 and 1.6.2):*

  - As mentioned earlier, the fixed costs are not affected by the mileage, and thus they are 29,077 DKK, regardless of the quantity of kilometers driven.

- *The TC curve both with and without "jumps" (figures 1.6.1 and 1.6.2):*

  - The TC curve shows the joined costs, which is why the curve is a vertical addition of the TFC and the TVC curves. Resultingly, the curve starts at 29,077 DKK and matches the tendencies of the TVC curve afterwards.

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Moreover, the cost model has been simplified such that no considerations are made for the greater value loss incurred by the initial kilometers. Likewise no considerations have been made regarding the fact that the maintenance costs are increasing during the period, due to the fact that the risk of damages and wear and tear are less pr 10,000 km between 70,000 and 80,000 km, than 10,000 km between 80,000 and 90,000 km.

So, what do I tell my uncle? Still an open question.

Situation dependency of the cost function

There are a number of issues other than the stated assumptions, which influence the costs, and result in the cost function being less than completely accurate; e.g. maintenance costs, tire and fuel are highly dependent on the manner in which the car is driven. Driving at 130 km/h results in higher fuel consumption than driving at 80 km/h. Driving in cities causes relatively more wear and tear on brakes than driving on a country road. Driving on salted roads during the winter in Denmark, causes higher value loss than driving on dry roads in summer.

The product "a driven kilometer"

Cost functions with the number of kilometers as measurement unit Q is problematic for the car case, as the purpose of owning and driving a car is not just the generating of mileage. The purpose, on the other hand, is to be able to drive wherever you want, whenever you want to. As a result, the product I borrow from my uncle depends on the circumstances; e.g. the product "one driven kilometer" in a city differs from a long trip on the highway, one kilometer at high speed is quite different from a kilometer driven safely, a kilometer by an unskilled driver is different from the same distance driven by a skilled driver. Moreover, the value of having a car is dependent on the condition of the public roads. The costs vary based on all these circumstances.

Decisions and costs

In connection with defining my uncle's costs of letting me borrow the car the specific decision-making situation is of great importance (= opportunity costs). In order to give an insight into this line of thought, a number of decision-making situations are presented, where the costs are to be treated differently:

- I am at a Christmas lunch at my uncle's, and all the family except me has had too much to drink. Suddenly my girlfriend calls and asks me to pick her up. In this case, my uncle's costs of letting me borrow his car can be regarded as the variable costs of the trip as the time horizon is quite short and he is not able to drive anyway because of his drinking.

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How much should I pay?

- I have just been offered a four week job, with relevant for my education, requiring me to spend every afternoon on a location outside Ringsted, where it is impossible to go with public transportation (I live in Copenhagen). My uncle tells me that I can borrow his car, despite the fact that he himself would have liked to use it in the same period. As a consequence of this, my uncle's costs of letting me use his car are regarded as the variable costs as well as a part of the fixed costs, e.g. the fixed costs divided into 365 days and multiplied by 28. Furthermore it would be appropriate for me to pay my uncle for "owning" his car during this period.

  How much should I pay?

- If the situation above is changed so that my uncle is on vacation and has no use of the car, the costs of letting me borrow the car are changed as well. Then the costs would be regarded as being the variable costs plus potential opportunity costs, in case my uncle could have rented the car out to a friend.

  How much should I pay?

The decision-making model 1.6 is generated in order to structure the above thoughts into a more general way, so that the model is applicable in different decision-making situations.

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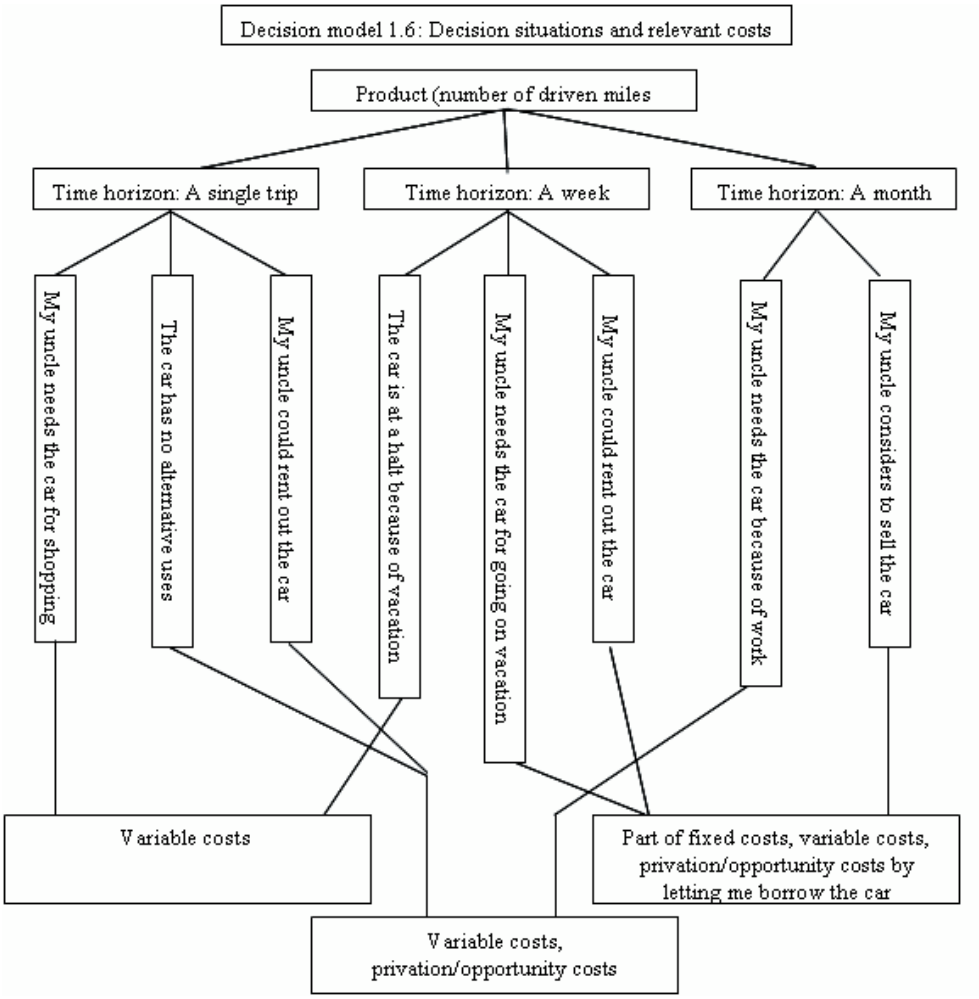

1.7 The Management Job

Control levels

To produce at the lowest costs possible requires attention being paid to all control levels – including the management levels. The control levels can be described as follows[11]:

The strategic control level: The management decides on the long-term goals of the firm and strategies are delineated in order to reach these goals. Furthermore the setting is as follows (not exhaustive):

- Core competencies, areas of activity, and growing demands
- Degree of internationalization
- Product design
- Product development
- Essential investments, including new technology
- Profit policy

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The time horizon is dependent upon the business sector, company size, entry/exit barriers, production machinery, etc., but is typically 2-10 years. Given the long-term horizon great uncertainties are often connected to decisions made on this level.

- For Harboe, the time horizon would be considerably longer than for an architectural firm. Among other factors, this reality is due to the fact that Harboe breweries have a significant market position, are heavily invested, and that the beer and soft drink industry is relatively stable. An architectural firm on the other hand is less heavily invested, and is at the same time highly influenced by market conditions.

The tactical control level: The management of this level works within the frames defined by the strategic level. The work consists primarily of planning and coordinating the activities of the firm, including:

- Adjustment of technology and production machinery
- Prepare budgets
- Plan production
- Prepare and adjust marketing plans
- Take charge of the human ressource administration of key employees.

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This writer does not compare key employees with "white collar workers," due to the fact that "blue collar workers" can be irreplaceable as maintaining production often is dependent on them.

The time horizon depends on the business sector, company size, entry/exit barriers, production machinery etc., but is typically 1–2 years.

The operational control level: The management job on this level is purely operational. The management has to provide a detailed planning and execution of production, administration, marketing, and sales in the short-term. The following factors must be included:

- Human ressource administration
- Carrying out of different types of control, including quality control
- Prepare costs calculations for concrete orders

An example may be the master brewer's decision regarding the summer's production of beer at Harboe.

The learning curve

In order to produce the good at the lowest possible cost, management has to exploit "the company's learning," i.e. exploiting that managers as well as employees learn how jobs are solved in the best possible way. This is due to the fact that "company learning" causes increases in efficiency which combined with a proper management effort produces lower costs.

- At Harboe the management wants to build a better environmental network down through the organization, improving working efficiency. Moreover the production workers will achieve a routine experience while also getting better at repairing the machines during production standstills, which increases efficiency.
- In the architecture firm, the management wants to learn the best way to hire new architects, including what characterizes good architects. Furthermore the management wants to learn how to motivate the employees so that they constantly do their best. Both factors will increase the firm's efficiency.

The effects of "company learning" are shown by the company's learning *curve*[12].

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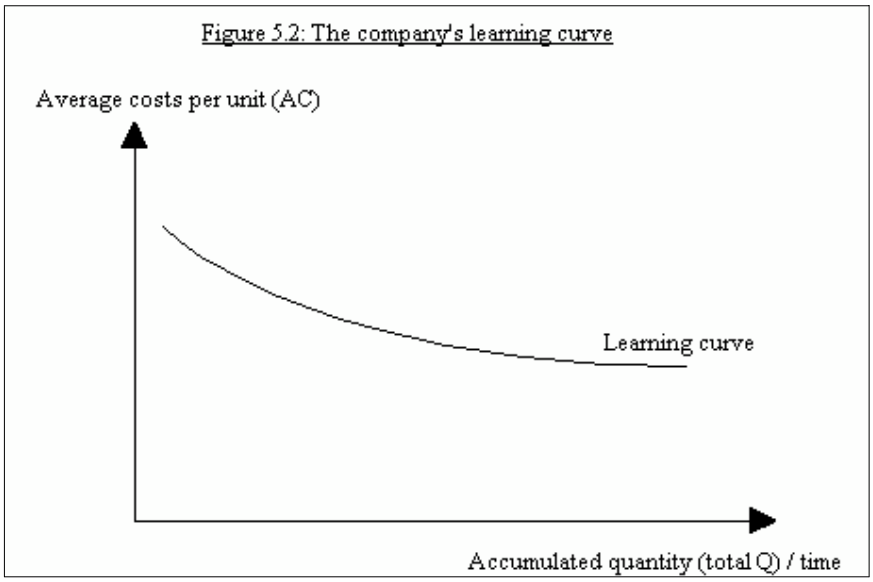

The learning curve and the short and long-term

The learning curve in figure 5.2 shows that the average costs per unit decreases with the greater the quantity produced, i.e. the longer the period of time the firm has produced the good or service. The time horizon has great influence on the learning curve, as more effects of the learning curve can be exploited the greater the time horizon. The time horizon could actually constitute a third, independent axis in figure 5.2. In the short-term, the firm will only benefit from the effects of improvement seen through leaders and employees. As the time horizon expands experience with production design can be exploited, as this can be changed in the long-term. However, the learning curve only expresses the effect of company learning. The average costs per unit do not inherently decrease as the number of produced units increases. This owes to that the fact that the average cost per unit are also influenced by capacity limits, discounts, availability of qualified work force, etc.

1.8 Assignments for Chapter 1

Mini case 1.1: "Innocence"

Innocence is a French fashion house established in the 1980s. First the fashion house exclusively produced exclusive lingerie for women. Later on, the fashion house expanded the assortment to include exclusive women's wear as a whole. Now the fashion house wishes to include perfumes in their assortment. Innocence has neither the facilities for development or production of perfumes, which is why this job is outsourced to an Italian perfumery. Suddenly, Innocence begins to have doubts as to whether the perfume project is economically viable. They want an analysis of the costs connected to the project from their own perspective. It should be mentioned here that the perfumes are neither wholly produced nor marketed.

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A list of the different activities connected to the project:

- The hours used by the French fashion designer and the management on the perfume project has an estimated value of 1.7 million €.
- The development of the designs of the perfume bottles, which are developed by Innocence's own designers.
- The hiring of a new internal head of marketing. The head of marketing is to be responsible for the promotion of the perfumes, including segmentation of markets, choice of marketing strategy etc.
- The marketing campaign for the perfumes, which is prepared by Innocence's head of marketing and an external marketing agency.
- The administrative work concerning the project, including the cooperation with the Italian perfumery.
- The Italian perfumery's future work on the production of the perfumes, i.e. the total production costs of the outsourcing.

Case assignment 1.1:
List three other relevant cost areas.

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Case assignment 1.2:
As part of the efforts of creating a survey of the costs, you are asked to list the activities after cost type, including fixed vs. variable costs, reversible vs. irreversible costs, and decision relevant vs. non decision relevant costs.

Case assignment 1.3:
How would you alter your decision structure if the perfumes had already been produced and marketed?

Question 1.1 A professor in economy tells you that short-term decisions regarding cost considerations do not have to incorporate fixed costs, as these do not vary with the output.

1. Is he right?
2. Is your reply situation dependent?
3. Give an example of a cost that sometimes is fixed and other times variable.

Question 1.2 The foreman in a production company wonders why the hourly salaries in production as well as the prices of raw materials have increased, while the average costs have decreased. What is a possible explanation?

Question 1.3 List three frequent decision situations that require a thorough knowledge of the firm's costs.

Question 1.4 A farmer, age 58, owns a farm in northern Jutland where he operates a 100 hectares of agricultural land. He has long been thinking about whether he would be better off selling the farm and possibly get another job. To help make this decision he has compiled the following information:

- Land and building total worth: DKK 12 million.
- Machine worth: DKK 2 million, and their worth in sales decreases by 0.3 million annually. If the machines were sold, a tax of DKK 0.5 million would be imposed.
- The farmer has loans totalling DKK 6.0 million, at 5% annually.
- The profit after tax and interest last year was DKK 400,000. This profit includes free housing provided by the farmhouse. He expects an equivalent profit next year.
- He can rent out the land at DKK 5,000 per hectare.
- For the time being he does not rent out the outhouses, but these could be rented out as storage room to a local master carpenter for DKK 50,000 a year.
- He has just been offered a part time consulting job in the local cooperative society with a yearly salary of DKK 150,000.

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- If he sells the land including the buildings, a tax of DKK 3 million is imposed.
- The farmer could invest surplus capital at 6% yield per year.
- The rent in an alternative satisfying residence would be DKK 50,000 a year.
- The farmer has an income and interest tax of 50%.

