Costs

8

This chapter covers . . .

- the importance of cost functions and their role in managerial decision making.
- the relationship between a firm's production technology and its cost function.
- different types of costs and their relevance.

8.1 What Are Costs, and why Are They Important?

Two roads diverged in a yellow wood,
And sorry I could not travel both
And be one traveler, long I stood
And looked down one as far as I could
To where it bent in the undergrowth.
(Robert Frost, The Road Not Taken)

If one goes shopping and buys a new pair of sneakers, the cost for one's sneakers is the price that one pays for them. The monetary price of a good is, however, only part of the story economists tell when they talk about costs. As covered in Chap. 1, scarcity implies that one's decision to go this way makes it impossible to go the other way; that all activities have opportunity costs. The opportunity cost of choosing one alternative is the value that one attaches to the next-best alternative foregone. The implication for the sneakers example is that the total costs of the sneakers are, in general, higher than the price one pays, because one has to invest time and effort to find and buy them. If one could have used one's time otherwise, then one has to take the opportunity costs of time into consideration to get a correct measure of the costs one has to incur to get hold of a new pair of sneakers. To give another example, opportunity costs are the reason why it may be silly to drive the extra mile to refuel your car, only because the gas station is a cent cheaper.

However, the true costs of sneakers are only higher than the monetary costs *in general*. It may be that one actually enjoys going shopping, which implies that the

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opportunity costs of time are negative, subtracting from the monetary costs. Moreover, to make things even more involved, the value that one attaches to the price sticker may depend on one's situation in life and one's expectations. If one assumes that there will be considerable inflation the next day, reducing one's purchasing power substantially, one will most likely do one's best to get rid of one's money that day. Thus, all costs are ultimately opportunity costs, which are psychological and subjective concepts of value that are related, but not identical, to market prices.

The fact that the relevant costs are opportunity costs may be interesting in and of itself, but the real importance of this observation becomes apparent if one considers the implications for decision making. Here is an example: assume one wants to make some extra money parallel to one's studies by offering tutoring services to other students, but one is not sure whether this is a good idea, because one does not fully oversee all the consequences of this decision. In order to get a better idea, one makes a business plan to identify the costs and benefits of one's decision. To keep the analysis simple, assume that one can help one student at a time (class size is one) and that the only things one needs to get one's business going is one's time and a room that one has to rent. Further, assume that one can teach up to 20 hours per month. The monthly rent for the room is CHF 500, and one can charge students CHF 50 for an hour of tutoring. A first back-of-the-envelope calculation reveals that one has to teach for ten hours per month to cover one's monetary costs (this is called the *break-even point*). If one teaches for the entire 20 hours, one ends up with a monetary profit of CHF 500. Given this calculation, the question is if one is willing to enter the tutoring business. Based on the above calculation, one should enter the tutoring business because of the positive monetary profit.

If, however, one does not feel completely happy with starting the business based on this calculation, the reason must be that one puts this number into a different context. What could that context be? For example, the next-best alternative on the job market could be to work as a barista in a café, at an hourly wage of CHF 30 (including tips). Thus, working 20 hours, one could earn CHF 600 per month. Even though the hourly wage is much smaller than the one that one could earn for tutoring, the income exceeds the profits from tuition, because one does not need to pay the rent. Therefore, compared to the barista job, one would *loose* CHF 100 by opening one's business. Hence, one should somehow take these opportunity costs explicitly into consideration.

Now, one could argue that tutoring is a more meaningful way to spend time for one than brewing coffee is. If this is the case, one should also include these psychological rewards and costs into one's calculation. Working may not just be about making money, but also about doing something that one finds meaningful, which implies that there is a difference between costs and expenditures. Assume that one assesses the intrinsic pleasure that one gains from tutoring by CHF 30 and the intrinsic pleasure that one gains from brewing coffee by CHF 20 per hour. In that case, these psychological benefits sum up to opportunity costs of brewing coffee of $\text{CHF } 20 \cdot \text{CHF } 30 - 20 \cdot \text{CHF } 20 = \text{CHF } 200$, which would tip the balance towards opening one's tutorial business.

