7 Calculating Economic Efficiency

The most certain of certain things is doubt.
Bertolt Brecht (1898–1956)

Opening Vignette
Judith and Tim Pollmer were exhausted. They had spent the whole day going from one car showroom to the next, taking test drives, discussing technical details in minute details with a lot of salespeople, all of whom had tried hard to get them to sign their names on the dotted line. The married couple had steadfastly refuse to do so despite the willingness of some of the salespeople to give them a 'special deal'.

Judith pushed aside the pile of brochures on the kitchen table as they sat down to drink a reenergising cup of coffee. "Right," she said, "it's time to make up our minds. What do you think?' Ninety minutes later they had narrowed the choice down to two models—an Audi A4 and a Toyota Prius.

"It's obvious," said Tim, "it's got to be the Audi. I feel so good when I sit in the driving seat, it handles so well, and. . .." He was interrupted by his wife.

"You can forget that. The Prius is much better for the environment!"

"But the handling is not so good, it feels soft when you turn into a corner," replied Tim.

The discussion continued for another 20 min, then Judith smiled. "We'll make a decision like we do at work when we buy a new machine for the factory. What we need is a spreadsheet!"

She started her laptop, opened Excel and spoke as she typed. "OK, we need two columns, one for each car. We have the purchase price, we need to estimate the maintenance costs, insurance, fuel costs. What else?"

"We got a better offer for a loan from Toyota than from Audi," Tim remarked. "And I think the Audi will last longer."

P. Eichhorn, I. Towers, *Principles of Management*, Springer Texts in Business and Economics, https://doi.org/10.1007/978-3-319-70902-4_7

"The Toyota probably has a higher resale value. So, let me just work out the depreciation." Judith entered the figure, pressed Enter and smiled when she saw the result.

"The Prius is going to cost us 2500 € less over the next 4 years. The choice is obvious."

"Wait a minute," Tim responded in an aggrieved tone of voice. "That's typical of you accountants, you reduce everything to numbers! What about the pleasure of driving the car? What about the impression the car makes on people?"

The smile left Judith's face. "The spreadsheet gives us the result, no arguing about it. Is it worth 2500 € to you to look cool and feel good when you're stuck in a traffic jam?"

"Yes, it is!" replied Tim heatedly. "You need to find a better way of calculating what we should buy that just doesn't rely on numbers, but on things you can't put numbers to."

"You may have a point," Judith replied, knowing the decision had now been made. "But then, the Prius would have won by even more because driving an environmentally-friendly car is good for society as a whole and I will feel good knowing I'm doing something to help. So if we could put that in our calculation, the decision would be even more obvious than it is now."

7.1 Ratio Calculations

7.1.1 Ratio Analysis

In order to calculate, figures are necessary. Indicators make it possible to represent activities, tasks, events, behaviours, procedures, goals, interrelationships etc. and this makes their planning, control and monitoring easier. Indicators of particular interest in this respect are those that reveal information on the **status and development of operations**. (In addition, economic entities require data on industries, markets, industrial sectors and regions, the national and global economy, legislation, population, education, technology and much more, but that is beyond the scope of this book.)

Ratios are helpful for operational purposes, and there are three types (Fig. 7.1 provides examples):

- classification figures, which show the relative size of parts of a whole,
- relationship figures, which are used to show significant relationships between two numbers, and
- indexes, which show changes over time (often 1 year) of a given measure, expressed as a percentage.

Normally ratios are not used in isolation but as part of a **ratio system**, whose aim is to offer a complete overview of the relationships within business activities. In such a system, the ratios are arranged in a hierarchy, and one central ratio is calculated on the basis of other ratios that have been fed into it, as illustrated in Fig. 7.2. The classic

Classification figure:

$$\text{Proportion of labour costs compared to total costs} = \frac{\text{Personnel costs}}{\text{Total costs}}$$

Relationship figure:

$$\text{Sales per member of staff} = \frac{\text{Sales revenues}}{\text{Number of staff}}$$

Index:

$$\text{Index on rent income 2017 in percent} = \frac{\text{Income from rent in 2017}}{\text{Income from rent in 2016}} \times 100$$