What would you advise him to do, and which other economic considerations would you include?

Question 1.5 The Danish Competition Authority continuously supervises mergers. This awareness is used to balance the extreme influence on market pricing, possible higher prices to customers, gained when merging into larger entities. Based on the cost perspective, you are to argue that merging companies can cause both consumer price increases and decreases.

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2 Cost Functions

Purpose of cost functions

For a given firm, pricing as well as production planning require thorough knowledge of the firm's costs at different activity levels

For instance the owner of a pizzeria needs to know about costs incurred to the firm at different activity levels (number of pizzas produced) when pricing in connection with a brochure that is to be distributed door-to-door. Costs vary with activity level, as purchases of raw materials, hiring of employees, choice of oven, and maybe even size of the location depend on the chosen level of activity. Which costs vary with the activity level depend on the owner's decision-making horizon, e.g. if there are big differences between planning the daily operations and strategic considerations regarding the pizzeria's future.

With the purpose of assisting the decision maker (e.g. the owner of the pizzeria) cost functions expressing cost as a function of the activity level are devised. Depending on the functions of the decision-making situation, the following cost functions are applied:

- Total costs (TC, TVC, and TFC)
- Average costs (ATC, AVC, and AFC)
- Marginal costs (MC)

Concerning cost functions, it is important to find a suitable measurement unit for the activity level. The measurement unit varies with business sector and industry. Examples of measurement units are:

- Produced units (number of baked pizzas, printed magazines, manufactured cars)
- Turnover (expresses the activity in restaurants and clothing stores)
- Working hours (expresses the activity for architectural firms and law firms)

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2.1 Cost Functions in the Short-Term

Total functions

In the following, the cost functions are explained within the frame of the firm's short-term time horizon, which is why both fixed costs and variable costs are involved. The basis of the firm's cost functions are the total-functions as described below.

- *"Total fixed costs" (TFC):* The fixed costs do not fluctuate with the activity level, within the chosen time horizon. For instance the pizzeria's rent, interest, oven installation, etc., do not vary based on the number of pizzas baked over a short-term time horizon.

- *"Total variable costs" (TVC):* The variable costs change based on the activity level within the chosen time horizon. For instance the cost of flour, meat, and workers' salaries, vary in conjunction with the number of pizzas baked, even within the short-term time horizon.

- *"Total costs" (TC):* The TC-function is found through vertical adding the TFC and TVC curves, i.e. by compiling the fixed and variable costs.

Average functions

As is the case when finding any average, the average-functions are calculated on the basis of the firm's total-functions, which are then divided by the relevant factor (in this case quantity). The average-functions are found as shown below:

- *"Average fixed costs" (AFC):* Expresses the fixed costs divided by the output, i.e. TFC/Q (Q = quantity, e.g. number of pizzas produced in a pizzeria).

- *"Average variable costs" (AVC):* Expresses the variable costs divided by firm output, i.e. TVC/Q.

- *"Average total costs" (ATC):* Expresses the total costs divided by firm output, i.e. TC/Q

Marginal functions

When the firm plans its production level, it is crucial to know how much the total costs change as related to a change in quantity. In this case marginal costs are applied.

- *"Marginal costs" (MC):* Expresses the change that appears in the total costs as a result of the firm producing one unit more. For instance, the marginal cost function for the pizzeria expresses the change in the total costs which appear when one additional pizza is produced.

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The firm's marginal cost function is thus found as the change in the TVC function (or the TC function), resulting from a change in the quantity produced. For this reason the MC function is found by differentiating the TVC-function (or the TC function, as the constant is neutralized in any case):

$$\boxed{\text{MC} = \frac{\partial\, TVC}{\partial\, Q} \text{ or } \frac{\partial\, TC}{\partial\, Q}}$$

The cost development

Costs can develop in the following ways:

- Proportionally, i.e. if the activity increases 1% then the total costs also increase 1%.
- Digressively, i.e. if the activity increases 1% then the total costs increase less than 1%.

  This phenomenon is called increasing returns to scale, or economies of scale. In modern production this is the norm, as many actions support this: The more you buy the cheaper it gets. Administrative systems are cheaper for each unit, and marketing as well as production lines are utilized more efficiently.

- Progressively, i.e. if the activity increases 1% then the costs increase more than 1%

  This phenomenon is called decreasing returns to scale or diseconomies of scale.

  In modern production this is not normal. If existing it is probably found in service sectors which are heavily knowledge-based.

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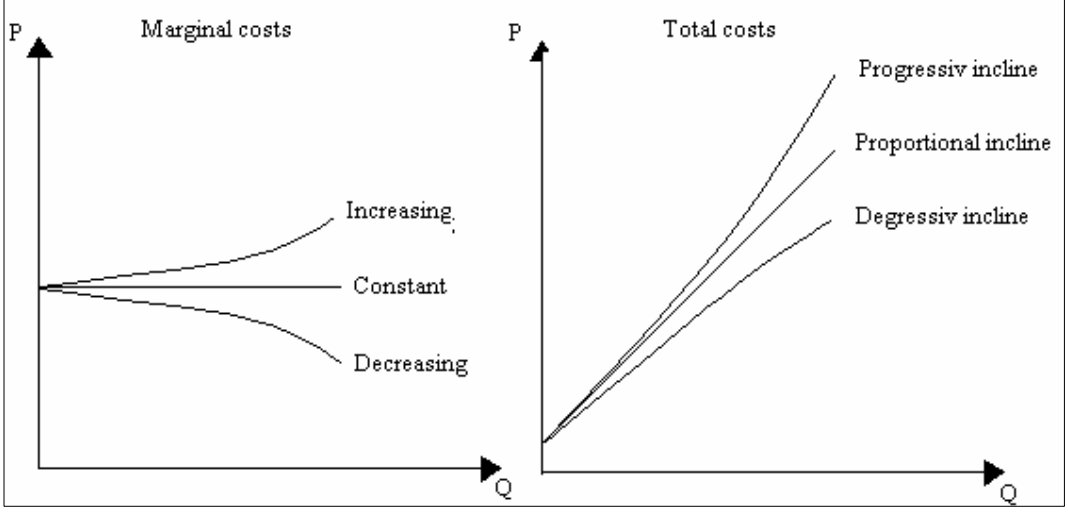
The connection is shown in figure 2:

Figure 2: The connection between MC and TC



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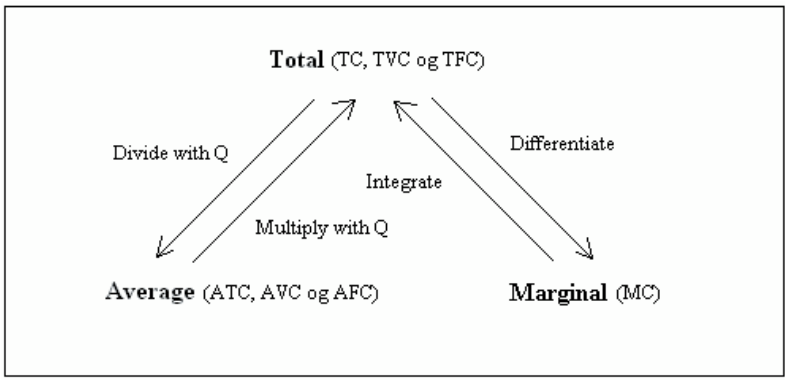
It must be emphasized that cost development is dependent on both activity level and decision-making situation. A firm may, for example, have a digressive cost development (economies of scale) at a low level of activity because of increasing discounts on purchasing, and at the same time experience a progressive cost development because of waste, discarding, less efficient employees etc. Often these circumstances are present simultaneously.

The connection between total costs, average costs, and marginal costs.

The connection between total costs, average costs, and marginal costs is shown in model below:



The triangle model depicts: **that when you have a mathematical term for the cost function** – moving from one cost function to another is possible in the following ways:

- You move from a total function to an average function by dividing with Q.
- You move from an average function to a total function by multiplying with Q

For instance, to move from TC to ATC you divide TC with Q – and from ATC to TC by multiplying ATC with Q.

Furthermore, the triangle model shows that movement from a total function (TC or TVC) to a marginal function (MC) is possible by differentiating the total function. In this way the marginal function reflects the inclination on the total costs curve. This relationship is logical as the marginal costs show the costs of the production of one additional unit, which is exactly the increase in the total costs.

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In the opposite direction, the triangle model also shows that you move from a marginal function (MC) to a total function (TVC) by integrating the marginal function. In this way the total function (TVC) reflects the area below the marginal costs curve. This relationship is equally logical as the total variable costs (TVC) are precisely the sum of all the marginal costs.

Moreover, it is shown that you move from an average function (ATC or AVC) to a marginal function (MC) by multiplying Q and thereafter differentiating the function; i.e. you first find the total function (TC or TVC) and thereafter find the marginal function.

2.1 The North Sealand Raspberry Plantation

North Sealand Raspberry Plantation

North Sealand Raspberry Plantation is a minor fruit plantation, that exclusively cultivates organic raspberries with organic methods. The plantation rents one hectare of land at an annual cost of 3,000 DKK Furthermore, it costs the firm 15,000 DKK to stretch out a net for protection against birds, to replant, to inspect, and cultivate the raspberries.

Harvest season is coming, which lasts about three weeks. All the raspberries are ready to be picked. The owner has to determine how many kilos are to be picked – and consequently how many pickers to hire. It is out of the question to harvest all of the raspberries as the costs of picking the last ones (the small ones or those that hang low to the ground) exceeds the value of the raspberries. The owner knows from experience that, due to internal competition the first pickers hired work faster, as succeeding pickers are hired. This positive relationship comes quickly to an end, as the pickers are in the way of each other, if too many are hired. The pickers are paid 100 DKK an hour, and with a variation each picks 8–13 kg. per hour. Naturally the best pick more and the worst pick less. Effort is put into hiring the best first.

In this short-term scenario, the costs of renting and cultivating the land are fixed. Only the costs of the raspberry pickers vary with the activity level.

The costs in a table

The costs incurred by North Sealand Raspberry Plantation for the picking of raspberries are listed in table 2.1, showing the costs as a function of the number of berries picked.

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Raspberries (100 kg)	TC	TVC	TFC	ATC	AVC	MC*	AFC
0	18.000	-	18.000	-	-	-	-
10	27.800	9.800	18.000	2.780	980	810	1.800
20	35.200	17.200	18.000	1.760	860	720	900
30	43.200	25.200	18.000	1.440	840	930	600
40	54.800	36.800	18.000	1.370	920	1.440	450

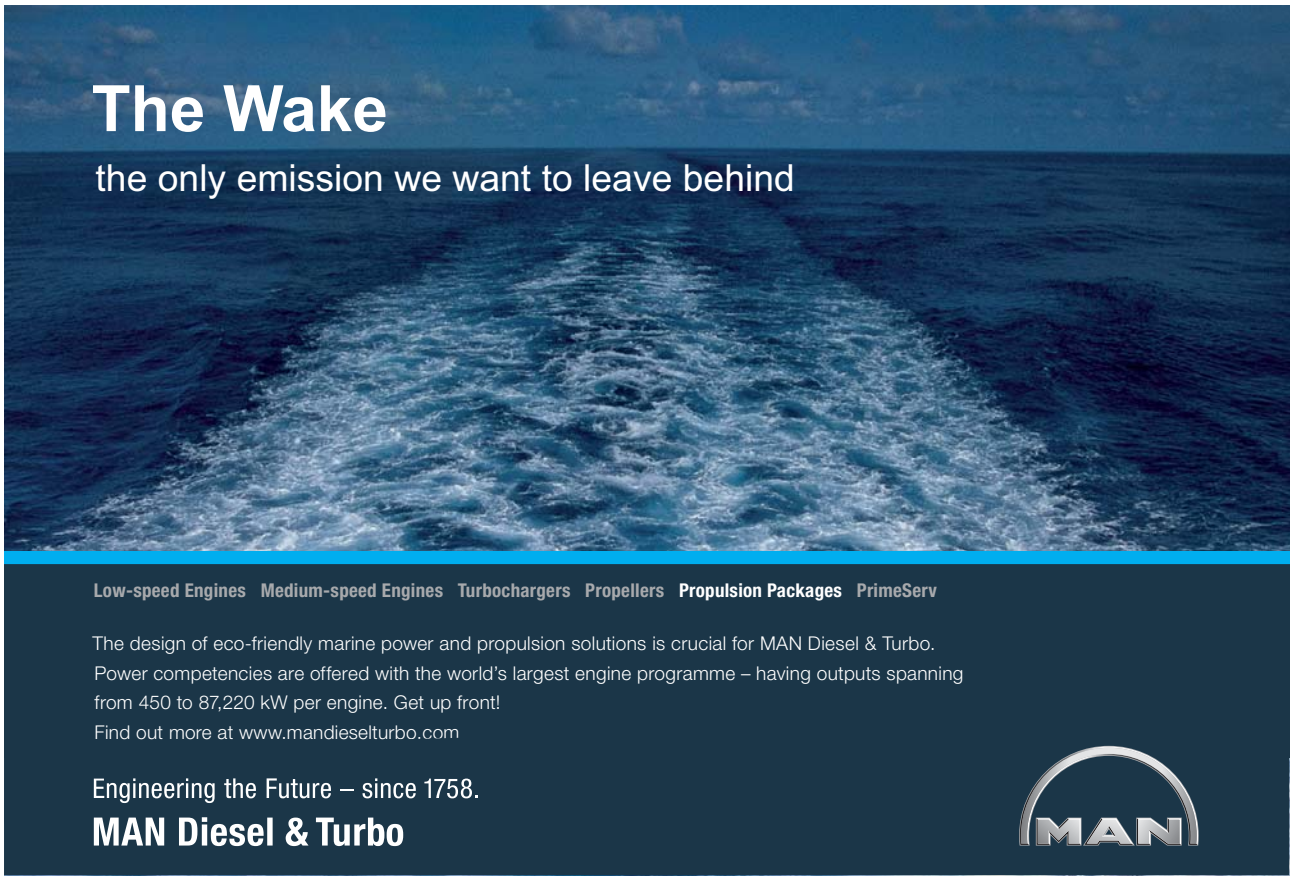
** MC has been calculated by differentiating the function below at point Q (give it a try).*

Table 2.1: The costs as a function of the number of raspberries picked

Costs shown mathematically.