Table 8.1 Optimal decisions depend on opportunity costs

	Tutor	Barista	Exam
Rental costs	500	0	0
Wages	1,000	600	0
Net	500	**600**	0
Intrinsic pleasure	600	400	500
Net	**1,100**	1,000	500
Future income	0	0	1,000
Net	1,100	1,000	**1,500**

One can elaborate on one more aspect of the problem of getting the business plan straight before summarizing it. Assume that the alternative to opening one's business is not working as a barista, but studying for one's exams. In that case, there are no direct monetary opportunity costs that can be taken into consideration. However, even in this case, one has to figure out how much the additional 20 hours of studying would be worth. These benefits might be completely functional, driven by the effect that one's grades get better and one is, therefore, more likely to qualify for better programs and jobs. On the other hand, they might be purely intrinsic, measuring the pleasure that one derives from learning. Regardless how one evaluates one's own situation, the theory suggests that one should be able to attach some monetary value to these alternatives in order to be able to make the right decision. Table 8.1 gives an overview of the example. It is assumed that one can attach a monetary value of CHF 500 to the intrinsic pleasure of learning and a monetary value of CHF $1,000$ to the better job prospects.

What the above example has illustrated is that costs are a tool that can help one to make smart decisions. However, in order to be able to support your decisions in a rational way, one has to think about costs in terms of opportunity costs. If the costs are calculated incorrectly, then one's decisions will not be smart.

One may wonder if it is always possible to attach a meaningful monetary value to psychological opportunity costs. Numerous psychological studies have shown that, for different reasons, people have trouble specifying their valuations of alternatives in a reasonable way. Section 5.3 discussed some of these reasons. How reliable is the figure that one attaches to the value of 20 hours of additional learning? Will one really use the time to learn? Can one anticipate how much fun it will be to help other students? People are very bad in what is called *affectual forecasting*, i.e. anticipating how they will feel in the future. Is one's perception of the psychological costs and the benefits context-dependent (the anchoring effect from Sect. 5.3)? There is also evidence that people have a tendency to rationalize their gut feelings by developing narratives that selectively focus on aspects that support their "guts." The term *narrative fallacy* describes how flawed stories of the past influence one's perception of the present and future. People have an innate urge to develop a coherent story about the events that shape their lives and simplicity and coherence often more important than accuracy. The mind is a sense-making organ and the narratives it cooks up reduce the anxiety that one would experience if one faced the complexity and unpredictability of life. This may help one in one's life, but it is not the same as descriptive accuracy.

Nevertheless, if one has ample reason to scrutinize the numbers that one assigns to psychological opportunity costs, would it not be better to abandon the idea altogether? This would throw out the baby with the bathwater, because one has to decide somehow and decisions that take all the relevant opportunity costs into consideration are, in expectation, better than decisions that neglect some of the tradeoffs. An awareness of the flaws and biases that exist when one thinks about psychological opportunity costs can help one to put the concept into perspective and to cope with the idiosyncrasies of one's mind.

The following three examples will illustrate how one can proceed in assigning opportunity costs. Assume that a firm produces a good using capital and labor. Profits are revenues minus costs. What are the costs and revenues that are associated with this activity?

- **Case 1, all costs monetary:** The firm borrows capital from capital markets, rents labor from labor markets and sells the good on a goods market. In this case, the revenues of the firm are the market price times the produced and sold quantity of the good (assume revenues are CHF 1,000). The firm's costs are the sum of interest payments for rented capital (CHF 400) and wage payments for hired labor (CHF 500). All relevant costs and revenues are monetary, because they involve market transactions. An accounting system that includes ("takes into account") all three costs and benefits makes the business appear profitable.
- **Case 2, goods not sold:** The firm borrows capital from capital markets, rents labor from labor markets, but the owner of the firm consumes the goods directly. The costs of the firm are, again, the sum of interest payments (CHF 400) for rented capital and wage payments for hired labor (CHF 500). However, it has no monetary revenues. A system of accounting that considers only monetary payments would support the decision to shut down the business, because it would show a deficit of CHF 900. There is no monetary equivalent for the satisfaction or utility of the owner from consuming the goods (again CHF 1,000). Hence, economically meaningful decisions can only be supported by an accounting system that attaches a monetary value to the satisfaction or utility of the owner.
- **Case 3, owner self-employed:** The firm borrows capital from capital markets, sells the good on a goods market, but the owner works himself. In this case, the firm's revenues are, again, the market price times the produced and sold quantity of the good (for example CHF 800 this time). The firm's monetary costs are the interest payments for rented capital (CHF 400). Without incorporating labor costs into the equation, the business appears profitable. However, this calculation would lead to the wrong decision. Assume the owner would make CHF 500, if he worked somewhere else. These opportunity costs should be taken into account to support the right decision. The business now appears deficient and, compared to the next-best alternative, it actually is: if the owner were to shut down the firm, he would earn CHF 500. Staying in business gives a monetary profit of CHF 400, so he actually loses CHF 100 compared to the next best alternative.