Fig. 7.1 Examples of ratios

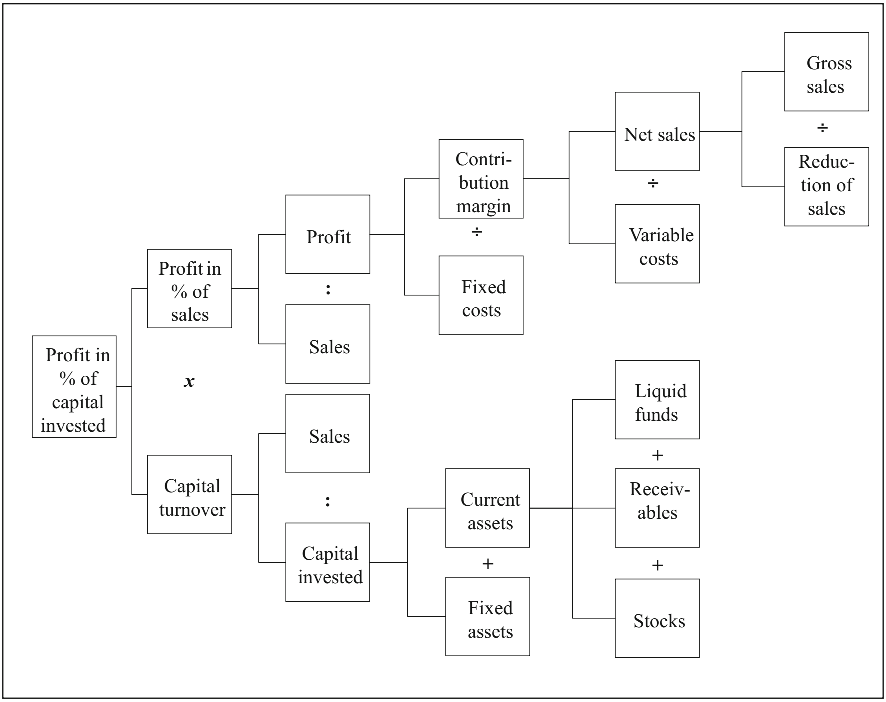

Fig. 7.2 RoI ratio system

model has Return on Investment (RoI) as the central ratio and was devised as early as 1919 by Du Pont de Nemours and Company.

Operational figures are used particularly for the purposes of comparison. By **comparing targets and results**, lessons can be drawn about the processes in question and how they might be better managed in the future. Internal **process comparisons** reveal advantages and disadvantages, information that is needed, for example, to decide which type of production is best for a product. C**omparisons over time** provide information on annual, quarterly, seasonal, monthly, weekly and daily developments.

Inter-company comparisons compare the ratios of one company with those of another; it is essential that the ratios be actually comparable (e.g. the companies should be in the same industry, or of the same structure or size). Several companies will often be compared to determine averages and individual rankings. These comparisons are, in essence, **benchmarking**, a favoured method of business consultants, which measures aspects of one company against other companies. This structured comparison starts with quantifying performances of the 'host' company and identifying differences to the best in class inside and outside the industry. The company should learn from best practices, adapt and then implement them.

All kinds of ratio analysis are done by economic entities—balance sheet, performance, cost, liquidity, employees, customer, market and demand—because ratios translate complicated situations into numbers that are somewhat easier to understand and use. The value of indicators should not be overstated, however, because details and quality can (and often do) suffer during the translation process, so it is wise to have a questioning attitude towards **simplification through the reduction of complexity**. Knowing the origin of the figures used in the ratios is essential.

7.1.2 Indicator Method

Indicators (in a narrow sense) are measurements that allow conclusions to be drawn (e.g. progress towards meeting a target) on the basis of certain hypotheses. Indicators form a **type of replacement value** in those areas where measuring and rating are either difficult or too expensive. Technical progress is recorded by productivity statistics, where it is assumed that the result is useful and marketable. The number of listeners to a radio news programme says something about how widely it was received, but nothing about the accuracy of the reporting. A low rate of staff turnover is sometimes interpreted as being due to high job satisfaction, but it can be heavily influenced by the local labour market. Permitted noise levels are based on what is generally acceptable, but can mean health risks for some individuals.

When using indicators, assumptions must be made explicit and closely examined because they directly affect the value of the information the indicators provide. Many are the **information sources** that can be used: internal and external analyses, reports, programmes, statistics, accounting statements, information systems, publications, official announcements, public tenders, laws and directives, development plans and other official documents. Indeed, there is so much information and data available that it is sometimes difficult to know where to start and when to stop. This is particularly true with big data; it will be interesting to observe the extent to which algorithms will help managers to make sense of all the data to which they have access.

7.2 Static Methods for Capital Budgeting

7.2.1 Cost Comparison Calculation

The difference between static and dynamic methods is that the former ignore the time value of money, and so they are highly popular in practice because of their simplicity.

Cost comparison methods are used mainly when analysing replacement and rationalisation investments, where the main criterion is cost saving. The decision as to which alternative to choose is based on the comparison of the costs of existing equipment with the costs of the equipment that is to be procured. Two types of procedures exist. The **total cost comparison method** employs average costs per unit of time (e.g. 1 year) and assumes that both alternatives (i.e. the old and the new systems) are equal in terms of quantity and quality of output. Equal output quantities are not considered by the **unit cost comparison method** which divides the total costs of each alternative by its output (expressed as a quantity), and identifies the best alternative as being the one with the lowest unit costs. One problem with this approach is that it does not take into account a possible reduction in capacity.

These cost comparison methods have been criticised for several reasons: the production oriented focus of their decision making, changeable cost determinants are not taken into consideration, outputs are assumed to have the same standard of quality and revenues are ignored.