The costs incurred by North Sealand Raspberry Plantation in conjunction with picking raspberries, can be listed as a mathematical function, with cost in terms of the amount of raspberries picked (100 kg.):

$$\mathbf{TC = 0{,}5Q^3 - 27Q^2 + 1.200Q + 18.000}$$



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The TC function can be divided into fixed and variable costs. The fixed costs do not vary in terms of production. Therefore, the TFC function and the TVC functions are found based on the TC-function:

TFC = 18.000

TVC = 0,5Q^3 – 27Q^2 + 1.200Q

Based on the total functions, the average functions can be found by dividing by Q:

ATC = TC/Q = 0,5Q^3 – 27Q^2 + 1.200Q + 18.000)/Q =
0,5Q^2 – 27Q + 1.200 + 18.000/Q

AFC = TFC/Q = **18.000/Q**

AVC = TVC/Q = (0,5Q^3 – 27Q^2 + 1.200Q)/Q = **0,5Q^2 – 27Q + 1.200**

The MC function is found by differentiating the TVC function (the TC function, as the constant unit is neutralized anyway). Below the TVC function is differentiated:

MC = (TVC)' = (0,5Q^3 – 27Q^2 + 1.200Q)' = **1,5Q^2 – 54Q + 1.200**

It is now possible to go "the other way" in the triangle model and see if the original functions result, which is a good way to check the validity of one's calculations.

The TC function is found by multiplying the ATC function with Q:

TC = (0,5Q^2 – 27Q + 1.200 + 18.000/Q) x Q =
0,5Q^3 – 27Q^2 + 1.200Q + 18.000

The TVC function is found by integrating the MC function :

TVC = ∫MC = ∫(1,5Q^2 – 54Q + 1.200) = **0,5Q^3 – 27Q^2 + 1.200Q**

As seen from the calculations above, the original functions appear by "going the other way" in the triangle model, which indicates that the mathematical part of the cost functions are correct.

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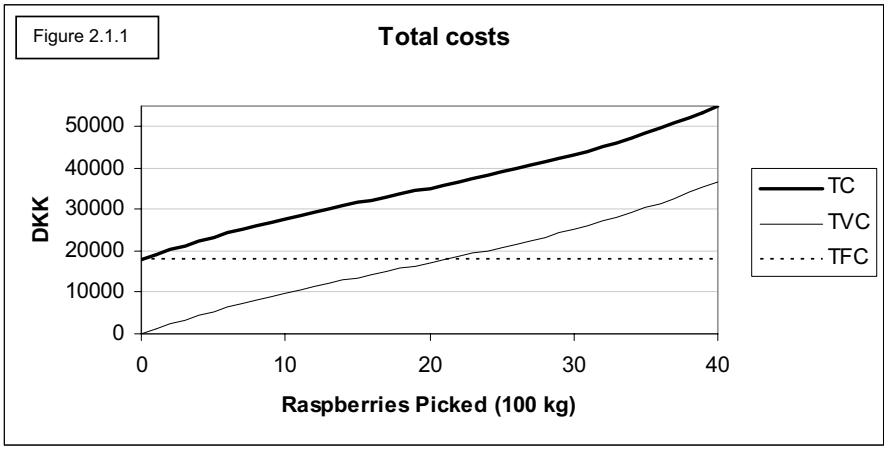
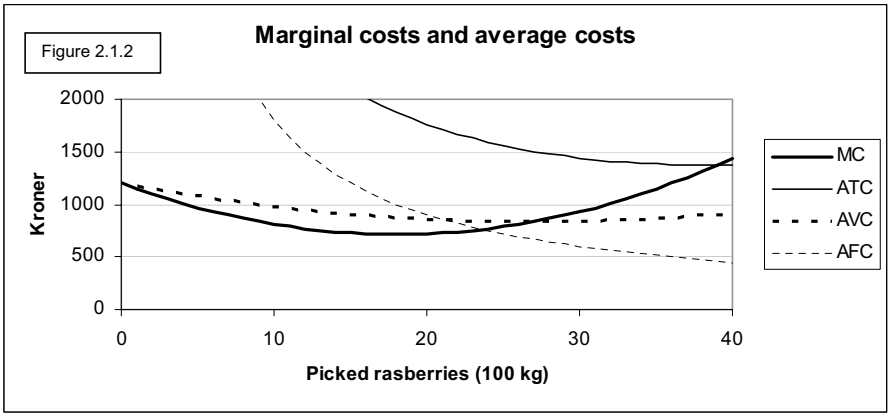
Costs shown graphically

The cost of picking the raspberries can be shown graphically, as is done in figure 2.1.1 and 2.1.2:





In figure 2.1.1 and 2.1.2 some important cost-related correlations are demonstrated:

- When MC increases and crosses AVC it always happens at a local minimum for AVC. The logic implied here is that when MC is below AVC then AVC decreases, and when MC is above AVC then AVC increase. The MC's crossing of the AVC demarcates the change between the descending and ascending sectors of AVC. This pattern corresponds to that MC, which is respectively below and above the AVC on each side of the crossing. Similar lines of reasoning are involved when MC is descending and crosses AVC.
- The reasoning explained above also applies to the relationship between MC and ATC. Notice that MC crosses ATC at a higher Q-level than when AVC was crossed. This is due to ATC being AFC+AVC, and thus ATC is at a higher level.
- In a continuous relationship, MC expresses the gradient of VC, and thus TC. When MC is low it is synonymous with TC ascending slowly.

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2.2 Easymap

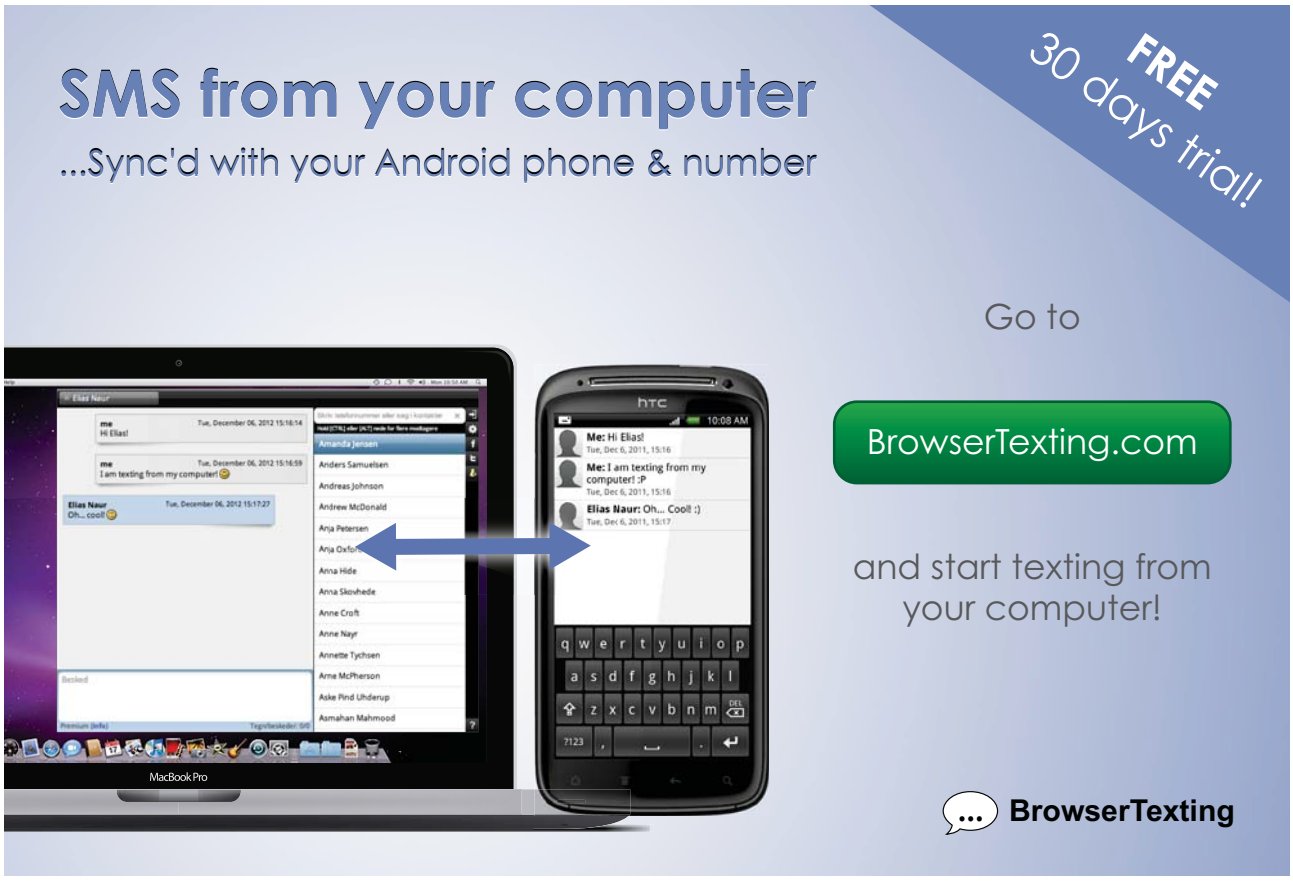
"Easymap" is a minor niche company producing computer mouse-pads, which are constructed in a manner that protects the mouse from collecting dirt or dust. This company's product is based on the principle that a clean mouse is fast mouse. These mouse-pads are a hit among young gamers.

Costs

Easymap has fixed costs of 400,000 DKK a year, which include rent, interests/ depreciation of machinery, management salaries, etc. Furthermore, Easymap has the following variable costs per mouse-pad produced:

- 1 DKK in materials
- 30 øre in electricity for machinery, repair and maintenance, sales commission etc.
- 3 DKK for salaries within normal working hours
- 6 DKK for salaries outside normal working hours

Variable costs within normal working hours:	**4.30 DKK per unit**
Variable costs outside normal working hours	**7.30 DKK per unit**



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It is possible to produce 60,000 mouse-pads within normal working hours. Overtime allows for the production of an additional 20,000 mouse-pads.

Costs shown mathematically

The cost functions are defined in order to create a general view of the costs involved in mouse-pad production. All cost functions are based on the TC function;

TC = 4.30Q + 400,000	representing the interval from 0–60,000 units produced
TC = 7.30Q + 220,000	representing the interval from 60,001–80,000 units produced

Based on the TC function, the TFC function and the TVC function are determined. This process is made possible by the fact that the fixed costs do not vary with production and are therefore not affected by Q:

TFC = 400,000	regardless of the activity level
TVC = 4.30Q	from 0–60,000 units
TVC = 7.30Q – 180,000	from 60,001–80,000 units

The average functions are determined when the total functions are divided by Q:

ATC = 4.30 + 400,000/Q	from 0–60,000 units
ATC = 7.30 + 220,000/Q	from 60,001–80,000 units
AFC = 400,000/Q	regardless of the activity level
AVC = 4.30	from 0–60,000 units
AVC = 7.30 – 180,000/Q	from 60,001–80,000 units

The MC function is determined when the TVC function (or the TC function) is differentiated:

MC = 4.30	from 0–60,000 units
MC = 7.30	from 60,001–80,000 units

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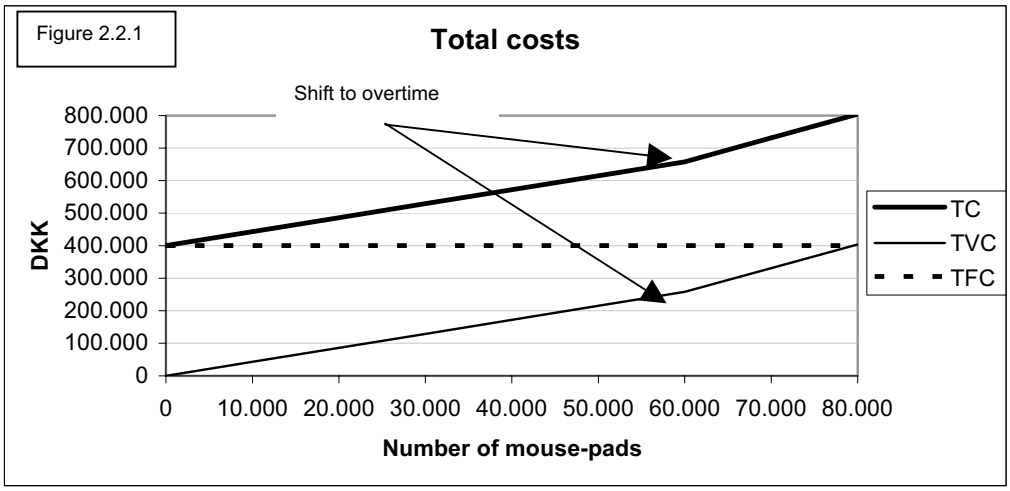
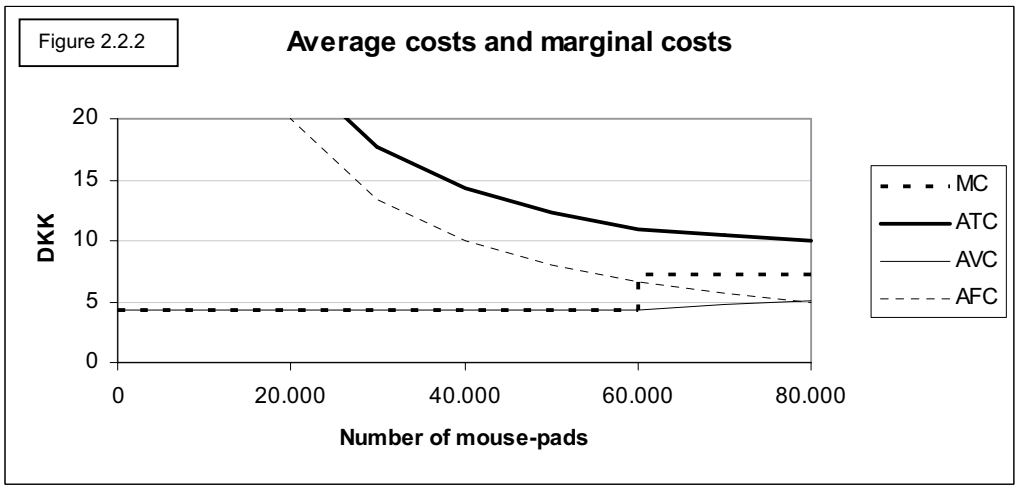
Costs shown graphically

The cost functions are illustrated in figure 2.2.1 and 2.2.2:





2.3 The Printing House

The Printing House

The Printing House specializes in fashion magazines. They are located in Viborg and have 3 employees. The company has annual fixed costs totalling 600,000 DKK, which include rent, interest, and installments paid on their printing machine, and insurances, etc. The cost of printing a fashion magazine is about 3 DKK, which includes materials, production worker wages, directly applicable electricity, etc. At this time, it is possible to print about 300,000 fashion magazines annually. The firm has the possibility of expanding production capacity by investing in a new and larger printing machine, which would cost 250,000 DKK. By replacing the printing machine the production capacity would be expanded to 700,000 fashion magazines annually. Simultaneously the costs of printing would decrease to 2.25 DKK per unit.