What are the consequences of the idea that costs and revenues have to incorporate non-monetary opportunity costs? First of all, it can serve as a guideline for the design of managerial accounting systems. One of the primary reasons for the existence of accounting systems is that they can support decisions. However, as one has seen, decisions are only accurate according to some objective (profits, in this example) of the firm, if the accounting system that supports decisions incorporates all opportunity costs. These opportunity costs are sometimes referred to as *imputed interest* or *calculatory entrepreneur's salary*. *Management accounting*, however, has to be distinguished from *financial reporting*. The primary purpose of the latter is to communicate a company's financial situation to the outside world. These statements are subject to legal constraints and regulations that are sometimes incompatible with the idea of opportunity costs. So-called *imputed costs* are a good example of opportunity costs that are, in general, considered in management accounting, but are not allowed to be considered in financial statements. It is, for example, possible to activate interest payments on debt capital, but not imputed interest payments on equity. Imputed interest payments on equity are opportunity costs, because they are equal to the interest payments one would have received, if the capital had been lent to someone else. $\mathcal{B}$

Digression 19. Opportunity Costs and Maximization

The idea that rational decisions are based on the correct identification, evaluation and comparison of opportunity costs is closely related to the idea of *maximization*. An individual is a maximizer, if she consistently chooses the best (according to her subjective standard) alternative among the available alternatives. There is a lot of evidence that people are rarely maximizers in this sense. One is seldom in a position to know and precisely evaluate all the alternatives, because of uncertainties regarding the relevant probabilities and cognitive limitations. Hence, a lot of people are not aiming for the best, but for a good enough alternative. Think of your decision to meet a friend for dinner. Most people browse their directory and call the first friend with whom it seems sufficiently interesting to spend the evening. Simon (1957) called this type of behavior *satisficing*. The idea is that individuals have certain aspiration levels and choose the first alternative that meets these standards. Because of that, the resulting choices are, in general, less than optimal. There may have been friends in your directory with whom you could have spent an even better evening.

At first glance, satisficing seems to contradict the idea of maximization and thereby the concept that one should start by identifying and evaluating all opportunity costs. However, advocates of the maximization approach have argued that the opposite is the case: satisficing is optimization where all opportunity costs, including the costs of processing information and optimization, are considered. Looking for the best friend to spend the evening with may be so complicated and time consuming that, in the end, one has dinner alone. It is disputed, however, whether this is a legitimate defense of the idea of maximization. It brings the whole concept close to a tautology, because it comes with the risk of explaining every type of behavior by identifying arbitrary and non-falsifiable opportunity costs.

What studies with monozygotic and dizygotic twins have shown is that the tendency to satisfice or to maximize has a strong genetic component and that people can be categorized into "maximizers" and "satisficers." Interestingly, maximizers tend to make better decisions than satisficers, but are less happy with them. One explanation for this apparent paradox is that even maximizers tend to fail to identify the best alternative in complex environments, but are more aware of the fact that they may have failed to achieve their goals. Hence, they often feel regretful when they evaluate their choices. Therefore, in the end, the satisficer goes to the first ok-looking restaurant with the first ok-looking friend and spends a happy evening, whereas the maximizer continuously questions whether sushi with Sasha would have been better than pizza with Paul.

8.2 A Systematic Treatment of Costs

One is now in a position to define costs in a systematic way. Costs are the sum of factor inputs evaluated by their prices (be they monetary or opportunity costs).