7.2.2 Profit Comparison Calculation

This approach is used most when analysing investments whose purpose is expansion. Current profit is compared with the profit expected after the expansion has been completed. Since the calculation is only applicable for single-period decisions, average values are chosen for operational life spans which are longer than a single period and the presumption is made that these values are valid for all periods. Unlike cost comparison calculation, revenues are included. The expansion alternative to be chosen is the one that realises the highest average annual profit. If the outputs of the expansion alternatives are expected to be equal, a **profit comparison per period** and a **profit comparison per output unit** can be carried out. Both methods lead to the same result.

The possibility of inaccurate forecasts is an issue with profit comparison methods because a comparison is being made between potential profits and profits already achieved. Furthermore, the assumption is made that revenues can be allocated to individual investments, which is extremely difficult but can be done by comparing the total revenues and total costs of the firm, but it should be noted that the method does not say anything about the return on capital invested. When looking at investment decisions from a commercial point of view, relative profit levels (the return on capital invested) are of greater interest than absolute profit levels.

7.2.3 Profitability Calculation

Profitability calculations represent an improved form of the profit comparison method. Starting with the result of the profit comparison calculation, the average annual return on capital invested in an investment object can be determined. This **return on investment** is calculated by dividing the profit earned in a period by the capital invested. The profitability method is used to analyse single period investments; average values are applied in the case of multiple periods. The method is suitable for rating property, as properties tend to be more or less unique, so finding comparisons is difficult.

In order to use this method, it must be possible to match revenues to operational and capital costs, and then allocate the difference between them to the equity and/or debt capital invested. It is necessary to assign an interest rate to equity capital or debt capital, depending of course on whether the investment is financed by equity or debt. The opportunity costs for the loss of profits on an alternative investment must also be added to the costs. Otherwise, this method has the same issues as other static calculations.

7.2.4 Payback Calculation

The payback calculation deals with the question of how long it will take to recover the costs of an investment, or in other words, how long will it be before the outflows (payments) for an investment are covered by the surplus of inflows. The method is also known as the capital recovery method, and payoff, payback or payout method. Capital recovery for replacement and rationalisation investments is determined by annual cost savings, and for expansion investments by annual surpluses, as seen in Eqs. (7.1) and (7.2).

$$Payback\ period\ (years) = \frac{Capital\ invested}{Annual\ cost\ savings} \tag{7.1}$$

Equation 7.1 Payback time of replacement or rationalisation investment

$$Payback\ period\ (years) = \frac{Capital\ invested}{Annual\ surpluses} \tag{7.2}$$

Equation 7.2 Payback time of expansion investment

The payback period is the time span within which the investment can be amortised; in other words, when the receipts of payment (normally the revenues) have covered the purchasing outpayments and the current outpayments. The payback calculation aims particularly at satisfying the need of investors for security. If—according to the investors' risk assessment—the length of the payoff period with which the investor would be comfortable is longer than the actual payoff period, the investment is judged favourably. The payback calculation uses average values if it can be assumed that surpluses will be constant over the whole economic life span of the investment (**average calculation**). If different payback flows occur, the payback period must be calculated by a cumulative method. This is done by adding the various effective annual payback flows until they equal the amount of capital invested (**cumulative or total calculation**).

Unlike the previous methods which are linked to the firm's goals, the payback calculation reveals the investment risk; however, time is emphasised more than the type of investment. The longer the payback period, the more uncertain is the recovery of the capital invested. The remaining useful life of the investment and the development of profit after its amortisation are not considered by this approach and nothing is learned about the profitability of the investment.

7.2.5 Equivalence Coefficient Calculation

An equivalence coefficient is an indicator that establishes a relationship between individual production factors or products. It is most often used to establish cost relationships. The goal is to **divide pooled costs among the individual outputs to which they are linked;** if it is not possible to clearly determine the cause of the costs, they can be allocated in a way that seems the most appropriate. The precondition for using this method is that the outputs should be similar—but not identical. For example: suppose a paper-mill produces different kinds of paper. The production process is identical, but the volume of consumables used in their production is different. Equivalence coefficients make it possible to compare the costs involved in the production of each type of paper—one that has high consumables usage is given (say) a coefficient of 1.5 while one with lower materials usage costs has a coefficient of 0.8. The costs associated with running the production process can then be allocated accordingly.

This method is not without problems. Even with closely related outputs it is not always possible to identify a reference value that allows a clear division of costs. A single reference value, normally assumed by the equivalence coefficient calculation, is rarely sufficient. The lack of separation between fixed and variable costs is a problem with this method because of the implicit assumption that fixed costs can be allocated. The equivalence coefficient calculation is only suitable for allocating variable costs on a fair basis. It is focused on what can be quantitatively measured and is thus production-oriented and one-dimensional.