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Cost functions

The Printing House would like to know what the costs are as related to different activity levels, which are especially relevant for their pricing considerations. For this reason, cost functions, which express cost as a the measurement function, are determined. The measurement unit, which defines the activity level, is the number of magazines printed.

Total costs

As mentioned earlier, the firm has annual fixed costs of 600,000 DKK. The variable costs are 3 DKK per magazine from 0–300,000 fashion magazines a year, and 2.25 DKK from 300,001–700,000 magazines a year. Total costs can therefore be described as seen below:

TC = 3Q + 600,000	from 0–300.000 fashion magazines per year
TC = 2.25Q + 1,075,000	from 300.001–700.000 fashion magazines per year

Based on the above information, the total variable costs (TVC) and the total fixed costs (TFC) are determined. TVC varies with production though TFC does not.

TVC = 3Q	from 0–300.000 fashion magazines per year
TVC = 2.25Q + 475,000	from 300.001–700.000 fashion magazines per year

TFC = 600,000 regardless of activity level.

Average costs

Based on TC, TVC, and TFC the average total costs (ATC), the average variable costs (AVC), and the average fixed costs (AFC) are found when the total cost functions are divided by Q:

ATC = 3 + 600,000/Q	from 0–300,000 fashion magazines per year
ATC = 2.25 + 1,075,000/Q	from 300,001–700,000 fashion magazines per year

AVC = 3	from 0–300,000 fashion magazines per year
AVC = 2.25 + 475,000/Q	from 300,001–700,000 fashion magazines per year

AFC = 600,000/Q regardless of activity level

Marginal costs

The marginal costs (MC) are deduced by differentiating the TVC function (or the TC function, as the constant will always be neutralized). The marginal costs are described below:

MC = 3	from 0–300,000 fashion magazines per year
MC = 2.25	from 300,001–700,000 fashion magazines per year

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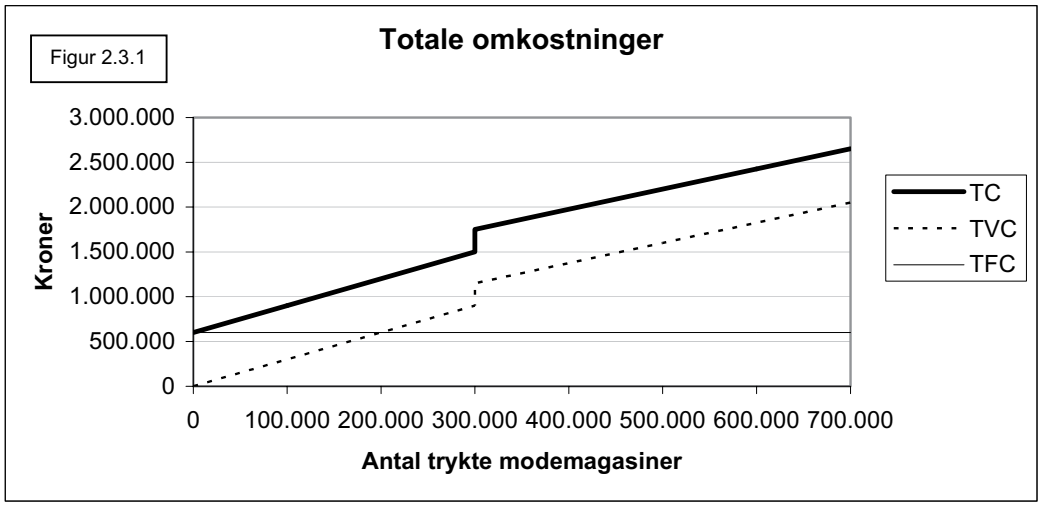
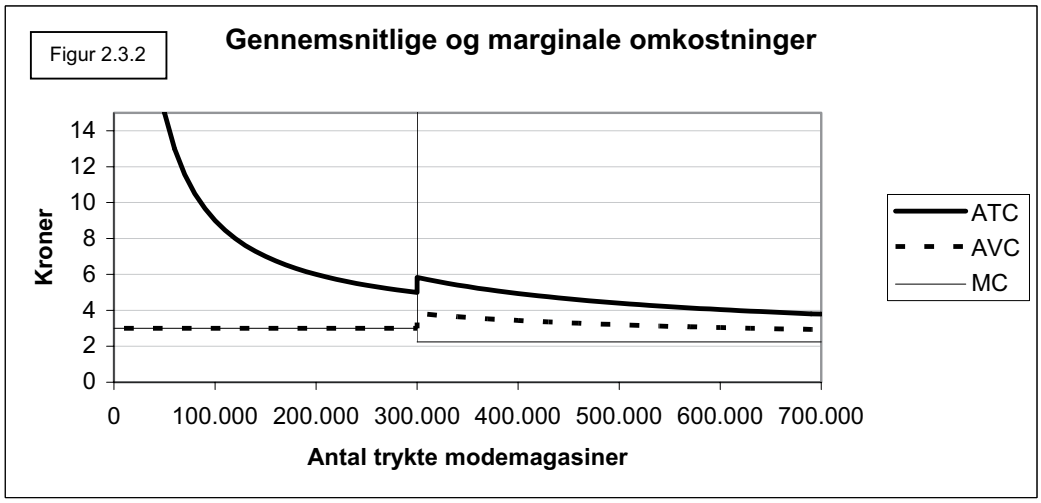
Graphic presentation of the cost functions

The costs are shown in figure 2.3.1 and 2.3.2:





Weakness of the cost functions

The weakness of the cost functions is that they do not consider the cost complexity. Understanding that a function cannot reflect the complex conditions of the firm is important. However, cost functions can, if they are drawn up in a sensible way, be a useful tool for decision makers.

The complicating factors include: Motivation, planning, production levels for other products, general market conditions, general employment conditions, etc. There are both internal and external conditions that complicate these terms.

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Case 2.4: Cost complexity

When a restaurant's master chef is about to price a dinner party, several factors are considered. One of these factors is the table setting. Even though setting the table is a simple process, it is actually quite difficult to establish exactly how much it will cost before the tables are set. That the costs are difficult to establish in advance is owing to the following factors:

- **The special wishes of the party** (arrangement of the tables, table dressing, napkins, flowers, table decorations, and candles etc.) vary from party to party, which results in that the costs varying from party to party.
- **The wages used on the table setting** depend on whether the employees have a good or a bad day, the time of the table setting (when the tables are set in the morning it happens a lot faster than in the evening), who is on the job, etc.
- **The wages spent on ordering** table dressings, napkins, decorations, flowers, and candles, depend on whether the supplier that was reached first is able to supply everything, or if alternative suppliers have to be reached. It also depends on whether the supplier has the relevant information about inventory on his computer or if he has to ask about the available inventory (which results in waiting time and additional phone calls)

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The master chef at Bowl'n'Fun in Viborg, Kim Bülow Mortensen, says:

"It is almost impossible to know how much it generally costs to set a table for a party of, lets say 100 people, before the table has been set. I have to know a lot of things before I can make a qualified answer. A bowling center is such a dynamic entity that plans often have to be changed; i.e. under optimal conditions I can have the tables set for about 12 DKK per person, but I run the risk that they have to be set in the last minute, with tired waiters working over time. In this situation, it may cost up to 20 DKK per person attending the party. That is why it is difficult to establish the costs in advance."

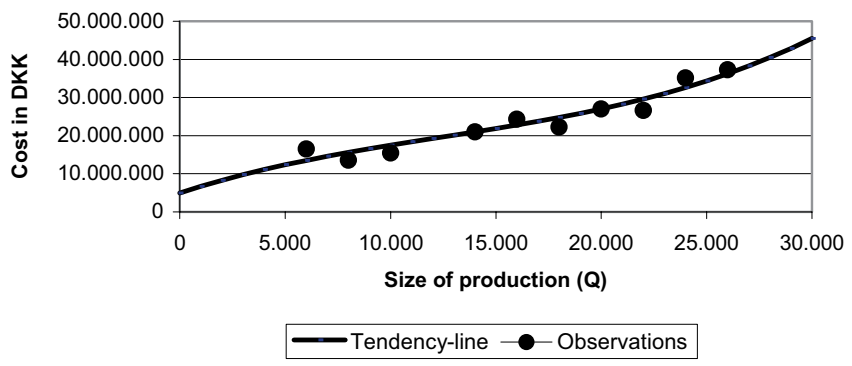
2.2 Assignments for Chapter 2

Mini case 2.1: "Guns and Thrills"

"Guns and Thrills" is an American production company with a number of quality products. The products are marketed and sold in the USA and most of Europe through national and international wholesalers, who distribute the products on to specialized stores.

"Guns and Thrills," despite quality difference, competes with some Asian paintball factories, who enjoy lower production costs. The management of the firm has been focusing specifically on cost perspectives. Management has estimated the firm's TC function for the product with the highest demand, a fully automatic AK-47 assault rifle. The TC function has been estimated based on historic cost observations, at different production levels, using Excel. Based on these observations, Excel has calculated a tendency-line, which subsequently has been applied as the management's estimate of the TC function. The observations and the resulting TC function, in this example converted into DKK, is shown in the figure below:

Figure 2.1: Estimate of the TC function



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The TC function (the tendency-line) has been determined with the following equation:

$$TC = 0{,}000002Q^3 - 0{,}075Q^2 + 1.800Q + 5.000.000$$

Case assignment 2.1:
Determine the MC function mathematically, and if possible, show it graphically.

Case assignment 2.2:
Explain the change in the MC curve.

Case assignment 2.3:
Determine the AVC mathematically.

Case assignment 2.4:
Find the production size where the AVC function reaches its minimum.

Case assignment 2.5:
Why would other similar assault rifle manufacturers probably have different cost functions?

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Case assignment 2.6:
Where can the firm go wrong in estimating the TC function?

Case assignment 2.7:
Which factors decide the development of the TC function?

Question 2.1 A company has estimated the following MC function in DKK, for production sizes of no more than 300 units:

$$MC = 0{,}003Q^2 - 0{,}8Q + 120$$

Determine the AVC function mathematically.
Draw the MC and AVC function in the same diagram and explain the connection between the two curves.

Question 2.2 Fill out the empty spaces in the table below. The company has fixed costs of DKK 1 million.

Q	0	1	2	3	4
MC	-	100.000	90.000	98.000	104.000
TVC					
TC					
AVC					

Question 2.3 Why integrate the MC function in order to get to the TVC function?

Question 2.4 A firm has an increasing MC function. Will the TVC function of this firm increase progressively, proportionally, or digressively? Explain why.

Question 2.5 Why does the AVC minimum occur at the point where the MC function crosses the AVC function from below?

Question 2.6 Why does the ATC function reach its minimum at a higher production level than the AVC function? And could you imagine a situation where ATC is minimized at a lower Q than AVC?

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Question 2.7 How is MC influenced by the following actions:

- an increase in the hourly wage for production workers
- an accumulated quantity discount
- increased real estate taxes
- increased administration costs

Question 2.8 How far does the short-term time horizon stretch when determining cost functions? – include examples of "short-term" for different industries.

Question 2.9 Why is it possible to determine the MC function based on the ATC function, when the ATC function cannot be found when the MC function is known?

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3 Different Cost Types as a Function of Different Decision-Making Situations

3.1 Introduction

General variability

In any given company there are a number of typical cost types which vary in tact with specific decisions: time horizon, product type, and production conditions, just to name a few.

- For a hotel, the cost calculation for a vacant room per night, depending on the decision-making occasion, could result in numbers as different as DKK 20 and 400.
- For an airline the calculation of costs per seat between Oslo and Copenhagen result in numbers as different as DKK 80 and 460.
- For Carlsberg the cost calculation of producing one premium pilsner result in numbers as different as DKK 0.80 and 2.20.
- For TDC the cost calculation for one minute of calling on the cellular net in numbers as different as DKK 0.15 and 0.65.

The decision-making occasion has to be specifically defined.

Cost types

Different cost types are composed of different integral aspects when examined from the perspective of specific decision-making occasions. Below, are a number of typical cost specifics:

Raw materials
Blue collar (hourly paid workers employed on short notice)
Production costs, direct
Production costs, indirect
Depreciation factors
Interest
Administration
Research
Management, consulting, and accounting

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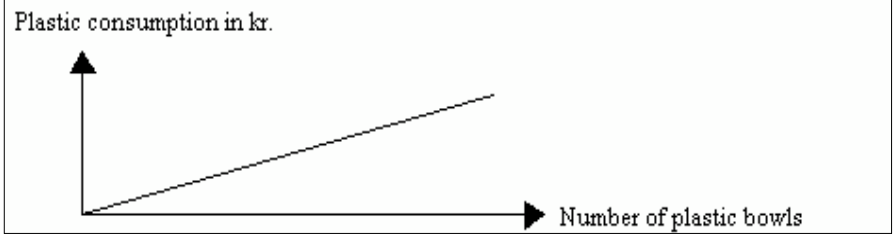
3.2 Examining Different Cost Types

Raw materials

In regards to a specific decision-making situation, raw materials are a direct variable cost, i.e. the size of the costs are dependent on the size of production. For instance, plastic is a raw material when manufacturing plastic bowls, and the amount of plastic used varies directly with the production of the plastic bowls. This relationship is illustrated in figure 3.1:

Figure 3.1: Consumption of raw materials in production

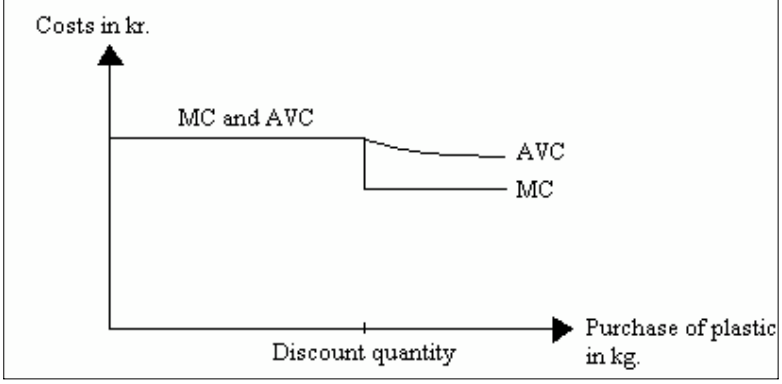


Purchasing discounts

When a firm plans production, the cost of raw materials are partially dependent on whether or not purchasing discounts (quantity discounts) have been achieved, which generally appear in two different forms:

- **Non-accumulated discount (normal discount):** In this case, the firm only receives a discount for the part of the purchase that exceeds the discount boundary quantity. A normal discount could, for instance, be structured so that the plastic bowl manufacturer obtains a 15% discount on the portion of the purchases that exceed the discount boundary quantity of 1 metric ton per month. This situation is shown in figure 3.2:

Figure 3.2: Non-accumulated discount



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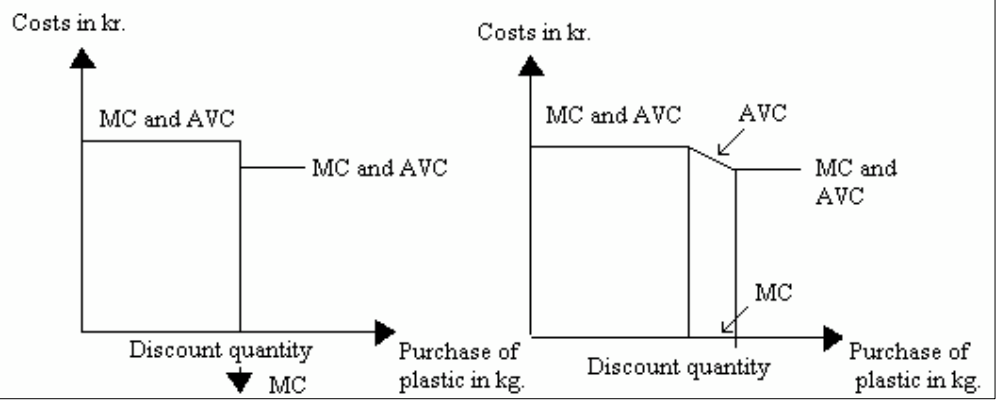
- **Accumulated quantity discount:** In this case the firm receives a discount for the entire amount purchased, provided that the purchase equals or exceeds the discount boundary quantity. A 15% accumulated quantity discount could be structured so that the plastic bowl manufacturer obtains a 15% discount on all plastic purchased, provided that a minimium of 1 metric ton is purchased every month. This scenario is depicted in figure 3.2:

Figure 3.3: Accumulated quantity discount



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- The first of the two figures shows the accumulated quantity discount provided, which is regarded as a bonus sum, paid when the discount quantity is reached. Here, MC has a negative value, i.e. a negative cost (read: an income).

- The second figure shows the accumulated quantity discount where the last quantity purchased before the discount quantity is reached, is free of charge. This discount format should be understood in terms of the following example: if the plastic bowl manufacturer obtains an accumulated quantity discount of 15% when buying 1 metric ton, then the amount of the discount can be explained by the purchase quantity between 850 kg and a ton, being free of charge.

Under certain rare circumstances, it is possible to buy more product than needed, with the purpose of obtaining the discount limit. In these cases, though they seem somewhat unthinkable, the cost of destroying or transporting the excess quantity complicates the model to some degree. This situation is highly academic and will not be discussed in-depth here. For a theoretic explanation, albeit in Danish, is available found in "Opgaver i Erhvervsøkonomi – med supplerende noter" af Michael Havsteen og Ove Hedegaard, DJØF's Forlag 2003.

Raw materials – opportunity costs

If a firm utilizes raw materials that experience price fluctuations (e.g. silver for Georg Jensen), it is the rebuy-price, at the time of the decision that should be integrated into the cost calculations. A possible profit or loss based on the difference between the original cost price and the cost price at the time the decision is made should be defined as a speculative profit or loss.

Under specific circumstances, the firm can build up raw materials as a "last production." In these situations, it is possible to do a cost estimate. This estimate should use the price the raw materials could be sold for, which is often well below the cost price. A fence manufacturer having bought wood cut to a specific length, could represent a hypothetical example. These pieces of wood could only be resold at a substantial price reduction. Other examples include: companies ceasing production of a certain item, or who are going bankrupt, etc.

Hourly wages – blue collar

Blue-collar workers, or employees with an hourly wage, have traditionally been people that could be hired and laid off on a short notice. In the traditional industrial perception these people have a relatively limited knowledge and represent low training costs.

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The reality in the industrial world is though quite different. The following circumstances are some of those which affect this scenario:

- There are very few jobs that do not have a required training-period, with attached training costs.
- For many jobs, the training of new employees constitutes a significant investment, which increases the repercussions of time horizon layoff decisions.
- Most hourly paid employees have a mandatory giving notice period, varying from days to weeks.
- Many hourly paid employees have competencies which are expensive for companies to replace. These competencies are often even more crucial for the firm than those possessed by white collar workers.
- Most of the job functions can be carried out in a more or less correct manner, with more or less confidence, and with a variable quality of production as a result. Therefore, employees should be ranked so that the ones most valuable to the firm are the first to be employed and so on. In this way, the wage costs per unit produced will increase with the size of production as a direct consequence of employees having different qualifications.

Production costs, direct

Direct production costs vary with production size. Regarding the production of beer, the following examples have relevance:

- Production unit element level (brew, bottle, label, top)
- Series element level (packing, internal transportation)
- Product element level (daily cleaning, power)
- Product line element level (systematic maintenance, product control)

Normally, a product or service unit would be estimated including the direct costs concerning all these element levels. This procedure is due to the decision-making situation connected with production, which also involves decision-making focusing on selling goods, and in this case, all production costs should be included. Read more about this topic in the chapter about calculations, where fixed and variable costs are addressed.

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Production costs, indirect

A number of indirect costs are also involved in the produced unit, and can neither logically or unambiguously be attributed to the production – but nonetheless they can be unavoidably connected to production. These costs often include service functions related directly to the production activity, such as:

- Raw materials (control, management, waste, etc.)
- Employees (cleaning, training, illnesses, cafeterias, etc.)
- Production lines (maintenance, repairs, updates)
- Communication

Especially the principles of Activity Based Costing (ABC), examined in the calculations chapter, methodologically treat these areas and their relation to handling of costs.

Administration

In terms of costs, administrative processes are often very difficult to measure because they, in the short-term, are regarded as fixed costs. At the same time, the scope of the processes and thereby the number of employees often varies, partly with the size of production, but also in relationship to a number of decisions made on the management level.

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One may be inclined to concentrate more or less on one process, such as sales, communication, IT and/or quality control. This decision is based on a number of considerations centered around increasing sales or savings.

In order to delineate processes in terms of products, or product lines can be very difficult, and it is most often necessary to estimate a percentage to cover these functions when production costs are to be assessed.

- Sales processes
- Production, production management
- Communication
- Controlling and accounting
- Human resources, training, etc.

In most cases the changes in costs, for these processes, are far slower than the changes in sales and production, and therefore they fluctuate much more slowly than the direct production costs.

If changes in production are short lived (1–6 months) adjustments in the costs for these processes can be very small, which is why they resemble fixed costs.

Depreciation

Depreciation, as related to the costs of a given production quantity, is very difficult to handle. Depreciation can be divided into a number of different components:

- Wear and tear of machinery/tools caused by use that has a direct negative impact on the machine.
  This factor applies, for instance, to cars, trucks, tractors, etc. In a situation where other influential factors remain unchanged, it is safe to say that a well used machine is in worse shape than a less used machine.
- Deterioration due to time, caused by the fact a machine getting older, and supposedly not being as technologically, or in other ways as up-to-date, as a new machine.
- Technological deterioration, caused by emerging new technology, better suited for a given job, and as thereby reducing the value of the machinery (IT hardware/software etc.).

Depending on the decision-making occasion, one or more of the above mentioned costs must be considered.

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Interest

Interest, in relation to production costs, is to be included to the extent to which the carrying out the production demands capital. If storage or machines could be liquidated, interest would be a part of the costs of carrying out production.

Interest should typically be represented by the most expensive part of the financing, and NOT as the average interest. If any special ways of financing are connected to a specific object, for example, cheaply financed trucks or cars, the interest pertaining to this situation could be included in cost calculations.

Insurance, design, etc.

Insurance, research, development, design, etc., are relevant for many industries focusing of producing goods for sale. Some example products include: cars, medicine, clothes, building materials, etc.

Research can succeed or fail, and of course the cost of research has to be recovered in the long run. If not in the first attempt then in the next.

Research is an investment, and R&D efforts are not to be included in the production price of the product. These expenditures are referred to as sunk costs.

Overhead "by-one costs"

In a given firm, a number of general costs have a certain status. These are:

- Management and work done by the board of directors
- Consulting and accounting
- IT systems

These elements are prerequisites for the firm's ability to take action, and most often they do not change with a smaller or larger production size. Only when using the "full cost" calculation model are these costs integrated in order to cover these costs. In relation to changes in production, and changes in costs, these factors have no significance.

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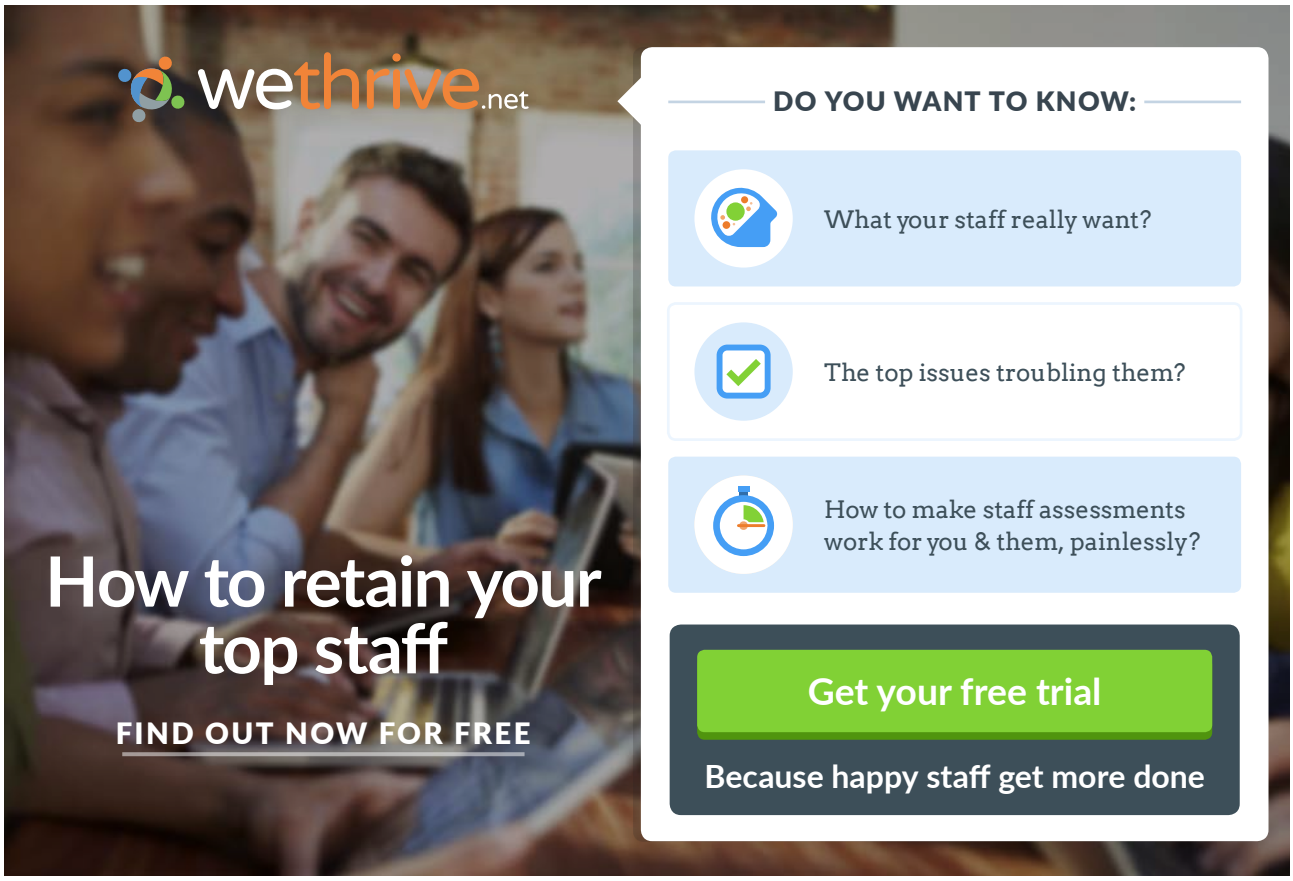
4 Calculations

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.



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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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).

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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.

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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."

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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.

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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

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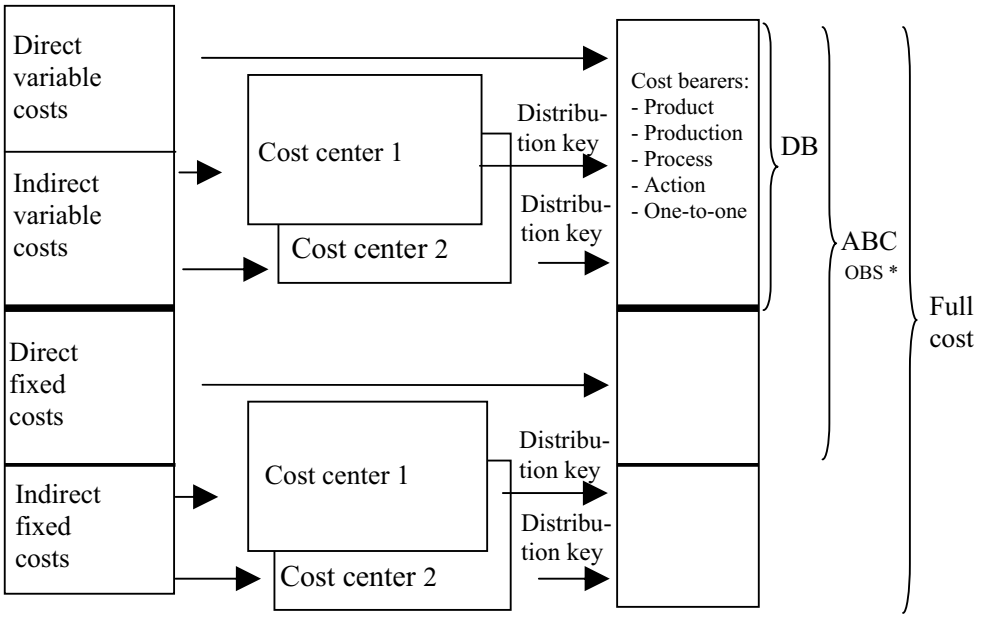

Figure 4.1
** The ABC model does not distribute all indirect variable costs*

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.

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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.

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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.