In the easiest case, there is only one input, whose quantity is denoted by q and that can be purchased at a price (per unit) of r. In this case, costs are simply $C(q, r) = q \cdot r$. If there are $i = 1, \dots, m$ different inputs with quantities denoted by q_i and prices by r_i, the *cost equation* can be defined as:

$$C(q_1, \dots, q_m, r_1, \dots r_m) = \sum_{i=1}^{m} q_i \cdot r_i .$$

The cost equation is easy to specify, but it is not particularly interesting for economic decision making. What one would like to understand is the relationship between *output* and *costs* or, more precisely, between output and the *minimum costs* that are necessary to produce this output. This information is given by the *cost function*.

► **Definition 8.1, Cost function** A cost function $C(y_i)$ assigns the minimum costs to the production of y_i units of a good i.

In principle, it would be possible to define certain properties of cost functions and see what they imply for the behavior of firms in different market contexts. Economists, however, usually take a detour and establish a causal link between the cost equation and the cost function, because it allows them to see how the cost function relates to the physical properties of production. This is important for assessing, for example, the effects of technological change on market behavior or market structure, and so on.

Production is, first of all, a physical activity that transforms matter from one state into another, generally more desirable state. The rules of transformation are summarized by the so-called *technology of production*. It is the set of all technologically feasible input-output combinations and is – mathematically speaking – a set. The boundary, or "outer hull," of this set is the subset of all productively efficient input-output combinations because at a point along the outer hull it is (for given quantities of inputs) only possible to increase the production of one good by lowering the production of some other good. This outer hull is called the *production-possibility frontier*. It can – under certain conditions – be represented by a function that one calls the *production function*.

► **Definition 8.2, Production function** A production function relates the output of a production process to the necessary inputs. It assigns the productively efficient output to any combination of inputs.

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Digression 20. Firms as Production Functions and Firms as Organizations; How Efficient Can One Possibly Be?
At this point, it is important to scrutinize the basic assumption that a point along the production function can actually be reached. Underlying this assumption is the view that firms are able to organize economic activities within the firm in a perfectly efficient way. Historically, economists were not particularly interested in the management structures of firms and treated the firm as a black box that entered their analysis as a production function. This simplification might be useful, if the primary focus of the analysis is the interaction of supply and demand on markets. As one knows from the short introduction into the philosophy of science, every scientific theory has to make simplifying assumptions; the question is if the simplifications are useful.

The firm-as-production-function view was challenged when economists started to realize that they cannot explain the existence of firms as subsets of transactions that replace decentralized market transactions with more centralized forms of governance (see Sect. 6.2 for more detailed information). Since then, a large body of literature on the internal organization of firms and the boundaries between firms and markets has emerged that allows one to better understand under what conditions and with what kind of organizational structure companies can get to or close to the production function. This issue boils down to understanding if firms can organize economic activities in a way that all interdependencies, which are internal to the firm, are internalized (i.e. no firm-internal externalities exist). The strands of the literature that focus on these problems are called *principal-agent theory*, *contract theory* or merely *theory of the firm*. The important point is that one has to conceptually distinguish between the production function and the relationship between inputs and outputs, which exists given the (possibly imperfect) way economic activities are organized within a firm.

Economists and business economists are usually no experts in the physical laws of production. Nevertheless, they have to be able to communicate with engineers and scientists (who are experts in respect of these laws of production) in order to understand how the production process influences the structure of the cost function. The idea is relatively straightforward and can be exemplified by means of a (hypothetical) production technology that transforms one input, labor (l), into one output, apples (y). The input price is equal to the market wage (w). The production function can then be defined as $y = Y(l)$, and the structure of the function $Y(.)$ summarizes the "laws" for transforming labor into the number of apples picked. A potentially interesting question is by how much the number of apples picked is increased by one additional unit of labor.

► **Definition 8.3, Marginal product** The marginal product of a production function measures the change in production y that is caused by an additional unit of an input l.