7.2.6 Break-Even Calculation

This method is concerned with determining the critical output volume at which the sales revenues cover the total costs. It should be noted that, unlike in pricing theory, the goal is not to determine the optimal profit. The **assumptions** of break-even calculations are: a single-product firm, production equals sales (in other words, there is no inventory), output volume is the sole determinant of costs, a linear relationship of variable costs to output volume, no stepped fixed costs (i.e. costs initially remain constant despite fluctuations in the operating level, but jump when production capacity is expanded) and the sales price remains the same, regardless of production quantities.

It is obvious that the information value of the break-even analysis is restricted by these assumptions. When managers do this in reality though, the necessity of being a single-product firm is not significant and inventories are basically ignored. It is imagined that costs can easily be split into fixed and variable, and that stepped fixed costs and volume discounts can be ignored. In spite of these restrictions the straightforwardness of this calculation method and its easy employment and application are commendable—see Eq. (7.3).

$$Break - even\ point = \frac{Fixed\ costs}{Price - Variable\ costs} \tag{7.3}$$

Equation 7.3 Break-even point

7.2.7 Value Added Calculation

This method establishes how high are the added value or the increase in value that an economic entity produces over a certain time period (as a rule 1 year). The value added calculation can be done by taking either a production approach or a use approach, as illustrated in Figs. 7.3 and 7.4.

Ultimately, the value added calculation is no more than a reordering of the income statement, but the calculation creates transparency. It illustrates the total output and allocates the operational expenses to the recipients of net value added. If

Fig. 7.3 Value added calculation—production approach

	Sales
±	Changes in inventories
±	Other company-produced additions to plant and equipment
±	Other operational returns (including financial returns, but excluding returns form valuations and liquidations)
=	Total output
-	Materials expenses (including bought-in goods and services)
-	Depreciation on tangible and financial assets
-	Other operational expenses
=	Value added

Fig. 7.4 Value added calculation—use approach

	Income from employment (wages, salaries, social security and pension expenses)
+	Income from debt capital (interest)
+	Income from equity capital (distributed profits and retained earnings)
+	Community income (taxes on income and profit)
=	Value added

comparable companies show different degrees of net value added, then the reasons are likely to be found in the area of production, usually the degree of automation and labour intensity—outsourcing and insourcing are often considered as options at this point.

7.3 Dynamic Methods for Capital Budgeting

7.3.1 Present Value Method

Static methods' single-period analyses with their calculations that use only average values are inadequate when longer time periods are concerned. Dynamic calculations include interest, so they are able to deal with the fact that receipts of payment and outpayments can and often do occur at different points in time during the total economic life of an investment object. Dynamic calculations are based on the principle of the time value of money, i.e. that the value of 1 euro in 5 years is not the same as the value of 1 euro today and vice-versa. They are oriented towards capital whereas static calculations are more concerned with production and related costs.

The point of the present value (also known as present discounted value) method is to determine current value, which is the difference between receipts of payment and outpayments once they are discounted to the beginning of the investment at a given interest rate. In other words: all receipts of payment and outpayments are related to the start of the investment, and differences caused by the fact that the timings of flows vary are removed by discounting. An investment is desirable in absolute terms when its present value is greater than or equal to zero (**problem of profitability**). If there are several investment alternatives, then the alternative with the highest present value is the most favourable one in relative terms (**problem of choice**). An old facility is replaced by a new one as soon as the present value of the new facility exceeds the present value of the old one (**problem of replacement**).

The basic formula for calculating the present value (PV) is straightforward, as Eq. (7.4) shows. C is the sum that must be discounted, n is the number of compounding periods and i is the interest rate per compounding period.

$$\mathrm{PV} = \frac{C}{(1+i)^n} \tag{7.4}$$

Equation 7.4 Present value

From a mathematical point of view, the present value method is not demanding, but from a business point of view this is not the case. The problems already start with the definition of the investment object: should the labour costs of the driver, for example, be included when deciding whether or not to purchase a vehicle? They continue with the estimating and allocation of receipts of payment and outpayments to the investment object: what returns can be expected from a fork-lift truck? They end with the determination of the discount rate and the economic life. Since the result of the calculation depends considerably on the interest rate, its determination is of significant importance. The **actual interest rate** can be decided on the basis of the medium-term costs of (debt) capital, the average return of companies in the same industry, the marginal return (i.e. the increase of profitability from an additional injection of capital) or a minimum return that the company itself establishes. The higher the interest rate, the lower the present value if payments are made that are greater than the concurrent payments received. The calculation becomes more complicated when interest rates vary over time.

7.3.2 Future Value Method

The future value of an investment is determined by establishing the difference between all the related flows of its economic life. An investment is profitable when the future value is greater than zero, where future value is the amount of money that an investor can take out at the end of the economic life of the investment while still being in a position to make any payments related to the investment—taking into account the interest rate that was previously determined—because the revenues generated by the investment cover these outflows. The future value method differs from the present value method not only by having a different reference date; it is also distinctive in that a **specific interest rate is determined for each period** of the capital investment, which means that the future value is not the same as the accumulated capital value. When comparing alternatives, the investment object with the highest future value is preferred. The time to replace an old asset is reached when its future value is lower than that of a new one.