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Cost pools / Cost centers

Resources are divided into **cost pools** (some writers[19] use the term **cost centers**). 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.

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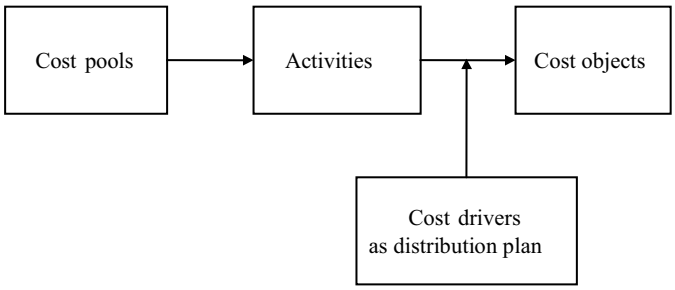
Cost drivers/ Activities

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.

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- **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.

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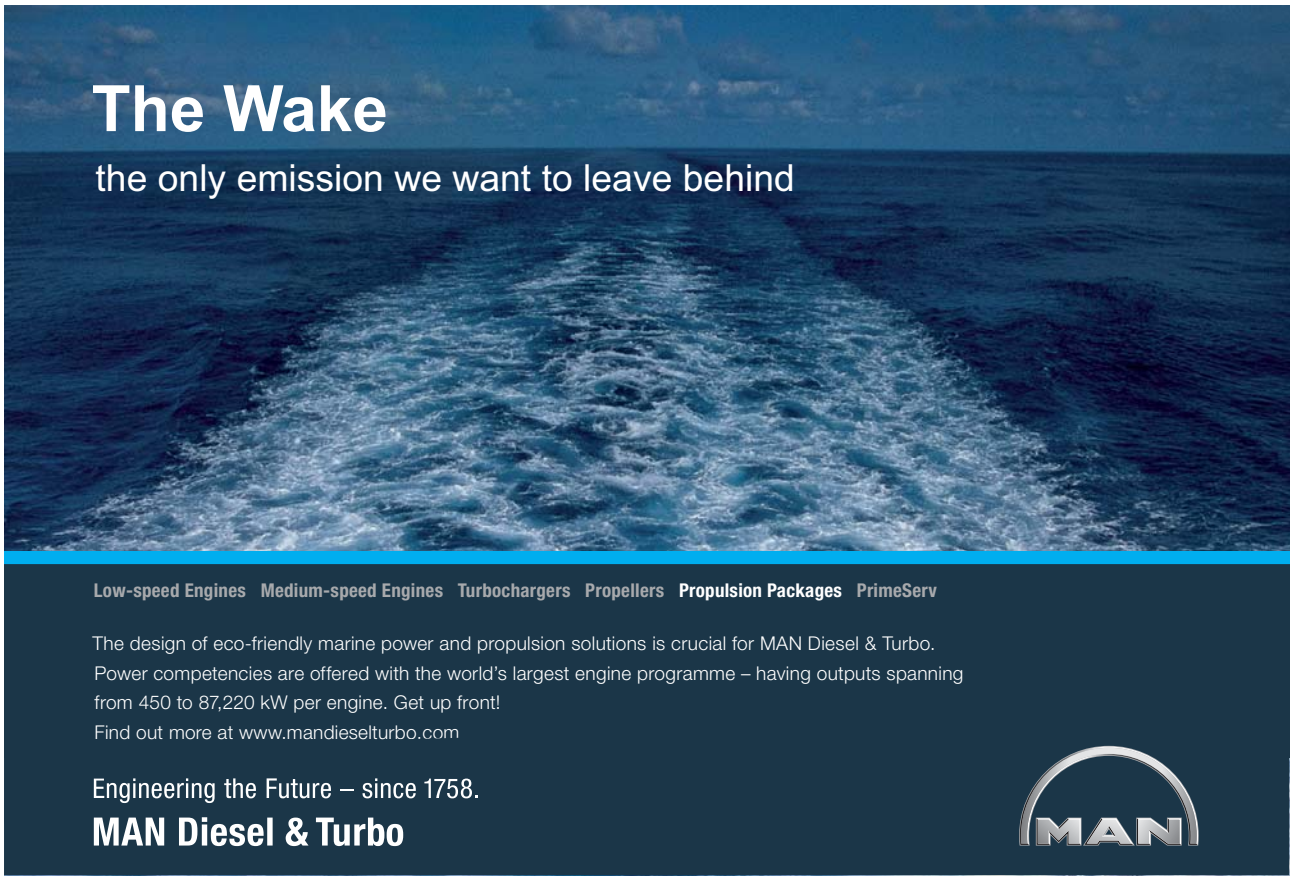
ABC and the full distribution cost model

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.



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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.

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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.

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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

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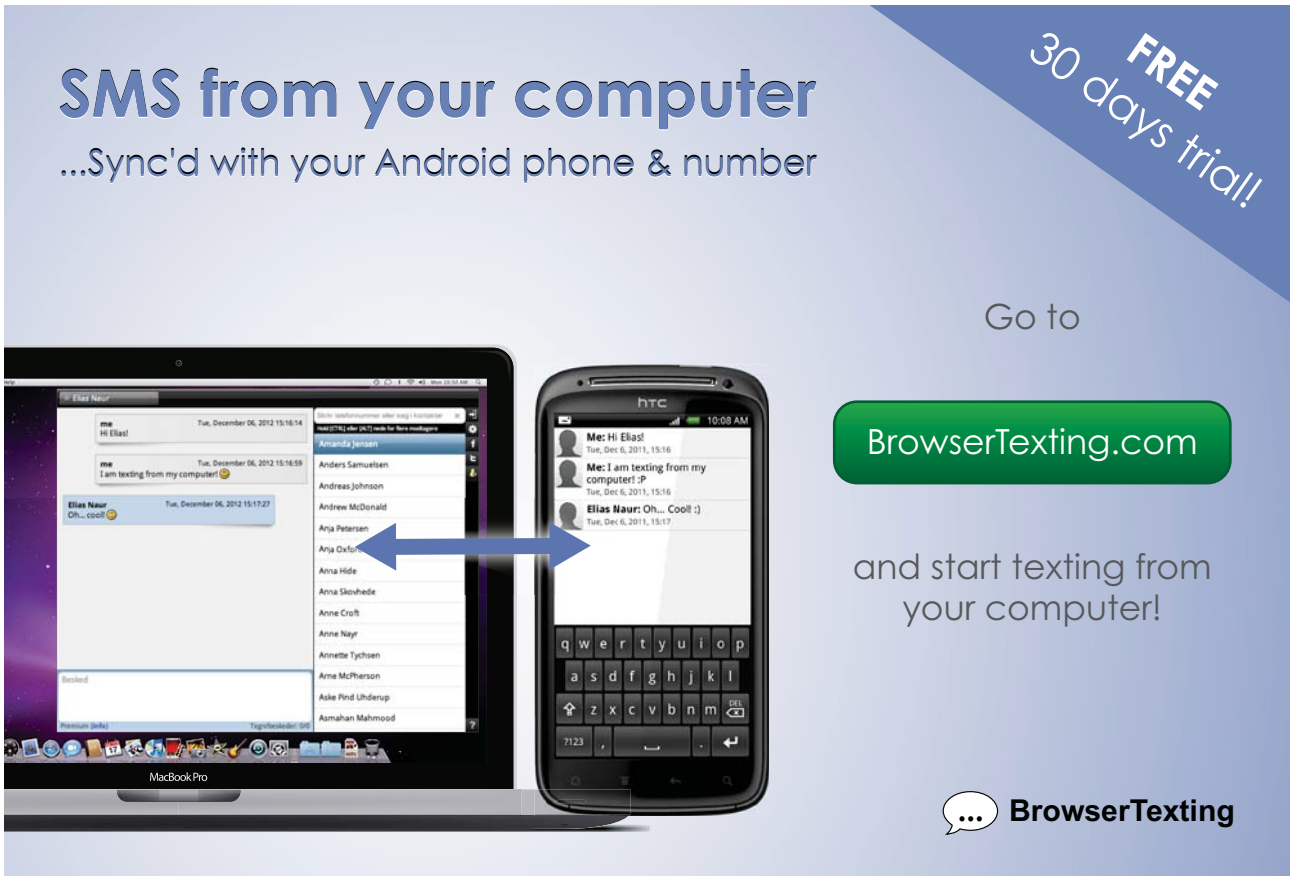
Choice of cost calculations

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.



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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

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• 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**

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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**

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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.

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- 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?

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5 Guiding Solutions

5.1 Guiding solutions for chapter 1

Case assignment 1.1

The three other relevant cost areas could for instance be:

- Accounting/Control
- Management "by one"
- Indirect costs

Case assignment 1.2

The activities can be listed according to cost types as follows:

- *The work time the French fashion designer and the management have already used on the perfume project*. This is a sunk cost as it has already been defrayed and can not be recovered; therefore the cost is not relevant for decision making.
- *The development of the design of the perfume bottle, to be developed by Innocence's own designers.* This is an irreversible cost as the costs of development can not be recovered even if the production is stopped. Moreover, the cost is dependent on the further progression of the project which makes it decision relevant. If no new people are hired the costs (the draw on resources of the existing designers) are hard to assess.
- *The hiring of a head of marketing in Innocence. The head of marketing is to be responsible for promoting the perfumes, including segmentation of markets, choice of marketing strategy etc.* This is a reversible cost, as the head of marketing can be laid off and the costs thereby terminated. As the costs depend on the further progression of the project, this cost is decision relevant. Moreover, this cost is fixed in the short-term and variable in the long-term, as the head of marketing supposedly only can be laid off in the long-term.
- *The marketing campaign for the perfumes. This is accomplished with cooperation from Innocence's marketing department and an external marketing agency.* This is an irreversible cost, as the costs of the marketing campaign cannot be recovered even if the production is stopped. The cost is dependent on the further progression of the project and thus decision relevant. In this case it is an interesting factor whether or not he campaign can be stopped.

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- *The Italian perfume manufacturer's future work with the production of the perfumes i.e. costs of the outsourcing.* This cost is reversible as it is terminated if the production is stopped. The cost is dependent on the further progression of the project and is thus decision relevant. The cost is fixed in the short term as Innocence presumably is tied to a contract, which is only able to be cancelled in the long-term, where the cost becomes variable.
- *The administrative work concerning the project, including cooperation with the Italian perfume manufacturer.* This cost is reversible as it is terminated if production is stopped. The cost is dependent on the further progression of the project and is thus relevant for decision-making. The cost is fixed in the short term as the administrative work concerning the outsourcing does not presumably end before outsourcing is terminated. Based on the same argumentation, the cost is variable in the long-term where it is possible to cancel the contract.

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Case assignment 1.3

The difference is that the two irreversible costs (development of the perfume bottles and the marketing campaign) have been defrayed. This means that they should be categorized as sunk costs, and are therefore no longer relevant for decision-making.

Question 1.1

1. It is presumably possible to support the statement of the professor by using numerous textbooks on business economic theory, but this does not mean that he is right – at any rate not in relation to the real world. This owes to the fact that sneaking costs are easily missed, if the fixed costs are not analyzed in connection to short-term cost considerations. Sneaking costs typically emerge together with additional administrative burdens (typically in administration and management).
2. Moreover the professor's statement will possibly have a problem concerning the division of fixed and variable costs. This division depends on the time horizon and thereby on the decision-making situation. If both the variable and fixed costs are not analyzed, this division will probably not be of any use.
3. The costs for the sales force is fixed in some situations and variable in others.

Question 1.2

A possible explanation could be that the foreman and/or the production workers have experience with the working process. This experience can have resulted in an increased efficiency, which in connection with a proper management effort, has reduced the average costs. This possibility can be attributed to *the learning curve.* Furthermore a simple answer could be that production has increased and that the reduction in costs per unit has been greater than the increase in variable costs. Besides, the fixed costs may have been reduced.

Question 1.3

1. When a business has to establish sales prices, the costs of production are one decisive factor, owing to that the costs should be included in the price/quantity optimization. Moreover the long-term raîson d'etre (reason for being) for the business depends on its ability to, at a minimum, cover the costs.
2. Regarding the decision of whether to produce or outsource the costs, both are decisive. This is due to the company needing to consider outsourcing only if the costs of outsourcing are lower than the costs of own production. Beside the costs, this decision-making situation should also include supplier dependence, confidence of delivery, quality, etc.
3. Likewise, decisions concerning the firm's production level also demand a thorough knowledge of the costs, owing to the production level having great influence on the costs. Therefore the production level has to be established considering the costs.

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Question 1.4 **Scenario 1. He sells the farm, takes the part time job and finds another place to live:**

1. He sells the buildings and the machines, resulting in a payment before tax of DKK 12 million + DKK 2 million = DKK 14 mill.
2. Tax has to be paid of DKK 0.5 mill. + DKK 3 mill. = DKK 3.5 mill (in relation to selling the land, the buildings, and the machines)
3. He now has DKK 14 mill. – DKK 3.5 mill. = 10.5 mill.
4. The loan of 6 mill. is repaid: DKK 10.5 mill. – DKK 6 mill. = DKK 4.5 mill.
5. DKK 4.5 mill is invested at an annual rate of 6%, which before taxes is DKK 4.5 mill. × 0.06 = DKK 0.27 mill. After taxes this is DKK 270,000 × 0.5 = DKK 135,000.
6. He accepts the part time job at DKK 150,000 a year. After taxes this equals an annual income of DKK 150,000 × 0.5 = DKK 75,000.
7. He finds another place to live, costing DKK 50,000 a year.
8. At his disposal after taxes Scenario 1 results in a total of DKK 135,000 + DKK 75,000 – DKK 50,000 = <u>DKK 160,000.</u>

Scenario 2: He rents out the land, takes the part time job and stays at the farm:

1. The land is rented out which before taxes yields DKK 5,000 × 100 hectares = DKK 500,000 a year. After taxes this equals an annual income of 500,000 × 0.5 = DKK 250,000.
2. The machines are sold, yielding DKK 2 mill. before taxes. In connection to the selling of the machines a tax of DKK 0.5 mill. is paid. After taxes 1.5 mill. remains.
3. The loan is reduced by DKK 1.5 mill. resulting in a loan of DKK 4.5 mill.
4. Interests of the loan equal DKK 4.5 mill. × 0.05 = 225,000 a year. After taxes this is an annual expense of DKK 225,000 × 0.5 = DKK 112,500.
5. He rents out the buildings which before taxes equals an annual income of DKK 50,000. After taxes this is DKK 50,000 × 0.5 = DKK 25,000.
6. He accepts the part time job yielding DKK 150,000 a year. After taxes this is DKK 150,000 × 0.5 = DKK 75,000.
7. At his disposal after taxes Scenario 2 yields a total of DKK 250,000 – DKK 112,500 + DKK 25,000 + DKK 75,000 = <u>DKK 237,500.</u>

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Scenario 3: He continues the operation of the farm, declines the part time job offer and stays at the farm:

1. He achieves an estimated profit after corporation taxes and interests of DKK 400,000 a year. After income taxes the yield is DKK 400,000 × 0.5 = DKK 200,000.
2. He rents out the outhouse which before taxes yields DKK 50,000. After taxes this is DKK 50,000 × 0.5 = DKK 25,000.
3. At his disposal after taxes Scenario 3 yields a total of DKK 200,000 + DKK 25,000 = DKK 225,000

The farmer should choose scenario 2, as this gives him the greatest annual amount at his disposal after taxes.