In order to access the powerful toolbox of Calculus, one has to assume that infinitesimal changes in inputs and outputs are possible and that the production function is continuously differentiable. These assumptions allow one to approximate the marginal product by taking the partial derivatives of the production function. Formally, let dl be a change in labor input and dy the associated change in output. With only one input and a marginal change in l, $dl \to 0$, the marginal product is given by

$$\frac{dy}{dl} = Y'(l),$$

where $Y'(.)$ is the partial derivative of $Y(.)$. If several inputs $q_1, \ldots, q_m$ are needed for production, the production function can be denoted as $Y(q_1, \ldots, q_m)$, and the marginal product for an infinitesimal change in input i, dq_i, is given by

$$\frac{dy}{dq_i} = \frac{\partial Y(q_1, \ldots, q_m)}{\partial q_i}.$$

The marginal product will be useful later on in the analysis.

Figure 8.1 gives a graphical illustration of a production function for the case of $Y(l) = \sqrt{l}$. The factor input (l) is drawn along the abscissa and the output (y) is drawn along the ordinate. The root function implies that additional labor input increases the output, but at a decreasing rate.

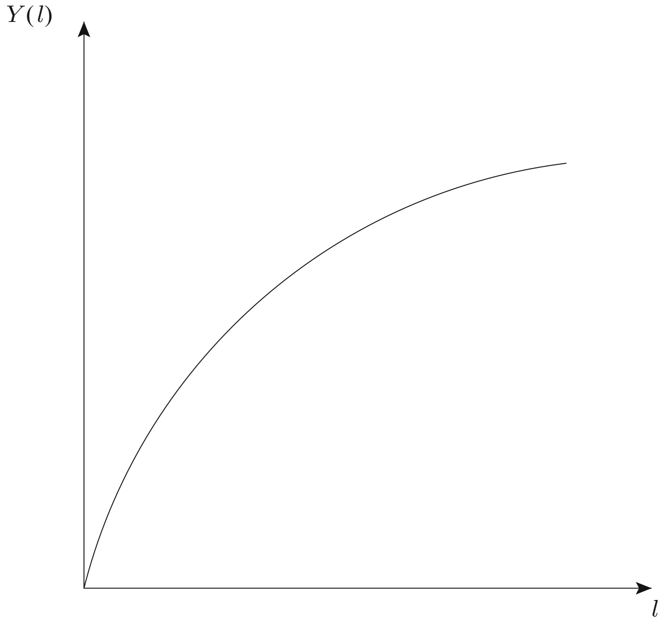

Fig. 8.1 The graph of the production function $Y(l) = \sqrt{l}$

Costs are inputs evaluated by input prices. The production function establishes a link between inputs and outputs. If one had the opposite link between output and input, one would be close to the solution of the problem: if one could associate a level of input with each level of output, the only thing that one would have to do is to multiply the input by the input price to get the cost function. However, the opposite link can be readily established as the *inverse function* of the production function. It gives an answer to the question of how much input one needs for a given output. Multiply this input by the factor price and you have the cost function. More formally, assume the production function is monotonically increasing (i.e. more input generates more output), let $\mathcal{L}$ be the set of all possible inputs and $\mathcal{Y}$ be the set of all possible outputs. The production function is a mapping from $\mathcal{L}$ to $\mathcal{Y}$, $Y : \mathcal{L} \rightarrow \mathcal{Y}$. Denote by $L(y)$ the inverse function of the production function, $L(y) = Y^{-1}(y)$. It is a mapping from $\mathcal{Y}$ to $\mathcal{L}$, $L : \mathcal{Y} \rightarrow \mathcal{L}$. Figure 8.2 illustrates.

This figure displays the relationship between labor input (l, along the abscissa) and output (y, along the ordinate). People are used to following the convention of interpreting the variable on the abscissa as the explanatory variable and the one on the ordinate as the explained variable. This is the interpretation as a production function: how much output can be produced with l units of labor input? Graphically speaking, one looks at the figure from the abscissa to the ordinate, indicated by the stylized eye in Fig. 8.2a. One can, of course, also look at the figure from another angle. In Fig. 8.2b, the stylized eye indicates that one interprets y as the explanatory