The basic formula for calculating the future value (FV) of a sum of money is straightforward, as Eq. (7.5) shows. C is the present value, n is the number of compounding periods and i is the interest rate per compounding period.

$$\mathrm{FV} = C\,(1+i)^n \tag{7.5}$$

Equation 7.5 Future value

A problem not faced by the present value method is forecasting the varying interest rates of future periods, so the additional informational value of this method has to be weighed against the costs of being in a position to provide reasonable forecasts.

7.3.3 Internal Rate of Return Method

In a manner of speaking, the internal rate of return method represents the inverse of the present value method, because no interest rate is set for the payments—the discount rate of interest is itself what is being calculated. The **effective internal rate of return** that is being sought is one that sets the present value of all cash flows to zero. This method answers three basic questions about an investment as follows:

- An investment is profitable if its internal rate of return is greater than the target interest rate (e.g. the interest earned by a comparable investment on the capital market).
- The investment with the highest internal rate of return is considered the best.
- It is time to replace an old asset when its internal rate of return is lower than that of a new asset.

The internal rate of return method is based on the assumption that surpluses generated by the investment can be invested at the appropriate internal rate of return, bearing in mind that there will be differences in the size and timing of the receipts of payment and outpayments of the investments to be compared. This reinvestment premise is also valid for the present value and future value methods, as well as for the annuity method. However, in this method the reinvestment premise is more realistic because it is assumed that the reinvestment of inpayment surpluses always occurs at the calculated interest rate which themselves should correspond to the capital costs of the investor.

7.3.4 Annuity Method

This method, sometimes known as the equivalent annual cost method, is a variant of the present value method. Its basis is a calculation of the cost per year of the investment over its lifetime, providing equally sized annual values. As a first step, positive and negative cashflows are discounted and their present values calculated. Then the present value is divided by the present value annuity factor, giving the discounted annual cost of the investment over its lifetime. For instance, this method allows a choice to be made between two machines, each with a different investment cost, expected lifetime and annual maintenance costs—each has a different equivalent annual cost.

An investment is profitable in absolute terms when the positive cashflow annuity is greater than the negative cashflow annuity. If several investment alternatives exist, the one with the highest surplus annuity (i.e. with the greatest difference between positive and negative cashflow annuities) is preferable. In other words, the best choice has the lowest equivalent annual cost (EAC); when the EAC of an old investment is greater than that of a replacement, it is time to replace it.

As with the previous described dynamic methods, the annuity method is based on the following assumptions:

- There are no fluctuations in interest rates over the economic life of an asset.
- A perfect capital market exists in which interest rates are the same for loans and deposits.
- There are no restrictions on credit.

The annuity method yields the same results as the present value method about the profitability of an investment (all things being equal), so is used if easier to calculate.

7.4 Optimisation Methods

7.4.1 Differential Calculus

Optimisation calculations are instruments whose aim is to help determine the best possible solutions in a complex decision-making situation. As a rule, they are characterised by one or more target functions and a number of restricting factors that place limitations on the target. The objective is to find that combination of factors that produces the best result, which is either a maximum or minimum value of the target function (e.g. the maximum profit, lowest cost, lowest quantity of materials used or highest quantity produced).

Fundamental to these types of calculation is differential calculus. In its simplest form, it has a **single variable** and the function to be optimised is then derived according to this variable and the result is set to zero. If the function to be optimised depends on **several variables**, the function is derived according to each variable and the resulting expression set to zero.

Using differential calculus as a method means assuming that the optimisation problem can be presented as a calculus problem with quantitative criteria, which is clearly not the case when decisions need to be made about qualitative goals. In addition, the use of differential calculus as a tool is based on future expectations being reduced to a single-value, which does not do justice to the complexities of economic life.

7.4.2 Linear Programming

This method is suitable for optimisation purposes if both the target function to be maximised (minimised) and the accompanying variables can be formulated as **linear equations**. Linear programming is helpful in the case of simple models of production, inventory, transportation, distribution and financial planning. It enables optimisation calculations with several restrictions to be carried out in a relative straightforward manner but, as with differential calculus, this method has limited applicability because it is a purely quantitative model that ignores qualitative aspects.

7.4.3 Vector Analysis

Vector analysis can also be employed for optimisation purposes because it enables large amounts of data to be processed in a well-structured way. Unlike the other optimisation calculations, vector analyses use complex equation systems of vectors and matrixes to produce a **simultaneous solution**. An example for the application of the vector calculation is internal service output allocation. The goal of a vector analysis in this case would be to capture all intra-plant relationships in terms of outputs between individual cost centres. The exchange of outputs between cost centres is described in a system of linear equations in which the quantities of outputs exchanged are known but the cost rates are unknown. The number of equations is equal to the number of cost centres that are included in the calculation. The output of a vector analysis applied to this problem is a determination of the costs of the internal outputs taking into consideration exchanges of outputs between the cost centres.

