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Alfred Endres
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Economics for Environmental Studies

A Strategic Guide to Micro- and Macroeconomics

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A Strategic Guide to Micro- and Macroeconomics

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P.S. Good news for economics lecturers: to facilitate the use of the present textbook as a teaching tool, Power Point slides are available on www.springer.com/978-3-642-31192-5.

Contents

Introduction

1

There are awfully many introductory expositions of economics available. Why bother to write another?

Well, think of economics as a gigantic architecture with deep cellar vaults and high towers. It has gorgeous dining halls, remote chambers, and balconies that allow breathtaking views of the surrounding countryside.

In this allegory, the author of a textbook is a guide and the readership a group of visitors taken on a tour of the complex. The architecture is large and the time the visitors may spend is short (moreover, they are easily bored and tire fast). So what the dutiful tour guide has to worry about is: where in the building do I take a group of visitors to, how long do I linger in a certain room, and what do I tell them while we are there?

The answers will certainly depend upon what kind of a group the guide is expecting. A group of engineers might be thrilled to hear about how the challenge to provide efficient air conditioning in such an enormous building has been met. However, the same presentation would probably bore a group of arts students stiff. They would rather like to hear about the ancient paintings in the hall. These paintings would possibly also be an attraction for a group of history students, but the guide's speech should be different. The former group of students might primarily be interested to find out about the style of the paintings, and about what techniques were used to produce them. Instead, the latter group might want to focus on what the paintings tell about both the social hierarchies and the everyday life of the period of their creation. Of course, there are some parts of the guide's presentation that are certain roads to success for the presenter, no matter who is in the audience. Almost everybody wants to hear the tales of the stormy love life of the sixteenth century painter; even some of the engineers specialized in air conditioning technology might be listening closely.

After some hesitation and with a certain reluctance, we go back to the (admittedly somewhat more prosaic) topic of economics introductory textbook writing. The foundations of economics were laid centuries ago (by people like Adam Smith, 1723–1790, Thomas R. Malthus, 1766–1834, and David Ricardo, 1772–1823) and in the meantime generations of economists (some of them famous, most of them

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forgotten) have contributed to its evolution into what it is today: a body of theory so large and differentiated, no single person can oversee all its aspects, with countless empirical policy implications and applications.

The author of a textbook is in a similar position as the tour guide referred to above, having to decide what subject to deal with, and how. The choice of content and the didactical mode depend upon the author's own talents and specialization, and on what audience to address. Many introductory economics expositions are designed for students of economics (and management). The typical reader of these books is in his/her first or second semester. The book is predominantly supposed to enable this group of readers to successfully participate in more ambitious endeavours of economics, awaiting them in subsequent semesters. However, there are also introductory textbooks aimed at readers who are not predominantly concerned with economics. These are general expositions of "economics for non-economists", or are specifically addressed to a certain subgroup of non economists, like "economics for lawyers".[1] Even though this is a rich portfolio, to the best of the authors' knowledge, there is no introductory economics textbook specifically designed for the needs of people concerned with environmental studies.[2]

People in environmental studies are a colourful lot with specialisations in a wide variety of fields, like biology, information technology, engineering, law, political science, and philosophy. As heterogeneous as they are, they all have one thing in common: during their studies, and after leaving university and working in interdisciplinary teams in the private sector, the public sector, and for NGOs, they ultimately have to communicate and to cooperate with economists. Moreover, they have to acknowledge, whether they like it or not, that the voice of the economist carries a lot of weight when decisions with environmental consequences are made. So in order to survive in these kinds of settings, and to be able to fruitfully contribute to team output, everyone in environmental studies must

- understand the fundamentals of economic thought,
- understand how the way of economic thinking is applied to environmental problems and to environmental policy.[3]

Helping our readers to meet this twofold requirements is exactly what we strive to do with this book.

[1] Examples are Cohen and Howe (2010) and Ippolito (2010). These books, general or specific, use less mathematics than the ones that seem to be primarily addressed to students of economics and management. This is certainly adequate for some non economist audiences, *judex non calculat* (the judge doesn't calculate), but not so for others, like students of natural and engineering sciences.

[2] There are books on *environmental economics* for non-economists, like Asafu-Adjaye (2005), Jaeger (2005), but that's a different story.