Other financial considerations that should be included (not exhaustive):

- Risks concerning operations of the farm, including the future prospects of agriculture in Denmark (e.g. developments in prices of purchase and sales, wage level for employees, etc.)
- Full or partial termination of EU agricultural subsidies
- Future circumstances concerning interests and taxes.
- Future prospects for the part time job, including wage conditions, and retirement age.

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Question 1.5 **Arguments for a reduction in consumer prices:**

When a number of companies are merged, double positions are typically eliminated, i.e. employees that before the merger held the same position are re-shuffled or laid off.

Moreover economies of scale are often achieved, leading to lower costs. The economies of scale could be a result of the following (not exhaustive):

- Cheaper access to raw materials, distribution, etc.
- Increasing production specialization, including simplification of work processes.
- Greater corporations => greater production => greater effect of the learning curve.

Arguments for lower consumer prices:

When a number of companies are merged, typically, the market competition is reduced. This can result in companies not constantly being pushed to minimize costs, as they are no longer in the same tough competitive environment.

Less competition => stronger suppliers => increased price supplements. One example of this is the debate about the pricing in Arla Foods after the merger of Arla and MD Foods in September 1999.

Moreover diseconomies of scale can emerge, resulting in increased costs. The diseconomies of scale could be a result of (not exhaustive):

- Major corporations typically have more management levels than minor companies in the same industry, as the communication tasks escalate as the business grows. More management levels can cause that the percentage of the workforce that is directly productive to decrease.
- Risks that the communication tasks and division of labor in practice do not work as well after the merger. This could be a result of the corporation becoming to large and bureaucratic. However, it could also be a consequence of well-run sections being split up, or of incompatible business cultures, etc.

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5.2 Guiding solutions for chapter 2

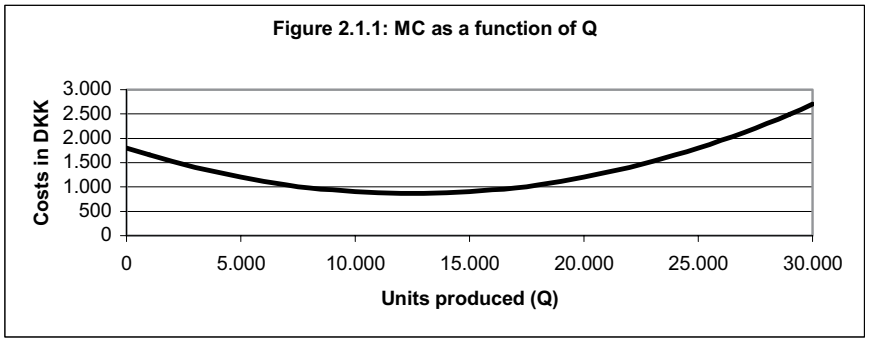
Case assignment 2.1

$TC = 0.000002Q^3 - 0.075Q^2 + 1.800Q + 5{,}000{,}000$

In order to find the MC function, the TC function is differentiated regarding Q:

$MC = TC' = 0.000006Q^2 - 0.15Q + 1{,}800$

The MC function can be illustrated as shown in figure 2.1.1:



Case assignment 2.2

The explanation for the progression of the MC function could be that Guns and Thrills achieve economies of scale at a low production level, e.g. because of increasing purchasing discounts, which explains why the MC function is declining until about 12,500 units. The company, can at the same time, have diseconomies of scale at a high production level, caused of increased waste, less efficient employees etc. explaining why the MC function incline after about 12,500 units.

Case assignment 2.3

$TC = 0.000002Q^3 - 0.075Q^2 + 1{,}800Q + 5{,}000{,}000$

First the TVC function is found by subtracting the fixed costs (5,000,000) from the TC function:

$TVC = 0.000002Q^3 - 0.075Q^2 + 1{,}800Q$

In order to find the AVC function, the TVC function is divided with Q:

$$AVC = \frac{TVC}{Q} = 0.000002Q^2 - 0.075Q + 1{,}800$$

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Case assignment 2.4

The minimum point for the AVC function can be deduced in the following two ways:

1. The AVC function is differentiated and put equal to 0:

AVC' = 0.000004Q – 0.075
0.000004Q – 0.075 = 0
0.000004Q = 0.075 (here 0.075 is added on both sides)

$Q = \frac{0{,}075}{0{,}000004} = 18{,}750$ (here a division of 0.000004 is carried out on both sides)

i.e. the minimum point of the AVC function is reached at a production of 18,750 units.

2. The AVC function is put equal to the MC function:

AVC = MC
$0.000002Q^2 - 0.075Q + 1{,}800 =$
$0.000006Q^2 - 0.15Q + 1{,}800$
$0.000002Q^2 - 0.075Q =$
$0.000006Q^2 - 0.15Q$ (here 1,800 is subtracted from both sides)
$-0.075Q = 0.000004Q^2 - 0.15Q$ (here $0.000002Q^2$ is subtracted from both sides)
$0.000004Q^2 = 0.075Q$ (here 0.15Q is added to both sides – and sides are swapped)
0.000004Q = 0.075 (here a division with Q is carried out on both sides)
$Q = \frac{0{,}075}{0{,}000004} = 18{,}750$ (here a division of 0.000004 is carried out on both sides)

i.e. the minimum point of the AVC function is reached at a production of 18,750 units.

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Case assignment 2.5

Other American manufacturers of the same type of assault rifles will probably have different cost functions because they have:

- Another production design
- Another combination of production factors
- Another kind of technology
- Another group of employees
- Another kind of outsourcing
- Another internationalization
- Another management and management philosophy

The explanation is that the above factors affect the costs and thereby the cost functions.

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Case assignment 2.6

The way in which the company estimated its TC function could be connected to a large number of possible sources of error, including:

- The different cost levels the estimate is based on, are defined at different times in history. Therefore the different cost levels could be affected by the other factors than production size, e.g. purchasing prices, wage level, coincidence, etc.
- The estimate is furthermore based on a other-things-equal philosophy (ceteris paribus) presuming that all relevant factors, including prices, wage level, production design, combination of production factors, technology, employees, outsourcing, and internationalization do not change in the future. However this is not the case, and it can be quite difficult to establish an overview of the cost-related consequences of changes in these factors.
- As seen in figure 2.1 the estimate is based on observations at production sizes of between 6,000 and 26,000 units. Consequently it is not absolutely certain that the TC function can be applied at production sizes outside this production interval.
- The TC function could be influenced by the other products produced by the company at the different times in history. The product combination could be different now as well as in the future.

Case assignment 2.7

The progression of the TC function is determined by, among others, the following factors:

- purchasing prices
- Economies/diseconomies of scale
- The learning curve
- Hourly rate in production, including overtime bonuses

Question 2.1

$MC = 0{,}003Q^2 - 0{,}8Q + 120$

In order to find the AVC function, the TVC function has to be deduced. The TVC function is found by integrating the MC function regarding Q:

$TVC = \int MC = 0{,}001Q^3 - 0{,}4Q^2 + 120Q$

In order to find the AVC function, the TVC function is divided with Q:

$$AVC = \frac{TVC}{Q} = 0{,}001Q^2 - 0{,}4Q + 120$$

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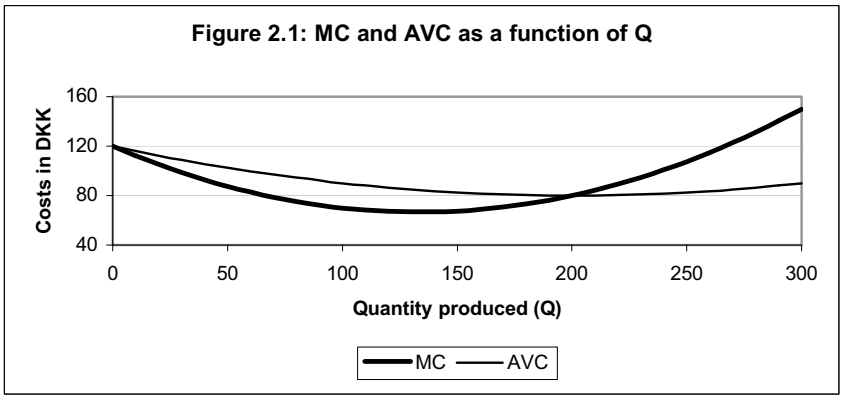
The coherence between the MC gunction and the AVC function is illustrated in figure 2.1:



As seen in figure 2.1 the AVC function is declining when the MC function is below the AVC function, while the AVC function inclines when the MC function is above the AVC function. The consequence of this connection is that the AVC has its minimum at the point where the MC crosses the AVC from below. (A further explanation of this connection is found in the guiding solution to question 2.5.

Question 2.2

Q	0	1	2	3	4
MC	-	100.000	90.000	98.000	104.000
TVC	0	100.000	190.000	288.000	392.000
TC	1.000.000	1.100.000	1.190.000	1.288.000	1.392.000
AVC	-	100.000	95.000	96.000	98.000

Question 2.3 When a mathematical function is integrated, then the area below the function is deduced. The area below the MC function comprises the total variable costs, i.e. the costs of producing unit no.1, unit no. 2, unit no.3…= $\sum_{1}^{n} MC$. Therefore the TVC function is found through integration of the MC function. This is explained by means of the following example:

A company has marginal costs of DKK 5 per unit, why the MC function logically is: MC =5

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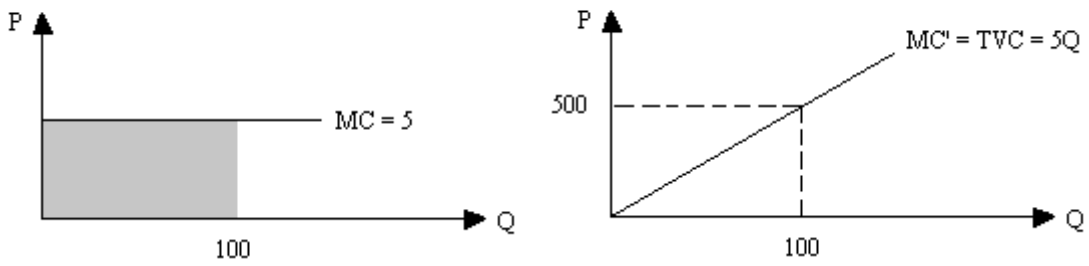
By producing 100 units the total variable costs DKK 500, which is found by applying basic reasoning, i.e. 100 units at DKK 5 each. The total variable costs could alternately be found by integrating the MC function – and afterwards put 100 into the TVC function. This is shown below:

Here the MC function is integrated: MC = 5 => MC' = TVC = 5Q
Here 100 is put into the TVC function: TVC = 5 x 100 = 500

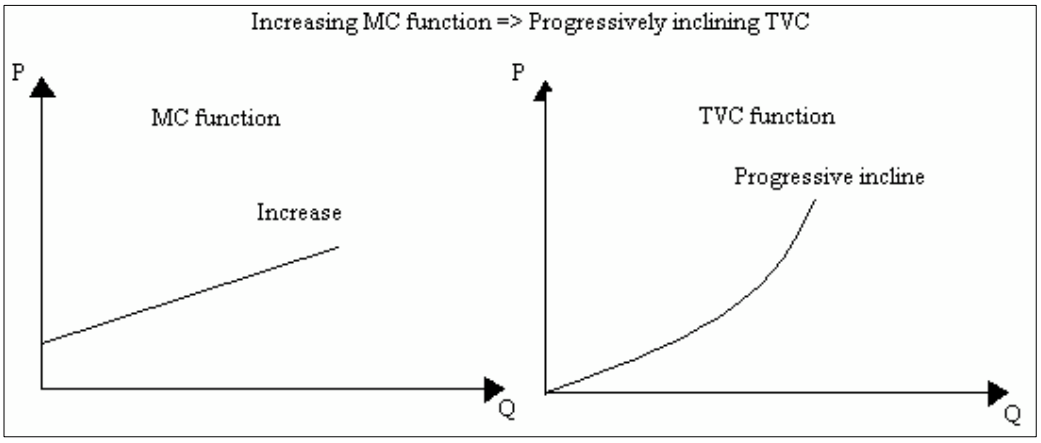
As seen this method yields the same result as the basis reasoning, i.e. total variable costs of DKK 500. The integration process is illustrated below:

Here the integration of the MC function is illustrated :



Question 2.4 When the company has an increasing MC function, the TVC function increases progressively.

The explanation is that an increasing MC function means that the most recently produced unit consequently causes a greater increase in total variable costs than the unit just before. As a result, the TVC increases more and more as a function of Q. This is illustrated below:



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Question 2.5

When the MC-function is below the AVC function, the AVC function is constantly pulled downward as the marginal costs are lower than the average variable costs. When the MC function crosses the AVC function from below, the marginal costs are getting higher than the average variable costs, why the AVC function is pulled upward. The AVC has its minimum in the point where the MC function crosses the AVC function from below as the MC function from this point changes from pulling the AVC function downward to pulling the AVC function upward.