7.4.4 Risk Analysis

Risk analysis is a core component of capital planning, where it is used to establish the risk profile of the present value of the result of the capital budgeting calculations, or put more simply, to determine the risk profile of an investment. The statistical basis of the analysis is **estimated subjective probability distributions** of what is being calculated, i.e. of the receipts of payment and outpayments and economic life of an asset. In this way, uncertainties regarding these elements are considered. The result of the risk analysis is a probability distribution that permits the risks connected to the realisation of the investment to be estimated. The risk analysis can then be used in the selection of the investment opportunity, as it shows which one has the highest expected value.

Expected value is not so unproblematic, however. On the one hand, risk neutrality is assumed; on the other, expected value can strictly speaking only be a decision criterion when an experiment to determine possible values is repeatedly carried out. For example, when a component supplier regularly orders raw materials to manufacture the parts for its main customer, the managers of the supplier must consider the risks of carrying on procurement as usual versus the risks involved with finding and using a new source of supply. Risk neutrality describes the attitude of a decision-maker who disregards the probability distribution and always prefers an alternative with a higher expected value to an alternative with a lower expected value, even if the former carries greater risks.

7.5 Forecast Analyses

7.5.1 Time-Series Analysis

Whereas static, dynamic and optimisation methods use mathematical tools, forecast calculations are mainly based on statistics. Forecasts are predictions of future developments that are based on observations and analysis; they are based on intellect and rationality and so are not wild guesses. The starting point is analysis of the past, where trends are identified and conclusions drawn.

In a time-series analysis the values a variable has taken are indexed in time order as a series of data points. Whereas qualitative forecasts are verbal, quantitative forecasts work with indexes, using a single value. With the **simple average method**, the premise is that all the past values included have the same weighting, so this method is only suitable if a low fluctuation of the dependent variable and a stable mean value can be assumed (for example, consumption rates of soft drinks have been constant for the past 3 years). The **weighted average method** argues that the more recent the data, the more relevant they are for forecasting, so they are given a higher weighting than older values. The influence of more recent data on the forecast is greater in this method than in the simple average method. An extension of this is the **moving average method**, in which the oldest values are replaced by the most recent on a continuous basis. The advantage is that forecast values more quickly reflect new developments. Related to the moving average method is **exponential smoothing**, where the analyst chooses a value to weight the values in time series. In this method, past values are not equally weighted; the relative weight of a value decreases with its increasing age.

These four methods described in this section neglect the possibility of a trend developing over time, i.e. they assume that demand is a function of time. A consequence of this is that when there is a growth or decline in the values of a variable due to what appears to be a trend (e.g. a particular kind of food becomes popular), the forecast values of the variable as used in the forecast calculation are either above or below its most recent actual values. It is precisely for this reason that **trend extrapolation** is helpful. It develops a function to establish the relationship between the variable and time, and it can then be used to extrapolate. The function is derived from past values using one of several available function types, depending on the basis of the fluctuation (e.g. linear or cyclical).

7.5.2 Regression Analysis

Regression analysis is based on the assumption that a causal connection (correlation) exists between a dependent variable and one or more independent variables, thereby enabling forecasts to be made of how the development of the dependent variable. A **simple regression analysis** explains the dependent variable through a single independent variable. Compared to the time-series analysis, the single regression is advantageous because the connection between time and the variable to be explained is abandoned in favour of a more specific statistical causal relationship (e.g. the weather and the number of umbrellas sold). This does not imply that a real causal relationship exists between a dependent and independent variable—correlation is not necessarily causation. A **double regression analysis** deals with one dependent and two independent variables, whereas a **multiple regression analysis** is employed to determine dependencies between more than two variables.

As with all forecast analyses, forecasting on the basis of single and multiple regressions is useful only if the relationships that existed in the past between independent and dependent variables also exist in the future. They are therefore predicated on stable environmental conditions.

7.6 Examples and Exercises

7.6.1 Forecasting Sales: Simple Linear Regression

Situation

Kindy, a chain of children's clothes shops is doing very well; its market share is increasing and this is related to the number of shops in the chain. Sarah, the vice-president of sales development and her team want to be able to forecast sales for sites where they are thinking of opening a shop and realise that size of the shop is a highly important factor. Her team puts together some information:

Shop	Area (sq. m.)	Annual sales (€ millions)
1	157	5291
2	148	5577
3	260	9581
4	520	13,585
5	121	4862
6	204	8008
7	121	5291
8	102	3861
9	297	7865
10	139	4147
11	483	15,301
12	427	10,868
13	539	16,874
14	279	5863

Solution

Using simple linear regression as a tool, Sarah's team enters this information into Excel to produce a scatter diagram with sales and area as the axes. The graph—see Fig. 7.5—also has a line of best fit which shows how well the regression equation fits the data. It will be noticed that there are a couple of outliers.