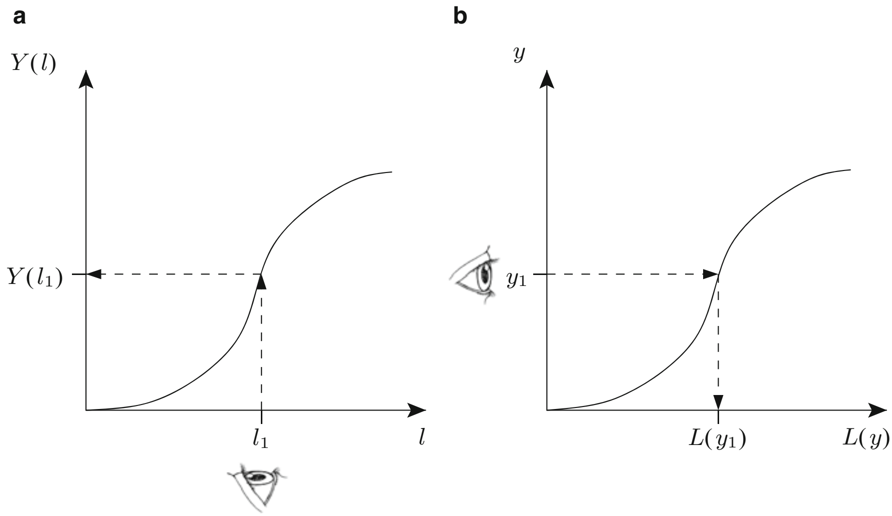

Fig. 8.2 Looking at graphs from two different angles, **a** Production function, **b** Cost function $(w - 1)$

and l as the explained variable. The question that one asks then is how much labor input one needs, if one wants to produce y units of output. The answer to this question is given by the inverse of the production function.

▶ **Definition 8.4, Cost function for one-output-one-input technologies** The cost function $C(y)$ for a production function $y = Y(l)$ is given by $C(y) = L(y) \cdot w = Y^{-1}(y) \cdot w$.

Figure 8.3 gives a graphical illustration of the inverse production function $L(y) = y^2$ and the cost function $C(y) = y^2 \cdot w$, which results if $Y(l) = \sqrt{l}$. I have used $w = 2$ in the graph.

Now, output (y) is drawn along the abscissa and input (l) along the ordinate. The cost function (see upper graph) is a multiple of the inverse production function (see lower graph).

This link between the production and the cost function allows one to understand how cost functions are related to production technologies. Two qualifying remarks have to be made in order to get the bigger picture.

- First, the assumption that the firm can rent or buy inputs at given input prices reveals the implicit assumption that factor markets are perfectly competitive. If the firm has market power on some input market (for example, if it is the only major employer in the region), then the relationship between costs and technology is no longer so straightforward and is also determined by the power of the firm to set wages as a function of labor input.