[3] Of course, what has been said above works both ways: economists involved in environmental studies must also understand what is going on in the other contributing disciplines. But this is a topic for the authors of textbooks like "Environmental Engineering for Economists".

Therefore, each of the three parts of the following text is designed according to two processes: discussing fundamental ideas of economics first, and then relating them to environmental issues.

In Part I, we first explain the kind of problems with which economics is concerned, how economics proceeds to analyse these problems and how it attempts to solve them (Chaps. 2 and 3). Then, we relate these general observations to the specifics of environmental issues (Chap. 4). Thereby, it becomes apparent to which extent environmental problems "qualify" as economic problems and how the analytical tools of economics may contribute to their explanation and solution.[4]

In Part II, consumers and firms are introduced as the protagonists on the stage of economics (Sects. 6.1, 6.2, and 6.3). Their behaviour is explained through elaborating the objectives of these agents, and the conditions under which they are able to pursue their goals. An important part of these conditions is determined by the features of the markets within which the agents operate (Sect. 6.4.).

In addition to this individual perspective, the concept of the common good of society as a whole is developed. Since individual and social goals might conflict, a role for the government is discussed so as to reconcile individual and social perspectives (Sect. 6.5).

Obviously, environmental problems generated by anthropogenic activities are a very significant example for private decisions detrimental to the societal good. Therefore, what is said about individual behaviour and social well-being in Chap. 6, in general terms, is applied to the specifics of environmental problems in Chap. 7. There, the agents play extended roles compared to their performance in Chap. 6. They are no longer only producers and consumers of goods sold and bought in the market, but also people generating pollution and suffering from it. The general idea of the government, mediating conflicts of interest, boils down to the concept of a policy maker regulating pollution with various kinds of instruments, like green taxes, etc.

In Part III, we do not focus on individual economic agents and their coordination any longer. Instead, we introduce a highly aggregated measure of economic activity called "Gross Domestic Product" (GDP). Departing from this concept, we consider two fields of macroeconomic analysis, namely "economic growth" and "national accounting".

Economic growth, widely interpreted as growth in GDP, is an important goal for both many economists and politicians. Therefore, in Sect. 9.2, we sketch some basic propositions of the theory of economic growth. In Sect. 10.1, these propositions are confronted with the scarcity and exhaustibility of natural resources. This imposes the question whether unlimited economic growth is feasible. In the literature, this question led to the emergence of a concept called "sustainable development", which is discussed in Sect. 10.1.2.

[4] Well, let's be modest and put "attenuation" instead of "solution".

National accounting is conducted in order to compute GDP as well as national wealth. In Sect. 9.3, we briefly explain the procedures used in these fields. With regard to environmental issues, it has been argued that the traditional system of national accounting neglects important components and functions of the natural environment. We explain some attempts to overcome these shortcomings by conducting an integrated environmental and economic accounting in Sect. 10.2. Eventually, some approaches to accounting for sustainable development are presented and assessed.

An illustrative example of how different introductory economics textbooks may turn out if written for different audiences is provided by comparing the textbook at hand to the excellent textbook by Fisher et al. (2010). The latter introduction is addressed to business students. Here, the criterion for what subjects of economics to be selected for extensive discussion is what is likely to be most interesting to managers-to-be. Accordingly, the focus is on issues like strategic interaction between firms, like price competition and product differentiation, as well as on issues of strategic interaction within the firm, like motivation of employees and vertical as well as horizontal integration. These issues are not dealt with in the textbook at hand since they are not of highest concern with regard to the interaction of the economy with the environment. On the other hand, issues of social welfare, which are at the core of any discussion on environmental problems and environmental policy, are dealt with extensively in the present book but only play a marginal role in the aforementioned managerial economics book by Fisher et al. All in all, designing each of the two books compared here to its own special audience leads to the result that their topical overlap is only about 10 % even though both texts are introductory economics books.

Let us close this introduction with some remarks on methodology.