The software produces the regression equation shown here, where Yi is the forecast for shop i and Xi is the area of the shop:

$$Yi = -22.7867 + 35.1953\ Xi$$

They can now use this equation to predict sales of shops of different sizes, as shown in the following table:

Candidate shop	Area (sq. m.)	Forecast annual sales (€ millions)
A	255	8952
B	610	21,446
C	555	19,511
D	520	18,279

Of course, size is only one factor when deciding on store location. The general surroundings, local competition and many more other issues play a role. Sarah and her team at least know what kind of sales figures they can expect simply based on the area.

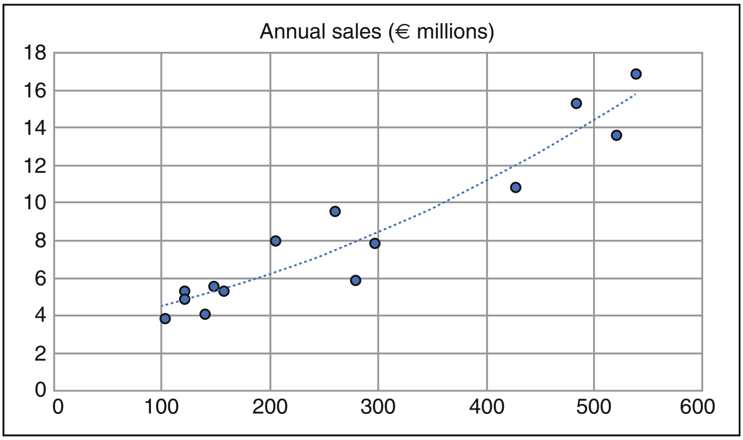

Fig. 7.5 Linear regression forecast

7.6.2 Forecasting Sales: Moving Average Method

Situation

Nils Britze works for a Hannover based producer of bottled non-alcoholic drinks, where he is the product manager for iced coffee and iced tea. The firm, H96 Drinks, has been in existence for 4 years and one of Nils' tasks is to forecast sales. He always has a few problems with this because the drinks for which he is responsible are seasonal products. The iced coffee product has been on the market for 2 years now and Nils has just received the latest sales figures, shown in the following table.

2016		2017	
Month	Sales (1000s of bottles)	Month	Sales (1000s of bottles)
January	34	January	36
February	42	February	43
March	38	March	43
April	46	April	50
May	50	May	54
June	55	June	59
July	62	July	64
August	66	August	70
September	50	September	52
October	48	October	50
November	40	November	42
December	39	December	41

It is his first day back at work in January 2018 and Nils has to produce a forecast for iced coffee sales for 2017. How can he approach this problem?

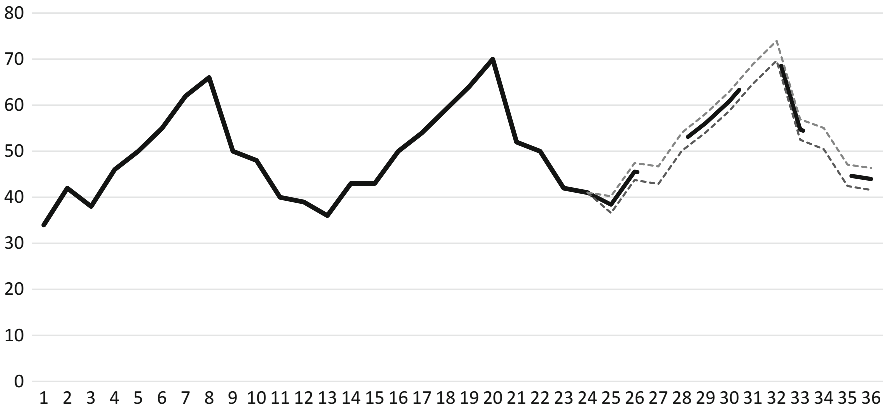

Fig. 7.6 Moving average forecast

Solution
Nils is aware of the several times-series forecasting methods—simple average method, weighted average method, moving average method and exponential smoothing, and decides to use the moving average method, given the seasonal nature of the product. He decides to use Microsoft Excel's built-in forecasting tool to forecast sales for 2018. He tells the software to use a seasonality of 12 months and it produces the following chart—the *y*-axis shows sales (thousands of bottles) and the *x*-axis is month number. Months 1–24 represent 2016 and 2017; months 25 and up are the months of 2018 (Fig. 7.6).

The thick dotted line represents the forecast sales; Excel has recognised the seasonality. The lighter dotted lines are the upper and lower confidence limits, i.e. they represent the maximum and minimum values of the forecast with a 95% confidence interval, which means that sales in 2017 will lie between these values nineteen times out of twenty.