This can be exemplified by using grades/marks. Imagine you get a 10, which is equal to your marginal grade is 10. This gives an average of 10. Your next grade is 9, resulting in your average being 9.5, i.e. your marginal grade has pulled your average downward. Your next grade is 8, resulting in an average of 9. Your marginal grade has once again pulled your average downward. Your next grade is 9, after which your average is still 9. Your marginal grade has not changed your average. Your next grade is 11, after which your average is 9,4. Your marginal grade has pulled your average upward. This is illustrated in figure 2.5:

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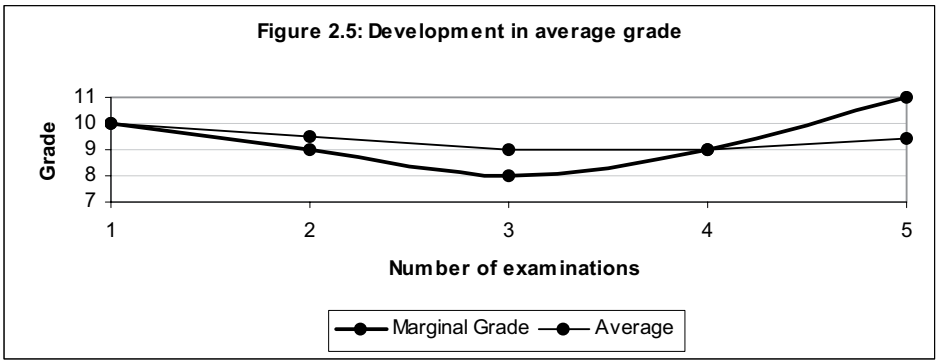

Question 2.6 The ATC function has its minimum at a larger production than the AVC function has because the ATC function contains fixed costs. The ATC function is on a higher level than the AVC at all sizes of production. This means that the MC function crosses the ATC function at a greater production than when it crosses the AVC function. It should be mentioned that both the AVC and the ATC functions are in their minimum at the point where MC crosses them from below.

Question 2.7 The marginal costs are influences in the following way:

An increase in the hourly wage for of the production workers => MC increases. This owes to the increasing production costs, and thereby the increase in the costs of producing one more unit.

An accumulated quantity discount => MC decreases. At the exact quantity that sets off the discount the MC will decrease noticeably, as the discount is retroactive. Thereafter the MC will be lower if the discount applies to the next purchased quantity.

Increasing taxes on real estate => MC is not affected. This owes to increasing real estate taxes causes increased fixed costs, which do not influence the costs of producing one unit.

Increasing costs of administration => MC is not affected. This owes to increasing administrational costs causing increasing fixed costs, which do not influence the costs of producing one unit.

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Question 2.8 The time horizon "short-term" cannot be defined definitely when working out the cost functions. This is due to the cost functions being dependent on both business sector and company, e.g. the time horizon short-term will probably be shorter in an architect firm than in a brewery. Moreover the time horizon short-term can be further divided into extremely-short-term and medium-short-term. However it should be mentioned that the classic definition of the short-term is that at least one of the factors of production within the time horizon cannot be adapted, i.e. it is considered a fixed cost.

Examples of short-term: Street seller = 1 day; Harboe = 3–4 weeks; haulage contractor = 3 months

Question 2.9 The MC function is deduced from the ATC function in the following way: The ATC function is multiplied with Q => the TC function. The TC function is differentiated regarding Q = The MC function. It is however impossible to deduce the ATC function from the MC function, as this does not include the fixed costs (FC). The point is that it is irrelevant whether the TC function or the TVC function is differentiated, as the constant of the TC function (the fixed costs) disappear when differentiated. When the MC function is integrated it is only possible to find the TVC function. On basis of this the AVC function can be deduced but not the ATC function.

5.4 Guiding solutions for chapter 4

Case assignment 4.1 **The contribution margin model for a single bicycle mending operation:**

Direct variable costs:

- The apprentice's wage per mending = DKK 75 per hour / 6 mending repairss per hour = **DKK 12.5**
  The mechanic's wage per mending = DKK 140 per hour / 10 mends per hour = **DKK 14**
- It is not known who receives the customer and thereby uses 6 minutes per mending. Therefore it is assumed that they take turns at this too. Assuming this the average wage for reception etc. => (DKK 75 per hour + DKK 140 per hour) / 2 = DKK 107.5 per hour = 107.50. As it takes 6 minutes per reception the costs of wage per reception etc. = DKK 107.50 per hour / 10 receptions per hour = **DKK 10.75.**
- Costs of patch, glue, power, etc. per mending is = **DKK 2**
- The direct variable costs per mending, if the mending is carried out by the apprentice = DKK 12.50 + DKK 10.75 + DKK 2 = ***DKK 25.25***
- The direct variable costs per mending, if the mending is carried out by the mechanic = DKK 14 + DKK 10.75 + DKK 2 = ***DKK 26.75***

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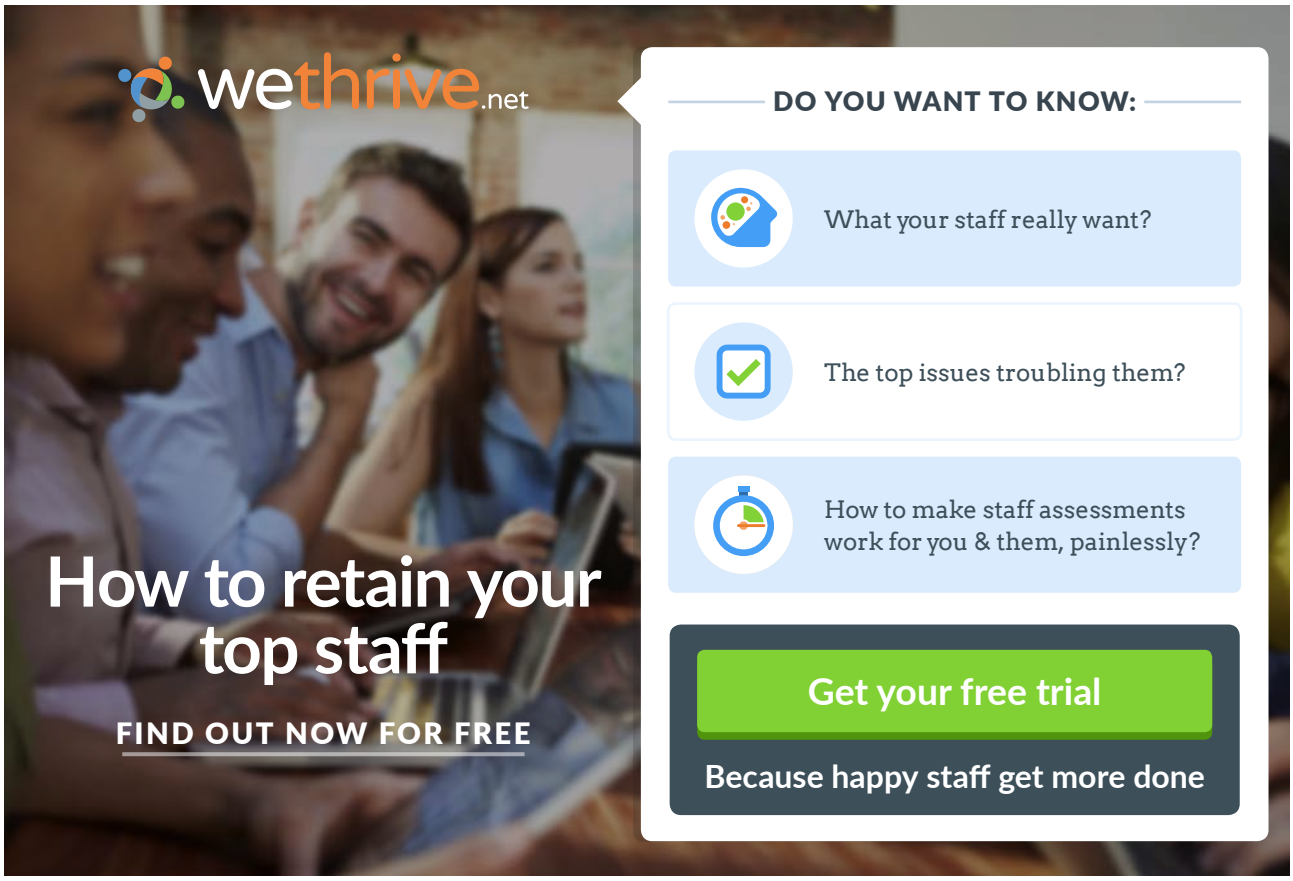
The indirect variable costs:

- In connection to each mending operation, the tools are worn to some degree. This wear and tear cannot be attributed to the single task in the workshop, why a distribution key must be applied. The distribution key in this case is the share in turnover. As 15% of the turnover are created by mending operations, 15% of the workshop maintenance is attributed to the mending as well. In this way DKK 30,000 × 0.15 = DKK 4.500 is attributed to the mends. Subsequently these costs are divided on to the number of mending operations carried out the year before. This yields an indirect variable cost of = DKK 4,500 / 6,000 mends = **DKK 0.75**
- Indirect variable costs per mend = ***DKK 0.75***

Costs for a single mending using the contribution margin model are, if carried out by the apprentice = DKK 25.25 + DKK 0.75 = ***DKK 26***

Costs for a single mending using the contribution margin model are, if carried out by the mechanic = DKK 26.75 + DKK 0.75 = ***DKK 27.50***



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The full cost model for a single bicycle mending operation:

As estimated by using the contribution margin model, the total variable costs per mending, if carried out by the apprentice = DKK 26, and 27.50 if carried out by the experienced bicycle mechanic.

The direct fixed costs:

- The rent for the workshop, which is a relevant part of the building, is distributed using the turnover as distribution key. In this way DKK 20,000 x 0.15 = DKK 3,000 are attributed to the mending operations per year. Subsequently this cost is divided on to the number of mending operations carried out last year. These yields a fixed cost per mending operation of DKK 3,000 / 6,000 mending operations = **DKK 0.50**
- The direct fixed costs per mending operation = ***DKK 0.50***

Indirect fixed costs:

- The rent for the sales and show room, which is a non-attributable location, can be distributed by using the share of turnover of 15%. This yields a total cost of DKK 40,000 × 0.15 = DKK 6,000 a year. This cost is distributed on the number of mends last year, yielding an indirect fixed cost per mend of DKK 6,000 / 6,000 mends = **DKK 1**
- The bicycle shop and the assets could be sold which would release capital worth DKK 2 mill. + DKK 1 mill. = DKK 3 mill. The released capital could be invested at 5% a year, which results in an opportunity cost of operating the shop of DKK 3 mill. × 0.05 = DKK 150,000 a year. This opportunity cost is distributed on to the mends using the share of turnover of 15% as distribution key. This results in a total cost of DKK 150,000 × 0.15 = DKK 22,500 for mends per year. These costs are distributed to the number of mends last year, which yields an indirect fixed cost per mend of DKK 22,500 / 6,000 mends = **DKK 3.75**
- The owner could earn DKK 200,000 annually by accepting another job, which likewise represents an opportunity cost. This opportunity cost can be distributed by using the share of turnover of 15% as a distribution key. This yields a total opportunity cost of 200,000 × 0.15 = DKK 30,000 for mends per year. This cost is subsequently divided on to the number of mends per year, yielding an indirect fixed cost per mend of DKK 30,000 / 6,000 mends = **DKK 5**
- Indirect fixed costs per mend = DKK 1 + DKK 3.75 + DKK 5 = ***DKK 9.75***

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By using the full cost model, the costs of a single bicycle mending operation is, if carried out by the apprentice = DKK 26 + DKK 9.75 = ***DKK 35.75***

By using the full cost model, the costs of a single bicycle mending operation is, if carried out by the experienced mechanic = DKK 27.50 + DKK 9.75 = ***DKK 37.25***

Case assignment 4.2

If the owner wishes to continue the operation of the store, and thereby just wants to assess whether or not the price of mending is to be raised, the contribution cost model is the most suitable. This owes to the owner in this situation just considers one activity that has no effect on the fixed costs.

On the other hand, if the owner considers to sell the store, and thereby wishes to assess whether or not the mends are profitable from a comprehensive point of view, then the full cost model may be more suitable. This owes to the owner in this circumstance has to include the fixed costs, as these are to be defrayed if operations are to be continued.

Case assignment 4.3

Besides the costs/turnover of the mends, the following consditions should be considered:

- The cheap mends' derived effects. When the customer has first entered the store, the employees are often capable of convincing him of changing tires and inner tubes instead of having it mended. Moreover it is possible to sell other bicycle equipment, and once in a while maybe a brand new bicycle.
- The customer reactions on changes in price of mends, including price elasticity.
- What tasks the apprentice and the bicycle mechanic could carry out in liberated working time.

Question 4.1

Frequent decision situations for a pizzeria:

1. How much should a pizza slice cost? Here could one distinguish between next week's price and the minimum sales price. Under both circumstances the pizzeria should know the costs of producing one pizza slice. Concerning next week's price, the contribution margin model would be suitable. If it is about the minimum sales price, then the full cost model will be more appropriate, as all costs in the long term are to be covered by the turnover.
2. How much should a special version cost? In this case it is relevant to know the extra costs of putting extra stuffing on the pizza. As this does not affect the fixed costs, such as rent, depreciations, etc. it only affects the variable costs. Therefore the contribution margin model is suitable.

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3. Should the pizzeria make the pizza dough itself, or should they outsource it to the local baker's? In this case the pizzeria should know all the costs connected to the production of pizza dough. In this case the ABC model should be applied as it focuses on the costs that would possibly be eliminated by outsourcing.
4. Should the pizzeria be open Thursday, Friday and Saturday night because of the active night life in the city? Here the pizzeria should know all the extra costs of this initiative. The fixed costs og rent, depreciations, etc. are defrayed under all circumstances. Therefore this change concerns the variable costs only, and as such the contribution margin model is most suitable. However is should be mentioned that the increased exploitation of capacity will pull the average costs downward from a full cost point of view, while the night bonus will pull the costs upward.

Question 4.2 Examples of distribution keys that could be relevant for Harboe in relation to calculations of production of Harboe pilsners:

- Size of the area of relevant building sections compared to the total production area.
- Turnover of Harboe Pilsner in relation to total turnover.
- Number of employees exclusively working with Harboe Pilsners, in relation to the total number of employees. Here you could distinguish between white-collar and blue-collar.
- Production of Harboe Pilsners measures in units compared to the total production.

Question 4.3 The time horizon is included in calculations relating to the division of costs into fixed and variable. In the short-term the company employs the existing facilities – and has thereby a number of fixed costs in relation to this. In the long-term the company can adjust the facilities in relation to the production and new technology, why more costs are considered variable.

Question 4.4 As the MC function expresses the costs of producing one unit more, only the variable costs should be included in this. Therefore the contribution margin model is typically the basis of the MC function. This owes to the ABC model and the full cost model both operate with distribution of fixed costs.

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The MC functions are hard to define in reality because of the following points (not exhaustive):

- It is difficult to assess the draw on resources when producing a single unit more, e.g. which unit triggers the additional costs of wage bonuses and administration, etc.
- The costs of producing one unit more depends on a number of factors that are difficultly established in advance, e.g. the fluctuating worker efficiency during the day.
- It is difficult to establish mathematical functions in real businesses because of the lack of full information, and unambiguous connections between the quantity produced and the costs, the continuity of production, etc.

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