Above, we have mentioned a few topics with which economics is concerned. Take "consumers" as an example. An obvious difficulty in making reasonable statements about consumers is that there is no single consumer but rather billions, and that they are all different. Individuals consuming goods have different tastes and different financial resources, both depending on a variety of determinants like family and cultural background, education, profession, gender and others. So what do we do? Write an individually tailor-made economic theory on Mr. Jones, Ms. Nakamura, and all the others? Obviously not. It would be an impossible task (and one of doubtful merits, too) to comment on the economics of each of these innumerable people. Instead, economics is on "the" consumer. This is the idea of a "prototype" of a consumer designed to represent important features common to all (most) people as far as their roles as consumers are concerned.

Of course, the question of what is considered to be "important" cannot be answered without value judgement. Most economists agree that it is an important common feature of all consumers that they buy commodities and services in the market to achieve some kind of satisfaction. Also their ability to do so is constrained by two unpleasant circumstances: the goods to be bought have to be paid for and the financial resources to do that are limited.

Take firms as another example. Again, the problem is that there are billions of firms and they are all different. A firm may be a bakery, a group of accountants, and a multinational enterprise, among others. It may be located in the United States, China, or elsewhere and be routed in the respective society. Again, economics is in search of what they all have in common. The totality of these common features constitutes "the" firm as this term is used in economics. A feature that most economists agree to be typical and important is that there exists a decision maker who strives to generate revenue by selling a commodity or a service in the market. Also, it is costly for this decision maker to generate the commodity or service in the first place. It is a standard assumption that firms strive to maximize the difference between revenue and cost (i.e., behave as profit maximizers).[5]

So when economics makes statements about the decisions and behaviour of consumers and firms it is neither specifically referring to Mr. Jones and Ms. Nakamura, nor to Smith's Computers or Wang Trading. Instead, it is referring to the decisions and the behaviour of "dummies" (generic entities), which are thought to be useful serving as representatives of consumers and firms, respectively. Since these prototypes are designed to represent important features that real consumers and firms have in common, talking about the behaviour of the representatives is not playing an idle game alien to the real issues of the real world. On the contrary, observing these prototypes can shed light on how real people and real institutions behave.

The role of economic models can be even better understood with a little help from David Lodge, the author of many amusing college novels. In his novel *Thinks* (London: Secker and Warburg 2001, pp. 61–62) the protagonist explains what a novel is. We quote this passage with a subtle modification, substituting the word "novels" by "economic models": "In that sense economic models could be called thought experiments. You invent people, you put them in hypothetical situations, and decide how they will react. The 'truth' of the experiment is if their behaviour seems interesting, plausible, and revealing about human nature."

Of course, the process going from the many real consumers to the idea of "the" consumer and from the many real firms to the idea of "the" firm is a demanding intellectual process of abstraction.[6] The result of this process of abstraction is, in the case of the consumer and the firm, an *economic model* of the consumer and the firm, respectively. In the economic models of the consumer and the firm the features of the respective prototype are defined more precisely than in the introductory remarks that are provided here. In addition to models of consumers and firms as individual

[5] However, it is sometimes useful to choose different assumptions regarding the objective of the firm. E.g., certain firms who enjoy tax benefits because they are deemed to operate in the public interest may not be allowed to make profits at all. For these kinds of firms other objectives, like maximizing market share or maximizing the well-being of their managers, might be assumed.

[6] We trust in the intellectual capacity of our readership to meet this demand and we sincerely promise to be helpful!

agents there are models of institutions within which these individual agents interact. Particularly, there exist numerous models of markets.

In addition to economic models of the consumer and the firm, there are models of other economic agents, e.g., models of the government. In most of these models of the government, it is depicted as the entity where the conflicts between individual members of society are attenuated and where overall social welfare is maximized. In other economic models, the government is depicted as the battleground for all kinds of different interest groups fighting each other. Remarkably, politicians may form an interest group of their own.[7] For the interaction of the government with consumers and firms, numerous economic models of regulation have been designed.

When we put a selection of the aforementioned models (or others) in a unifying context, we generate an *economic theory*.

In this book we explain and apply a lot of economic theory. We are confident that this will neither be frightening nor boring, as some might have expected. On the contrary, economic theory is an attractive intellectual adventure, and – *there is nothing as practical as a good theory!* – it can teach us a lot about real life. Moreover, it is very fruitful to apply it to an area that may seem, at first glance, to be an unlikely candidate: *environmental problems* and *environmental policy*.