Nils recognises that a forecast is only as good as the historical data that is entered and also realises that any number of external or internal events could make the forecast worthless—a competitor may reduce prices, the price of coffee beans could increase sharply, or even that there is a trend away from caffeinated drinks. He will of course need to do a risk analysis and plan appropriate measures.

7.6.3 Time Value of Money

Situation
Deborah has just joined one of the Big Four auditing firms and is training to be an accountant. On her first day, she has been sent to audit a medium size company and her supervisor has asked her to test the client's accounting software to ensure it is producing the correct answers. The supervisor selects two transactions at random and asks Deborah to verify the numbers that the client is using in its accounts:

- The Chief Financial Officer has just invested 10,000,000 € in a fund with a maturity of 5 years offering a promising semi-annual return of 2%. What is the amount available when the fund matures?

and

- The company will need a sum of 50,000 € in 3 years to pay for the chairwoman's retirement party. How much does the company have to deposit today into an account earning 6% annually in order to have this sum?

As she works on these two problems, Deborah thinks about the question her neighbour asked her. Harry has just bought a lottery ticket and won 100,000 €. He wants to finance the future study of his newly born daughter and invests this money in a fund with a maturity of 18 years offering a return of 4%; the interest is compounded semi-annually. What is the amount available on the 18th birthday of his daughter? Will it be enough to pay for her education?

Solution
Deborah understands that all three problems are related to the time value of value of money.

The Chief Financial Officer's is interested in the future value of his investment, where the relevant formula is:

$$\mathrm{FV} = C\,(1+i)^n$$

Here, C = 10,000,000 €, $i = 0.02$, and $n = 10$ (because the interest is compounded semi-annually). The formula looks like this:

$$\mathrm{FV} = 10{,}000{,}000\ €\ (1+0.02)^{10} = 12{,}189{,}944.20\ €$$

The issue of having enough money for the party is related to present value, where the formula is:

$$\mathrm{PV} = \frac{C}{(1+i)^n}$$

Here, C = 50,000 €, $i = 0.06$, and $n = 3$, giving:

$$\mathrm{PV} = \frac{50{,}000\ €}{(1+0.06)^3} = 41{,}980.96\ €$$

Deborah checks her results against what the company's software said and finds that they are the same: the CFO's investment of 10,000,000 € will be worth 12,189,944.20 € in 5 years, and the company will need to invest 41,980.96 € today to have 50,000 € for a retirement party in 3 years' time.

Her neighbour's problem is also about future value, and the formula looks like this:

$$FV = 100{,}000\ € \ (1 + 0.02)^{36} = 203{,}988.73\ €$$

Harry will be happy to learn that his winnings of 100,000 € will be worth more than twice as much in 18 years, thinks Deborah. But she also realises that tuition fees could be even higher in 18 years.

7.6.4 MyCompany Project

Business in the café continues to go well. Customers are satisfied, the workers are happy and revenues are coming in. You are in fact so busy that you decide to buy a bigger espresso machine. The one you have now is purely manual; the serious barista working for you really likes it, but it is too slow and labour intensive. After looking over what's available on the market, you are left with a choice between a Vasari 2S made by La Pavoni or a Grindmaster-Cecilware ESP2-220V Venezia II. Both are semi-automatic continuous brewing machines.

- There are several calculations that can be used for capital budgeting—cost comparison, profitability, payback etc. Which one would you choose and why? Find the relevant information on the internet and work out which machine you would buy.

You will probably need to go to the bank to get a loan to buy the machine, and you expect the bank manager will want to know about how you are managing the café. It strikes you that it would be ideal if you could show her some ratios, such as sales per member of staff.

- Which other ratios would be useful to you as you manage the café?

The bank manager will probably be particularly interested in your justification for the purpose. You know intuitively that you will be selling more cups of coffee in the next year, but you will need to show this in black and white and so decide to prepare a forecast.

- Which forecasting method would you use? What might affect your actual sales in the next year? Make a list
- What measures would you have ready to react to the items on your list (such as a new Starbucks opens up two doors away or coffee prices rise dramatically)?

7.6.5 Self-Test Questions

- *What is a ratio system and what does it include?*
- *Why are ratios so popular?*
- *How are the characteristics of static calculations? And dynamic calculations?*
- *Describe how the profit comparison method works.*
- *What is the prerequisite for the use of profitability calculations*?
- *What conclusions can be drawn from payback calculations?*
- *What conclusions can be drawn from a break-even calculation?*
- *What are the two ways of calculating added value*?
- *What is meant by capital value and what are the problems of the capital value method?*
- *What is the assumption behind the interest rate method?*
- *How is the profitability of an investment calculated with the annuity method?*
- *How can the vector analysis be applied in operational business activities?*
- *What is a risk analysis used for?*
- *How does the moving average method work?*
- *What is the advantage of regression analysis compared to time-series analysis*?