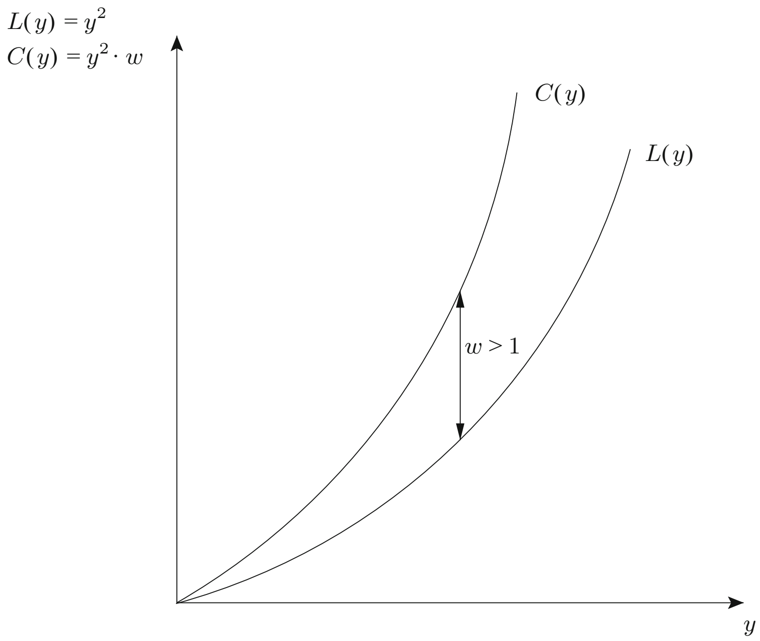

Fig. 8.3 Inverse production function and cost function

- Second, it is, of course, a completely unrealistic assumption that production requires only one input. Some production processes lead to co-production, such as when crude oil is separated into its different marketable components. Multi-input production gives rise to the more complex question of how to determine the optimal mix of inputs. This optimal mix is influenced by the technologically determined degree to which the different inputs can be substituted for each other and the input prices. Manufacturing, for example, can be relatively capital-intensive or relatively labor-intensive, and the capital-labor ratio depends on the relative prices of capital and labor. In order to determine the cost function, in this case, one has to solve what is called a *cost-minimization problem*. For understanding this and the following chapters, it is sufficient to work with the insight that one gets from the one-input-one-output model. ✍

With this understanding of a cost function, one can now move on and use it as an explanatory tool for different theories of firm behavior in markets. As one will see throughout the following chapters, different types of costs will turn out to be important explanatory factors. Therefore, this subchapter will introduce them now, filling the toolbox with additional tools that one will use later on.

If one takes total costs and distributes them equally among all the units that one produces, one gets the average costs of production:

▶ **Definition 8.5, Average costs** The average costs of production equal the total costs of production divided by the quantity produced, $AC(y) = C(y)/y$.

Some costs vary with, and some are independent of, the quantity produced. Take computer software or cars as examples. Before one can sell a new product, one has to incur development costs. These costs are independent of the number of licenses or vehicles that one produces and sells; they are a prerequisite for their production. The reason why these costs do not vary with the volume produced is technological. They have the property that, from an *ex-ante* perspective (before one makes the investment decision), they are zero, but immediately "jump up," if one decides to develop and sell the new product. One calls these costs *technological fixed costs*.

▶ **Definition 8.6, Technological fixed costs** The technological fixed costs of production are the costs that occur once a firm starts production and they are independent of the volume of production,

$$TFC(y) = \begin{cases} 0, & y = 0 \\ FC, & y > 0 \end{cases} .$$

Costs are related to prices and prices exist within an institutional framework as part of a contract. This is why costs can also be independent of production volume, because of contractual reasons. Take a long-term rental agreement as an example: the rent has to be paid throughout the duration of the contract, irrespective of the firm's performance on markets. Such costs have the peculiar feature that they are fixed throughout the duration of the contract, but can be variable over longer periods of time or with different contractual arrangements. These costs are called *contractual fixed costs*.

▶ **Definition 8.7, Contractual fixed costs** The contractual fixed costs of production are the costs that are independent of production: $CFC(y) = FC$ for all $y \geq 0$.

The major differences between contractual and technological fixed costs are, therefore, their causes and their behavior around $y = 0$. Technological fixed costs can become contractual fixed costs, for example, if the engineers who develop a new product have long-term contracts. For a lot of economic applications, it does not matter whether fixed costs are contractual or technological, but there are some important exceptions. If the difference is without relevance, one simply calls them fixed costs; otherwise, one explicitly refers to their cause.

▶ **Definition 8.8, Fixed costs** The fixed costs of production include the technological and the contractual fixed costs.

Contractual fixed costs are also costs that cannot be recovered: once one has signed the contract, one has to pay them. This is true for all costs that are necessary for production, as well as those that occurred in the past. The fact that the monthly payments fixed in a long-term rental agreement will occur in the future is irrelevant for this, because the legally relevant act, the signature of the contract, happened in the past.

► **Definition 8.9, Sunk costs** Sunk costs are costs that have already been incurred at a given point in time and thus cannot be recovered.

It can be argued that sunk costs are, necessarily, fixed costs: from today's perspective, they cannot be influenced and are, therefore, independent of the volume of production. However, if all costs are opportunity costs, then sunk costs are not "proper" costs at all, because they refer to events in the past and are, therefore, irrelevant for one's decisions. They are like gravity: one can complain that it exists and that it makes flying difficult, but the only thing one can do is to cope with it.

The costs that vary with production are called variable costs. If one is in the fruit-picking business and one hires fruit pickers every morning, then labor costs are variable on a daily basis.