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[7] In the economics literature you find the first kind of models under the headline of *welfare economics*, the second under the headline of *public choice*. Below, we concentrate on the welfare economics approach. This does not imply that the authors believe that governments always strive for the common good. Instead, the idea of a welfare maximizing government is used as a norm against which the performance of real governments can be measured.

Part I

Economics: What Is It About and How Does It Relate to the Natural Environment?

The Fundamental Problem

2

2.1 Needs

In the present Part I, we will present some fundamental notions frequently used in economics. The sequence of the ideas to be discussed is not chosen arbitrarily. On the contrary, the discussion of each concept will generate a question leading directly to the following one.

At the beginning of our journey through economic thinking we refer to the observation that human beings are endowed (and burdened!) with needs and are permanently attempting to satisfy those needs.

A need is a feeling of suffering or dissatisfaction. Hunger, fear, loneliness, rejection and boredom are just a few examples which every reader may already have experienced to some degree. Probably the most prominent attempt to classify human needs stems from the psychologist Abraham Maslow.[1] Maslow elaborated in detail on what he called the "need hierarchy". At the bottom of this hierarchy he located the so-called *basic needs*. These he defined as fundamental physiological needs like hunger, thirst, tiredness or pain.

At the next level above the basic needs Maslow saw what he called *safety needs*. Safety needs can be best circumscribed using the terms "fear" and "anxiety". Human beings may perceive the world as hostile and threatening. They feel endangered by wild animals, criminal assault, murder, social chaos, revolution, tyranny, war, disease, natural catastrophes, breakdown of authority and so on.

At the third level Maslow described *belongingness and love needs*. Love needs are in existence whenever humans suffer from loneliness, ostracism, rejection, friendlessness, and rootlessness. Maslow identifies belongingness needs as feelings of alienation and strangeness. Belongingness needs manifest themselves as a lack of group feelings, contact, intimacy and real togetherness.

[1] For more detail on the following, see Maslow (1987, pp. 15–22).

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Esteem needs follow at the fourth level. These appear as feelings of inferiority, of weakness, and of helplessness. Maslow divided the esteem needs into two subsidiary sets. The first set comprises the desire for strength, achievement, adequacy, mastery and competence, confidence in the face of the world, independence and freedom. The second set contains the desire for reputation or prestige (defined as respect or esteem from other people), status, fame and glory, dominance, recognition, attention, importance, dignity, or appreciation.

Finally, at the top level Maslow located the *self-actualization needs*. Human beings suffer from failing to make full use of their actual potential. They have a desire for self-fulfillment in the sense of becoming actualized in what they are potentially. People want to become everything that they are capable of becoming.

Through his hierarchical ordering of needs Maslow (1987, pp. 56–61) intended to stress the point that needs at lower levels are stronger than needs at higher levels, while both remain unfulfilled. Moreover, needs at higher levels are unimportant, even non-existent, as long as needs at lower levels are unsatisfied. In Maslow's own words:

> [T]he common feature of the needs for self-actualization is that their emergence usually rests upon some prior satisfaction of the physiological, safety, love, and esteem needs. (Maslow 1987, p. 22)[2]

However, when both needs at low levels and needs at high levels are satisfied, a greater value is placed upon the higher need than upon the lower.

In economics, the needs of human beings are perceived as principally unbounded. This does not mean that it would be impossible to get rid of hunger or tiredness for the moment. But a look at Maslow's needs hierarchy reveals that, once the needs at lower levels are satisfied, other needs at higher levels come into focus. Eventually humans, being sated, safe, socially involved and respected, strive for ever new forms of self-fulfillment. Consequently, for every human individual there is, at any point in time, at least one facet of the needs spectrum where it is possible to enhance the degree of satisfaction. This is called the postulate of *local non-satiation*. Thus, there always remains a certain feeling of suffering, even in the billionaire's life. To Maslow himself we owe an impressive explanation:

> It is quite true that humans live by bread alone – when there is no bread. But what happens to their desires when there *is* plenty of bread and when their bellies are chronically filled? . . . *At once other (and higher) needs emerge* and these, rather than physiological hungers, dominate the organism. And when these in turn are satisfied, again new (and still higher) needs emerge, and so on. (Maslow 1987, p. 17, italics in the original)

Once we know the point of departure of economics – human needs – the question arises of what is required to satisfy those needs.

[2] In his Threepenny Opera, Berthold Brecht puts it colloquially: "Grub first, then ethics".

2.2 Goods

2.2.1 Satisfying Human Needs

We call all aspects of reality that are able to satisfy human needs "goods". Many goods have the ability to satisfy human needs directly, and such goods are called *consumer goods*. Maslow (1987, pp. 15–22) himself gave plenty of examples of consumer goods in relation to the five levels of his needs hierarchy.

At the level of the basic needs, consumer goods might include an apple that relieves hunger, a coat given to a person who is cold, or medicine used to cure pain.

Safety needs can be satisfied by security, protection, and structure; by order, law and limits. A savings account and insurance of various kinds (e.g., medical insurance, unemployment insurance) can serve as goods satisfying safety needs as well. Even religion or world philosophy that imposes order upon the universe can contribute to the satisfaction of safety needs.

As some examples of consumer goods corresponding to the belongingness needs, Maslow considered one's neighborhood, territory, clan, own kind, class, gang or familiar work colleagues. The good satisfying love needs is affection received by *and* given to friends, partner or children.

Esteem needs may be satisfied for some people by a fast and expensive car which will carry prestige. Others may seek to gain respect through a chic outfit or academic grades.

The specific consumer goods satisfying the self-actualization need will vary greatly from person to person. For one individual, a child may represent a good which opens up the possibility of becoming an excellent parent. For another person, a studio may be the good that allows that person to express him or herself by painting pictures.

On the level of consumer goods, the postulate of the boundlessness of human needs introduced in Sect. 2.1 above does not mean that every human individual at every point in time wants more of every good. On the contrary: sometimes an additional unit of a certain good even implies a decline in the degree of satisfaction of needs. Think of beer, or any other kind of drugs, including medicine. Nonetheless, human needs are unbounded in the sense that at each instant in time there can be identified, for each human individual, at least one good of which an additional unit would enhance the degree to which the individual's needs are satisfied. Which good it is depends on the individual and on the concrete situation. This has already been labelled "local non-satiation" in Sect. 2.1 above.

2.2.2 Commodities and Services

Different goods have different characteristics. For example, a drop of lemonade directly relieves thirst and a massage directly alleviates muscular problems. However, there is a difference between lemonade and massages which leads to the distinction between *commodities* and *services* as two subsidiary sets of goods.

While you can touch physical goods like lemonade, bread, shirts and houses, many other goods are represented by certain actions carried out by other people like the massage given by a masseur, the investigations of a policemen which may help to overcome fear, having one's hair dyed by a hairdresser, an actor's play and the explanations provided by a tax adviser. We call every physical good which can be touched a "commodity".[3] Actions undertaken by other people which satisfy our own needs, however, are called "services".

2.2.3 Excludability and Rivalry

There is another common way of classifying goods based upon the two criteria of *excludability* of use and *rivalry* in use. This classification is of special importance for economists because certain problems arise concerning the provision of goods which do *not* exhibit the characteristics of excludability and/or rivalry. As will be argued in subsequent sections, such problems are crucial in the case of some natural goods, and cause, for example, phenomena like global warming and overfishing.

By excludability of use we mean the possibility of preventing potential users of a good from actually using it, after the good has already been provided. For example, a zoo can be surrounded by a fence, preventing everyone who is not willing to buy a ticket from entering. Jewellery can be stored behind armoured glass, waiting to be handed out to someone willing (and able) to pay the price asked for it.

If, however, non-excludability is a feature of a good, it is not possible to prevent any person from using the good once it has been provided (or possible only via measures imposing non-justifiable costs). A TV program transmitted terrestrially may serve as an example. Such a program, once broadcasted, can be received by everyone living in the transmission area (given that the person owns a receiver).

If there is rivalry in using a certain good, the fact that person A uses the good makes it difficult or even impossible for Person B to use the good simultaneously. A pizza might be an illustrative example. After A has eaten the pizza, B can't eat it anymore.