► **Definition 8.10, Variable costs** The variable costs of production are the costs that vary with the quantity produced: $VC(y) = C(y) - FC$.

One can now look for averages in fixed and variable costs, which motivates the following two definitions:

► **Definition 8.11, Average fixed costs** The average fixed costs of production equal the fixed costs of production divided by the quantity produced: $AFC(y) = FC/y$.

The concept of average fixed costs can be applied to both contractual and technological fixed costs.

► **Definition 8.12, Average variable costs** The average variable costs of production equal the variable costs of production divided by the quantity produced: $AVC(y) = VC(y)/y$.

Last, but not least, one might be interested in the costs that result if one produces an additional unit of output:

► **Definition 8.13, Marginal costs** The marginal costs of production are the costs that result from the production of an additional unit of output: $MC(y) = dC(y)/dy$.

Marginal costs $MC(y)$ are approximately equal to the partial derivative of the cost function $C'(y)$, if one allows for infinitesimal changes in inputs and outputs. Marginal costs are a key concept in mainstream economics, because they play a prominent role in determining the behavior of firms, which seek to maximize their profits.

The above office-rental and fruit-picker examples suggest that the relationship between fixed and variable costs is a matter of time frame and contract structure. As soon as one has signed a contract with a specific duration, the costs that emerge from this contract are sunk and, therefore, fixed during the term of the contract, but variable for larger time spans. Thus, the question of which inputs contribute to fixed costs and which to variable costs depends on the contract structure and the contract structure may be culture-specific. In countries with extensive employment-protection laws, it is difficult to fire employees on short notice, so one gets a certain downward rigidity. In countries with hire-and-fire cultures, it is much easier to adjust one's workforce on short notice. The same is true for capital, where one needs to understand the contract structure in order to know whether rental agreements, etc., contribute to sunk and fixed or variable costs. In the long run, however, all costs are either variable costs or technological fixed costs. (For nerds: strictly speaking, technological fixed costs are a special case of variable costs, because they depend on production, even if only at $y = 0$. Classifying them as such, however, makes it harder to build an understanding about the underlying economic phenomena, which is why one summarizes them in a specific category.)

Digression 21. The Profits for the Apple Watch Are …

According to the news agency Reuters (May 01, 2015), Apple Inc's Watch has the lowest ratio of hardware costs to retail price of any Apple phone. The hardware costs of the Sport edition was about 24% of the suggested retail price (29–38% for Apple's other products). The suggested US retail price for the watch is $349, and the hardware costs (including manufacturing costs of $2.50) amount to $83.70.

One could argue that this is a nice profit margin and a proof of Apple's strong monopoly position in the industry. Nevertheless, be careful! It may be safe to say that Apple will make a nice profit with its new product line, but to conclude from the above report that it amounts to $265.30 per watch would be premature.

Based on the costs analysis, one knows that total costs consist of variable plus fixed costs and that hardware and manufacturing costs are usually variable costs. Hence, $265.30 is closer to what we have called producer surplus.

Fixed costs are usually substantial for products like the Apple Watch, because they include costs for research and development and also for marketing. What makes the above numbers almost impossible to interpret is the fact that one does not know to which extent these costs are already figured into the hardware costs.

Here is an example why this is complicated. Apple buys the processor from Samsung. If Samsung did all the research and development, these costs must already be figured into the price Samsung charges Apple for this part. The same is true for all the other components that make up an Apple Watch. Therefore, if Apple mainly assembles components developed by other firms, a substantial part of the technological fixed costs are not contractual fixed costs from the perspective of Apple. In this case, the per-unit profit is closer to $265.30. But wait! Maybe the contract between Apple and Samsung specifies a so-called two-part tariff where Apple makes a fixed, upfront payment and pays a lower price for each processor. Such a contract would bring the price structure more closely in line with Samsung's cost structure, which may be beneficial from an efficiency point of view. Nevertheless, if this were the case, the upfront payment should not count as part of the variable hardware costs ... unless Apple divides them among the expected sales, which again would make them appear in the hardware costs.

To make a long story short: one should be very cautious when reading news like the above, because the information is usually much too crude to draw any reliable conclusions about profits.

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Further Reading

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