On the contrary, non-rivalry means that the use of a certain good by one person does not prevent the same good simultaneously being used by many other people. Obviously, this holds for terrestrial broadcasted TV programs. Once transmitted, anybody who owns a receiver can view the program without preventing others from viewing the same channel at the same time.

Using the criteria of excludability and rivalry, goods can be classified according to Table 2.1. If a good is characterized by both excludability and rivalry, it is called a private good. Think of a bottle of wine stored in the cellar. Since the cellar can be locked so that no unauthorized person has access to it, excludability is at hand. Moreover, after the owner has enjoyed the wine, no other person can do so anymore, so there is rivalry.

[3] For a more sophisticated discussion of the terms "good"and "commodity" see Milgate M (2008) Goods and commodities. In: Durlauf SN, Blume LE (eds), The New Palgrave Dictionary of Economics, 2nd edn. Palgrave Macmillan.

Table 2.1 Classification of goods

	Excludability	Non-excludability
Rivalry	Private goods	Open access goods
Non-rivalry	Club goods	Collective goods

On the other hand, collective goods[4] are characterized by non-excludability and non-rivalry. Military protection of a country's borders provides safety from exterior threats for all people living within these borders without exception. No person living within these borders can be excluded from consuming the resulting safety. Furthermore, the fact that person A enjoys this safety does not in any way prevent all the other people being safe as well, so there is non-rivalry.

If there is excludability and non-rivalry, we speak of a club good. Think of a swimming pool built and cared for by a swimming club exclusively for members. Non-members who refuse to pay the fee are rejected at the entrance. If, however, the membership subscription has been paid, there is no rivalry among members concerning the use of the pool (if one neglects possible overcrowding).

Another example for a club good is cable TV. As opposed to the terrestrially broadcast TV programs mentioned earlier, a potential user not willing to pay for the cable TV program can be excluded from watching it. Those who did pay, however, do not rival at all for the use of this good because they can watch it simultaneously in identical quality, irrespective of the number of users (even overcrowding is impossible).

Finally, if non-excludability meets rivalry, an open access good is at hand. Think of an account accessible to both married partners. Neither of them can be prevented from withdrawing money (hence, there is non-excludability concerning monthly earnings). But the amount of money withdrawn by one of them is no longer available to the other (so we have rivalry concerning withdrawn money). Another example of an open access good which might be quite familiar to many readers is a buffet. A buffet is characterized by non-excludability because all guests have free access to the table where the meal is presented. However, once vegetables and cold meat are located on the plate of a certain guest, there is rivalry, because it is quite unusual to serve oneself from one's neighbour's plate.

If goods are necessary to satisfy human needs, the question immediately arises of where the goods should come from.

2.3 Production

If humans seek to obtain goods in order to satisfy their needs, they usually produce those goods. The notion of production characterizes a process in which inputs are combined in a certain manner to obtain a desired output. Think of a bakery as an

[4] These are often called "public goods" as well.

example, where flour, water, yeast, the baker's work time, an oven and fuel are combined according to a special recipe to obtain, eventually, a loaf of bread.

This example reveals that inputs often do not have the ability to satisfy needs directly. But, although humans can't eat ovens, ovens can make a contribution to the satisfaction of human needs and, therefore, they should be called "goods" as well. Consequently, we use the term "investment good", as opposed to consumer goods as defined in Sect. 2.2 above, when a good's ability to satisfy human needs is of an indirect character, i.e., activated by a process of production. The example of a bakery also reveals that investment goods can, like consumer goods, be classified into commodities (oven, fuel, etc.) and services (a baker's working time).

Note that the distinction between consumer goods and investment goods does not always depend on the characteristics of a certain good but often on its mode of use. For example, the same pen could be classified as a consumer good if used for writing a love letter, or as an investment good if used to sign a contract in a firm.

Even the primitive hunters of the Stone Age[5] were already engaged in production, where arrows and bows served as inputs, while roasted meat and fur clothing represented the outputs. Since then, of course, permanent improvements in production technologies[6] have made it possible to enhance the way in which many people are provided with goods enormously in comparison to the situation of the Stone Age hunters. Does this imply that nowadays human needs are perfectly satisfied?

2.4 Scarcity

In the Stone Age, the bounded availability of game restricted hunters' opportunities to satisfy their basic needs. Stone Age famines, e.g., due to animal epidemics, were by no means an unrealistic scenario. In spite of the fact that in modern times the provision of goods is much better than in the Stone Age, our own opportunities to satisfy our needs are restricted as well. Certainly, the nature of the desired goods may have changed. While Eolithic hunters were probably just missing an additional roebuck, we may be striving for an additional holiday trip or a second car (and maybe for an additional roebuck as well). But the character of the problem has not changed at all: there is a fundamental tension between the bounded availability of goods, on the one hand, and the boundlessness of human needs, on the other. This tension is called scarcity. The land in which such a tension does not exist is usually

[5] Imagine roughly the time span from 2,600,000 years ago to 2000 BC. The fact that the economic approach enables researchers to interpret the life situation and hardship of mankind thousands, even millions of years ago reveals the importance of economic science for humanities.

[6] Böhm-Bawerk (1959, pp. 79–101) describes industrial production of the modern age as "roundabout" which means that consumable goods available at present are not consumed immediately but, instead, used to produce investment goods. Using these investment goods productively yields a higher amount of consumable goods in the future than were available initially.

called *Cockaigne* – an imaginary land of plenty, where all goods are always immediately available[7] and hardship does not exist at all.

The problem of scarcity existed (and exists) at every level of cultural development. Scarcity does not necessarily mean that people starve, that they have to run naked and sleep in trees. The mere fact that basic needs are satisfied does not ensure that there are no unsatisfied needs left, for example at the higher levels in Maslow's needs hierarchy. Scarcity, defined as the tension between the bounded availability of goods and the boundlessness of human needs, implies that it is impossible to satisfy all the needs of all the people simultaneously. What is the observed reaction of human beings to that fact?

Review Questions

1. What is a human "need"?
2. Which levels of human needs did Maslow describe?
3. Please explain the hierarchical ordering of human needs according to Maslow.
4. What is required to satisfy human needs?
5. What is the difference between a "commodity" and a "service"?
6. Please clarify the characteristics of a "collective good" as opposed to a "private good"!
7. Please outline the characteristics of an "open access resource"!
8. What is the basic structure of the "production process"?
9. What is the difference between a "consumer good" and an "investment good"?
10. What is the meaning of "scarcity"?

Exercises

1. Please find an example for services that might satisfy human needs on the various levels of Maslow's needs hierarchy!
2. Please discuss the practical relevance of the various levels of Maslow's hierarchy of needs for different people who are:
   (a) Living in a country of your choice today, 500 years ago, and in 2050, respectively;
   (b) Presently living in a country of your choice and belonging to the poorest 10% and the richest 10%, respectively;
   (c) Presently living in a developing country and in a developed country, respectively.
3. How do the following goods fit into the classification scheme that includes the criteria "excludability of use" and "rivalry in use"?

[7] "There you cannot help but thrive; The geese, they roast themselves alive. Meat, fish, fat capons, it's no ordeal, Cook themselves for the midday meal" (Pleij 2001, p. 38). And maybe the best of all: "This is the land that God holds dear! Those who sleep longest earn the most here" (ibid., p. 37).

(a) A zoo;
(b) A street light;
(c) A family size pizza;
(d) A smartphone.

4. Is it possible to classify the following goods unequivocally as a "consumer good" or an "investment good", respectively?
   (a) A limousine;
   (b) A laptop;
   (c) A software package for bookkeeping;
   (d) A video game.
5. How could scarcity appear to
   (a) A farmer in Israel;
   (b) An owner of a successful business in Germany;
   (c) A student preparing for an examination.

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The Economic Approach

3

3.1 Acting Economically

Because humans have never experienced Cockaigne, they have developed economic sciences. Economics is the science of dealing with scarcity. It departs from the insight that, while it is impossible to remove scarcity completely, it is at least possible to minimize the negative consequences of scarcity. In particular, economists observe that people, facing situations of scarcity, make an attempt to influence the relation between the amount of goods used, on the one hand, and the degree of satisfaction of needs, on the other. This relation would be irrelevant if goods were available in unlimited amounts, because then the consumption of goods could be increased indefinitely – and so could the degree of satisfaction of needs.

However, scarcity forces people to pay attention to this relation. For it would be literally unsatisfying if, given the amount of goods available, only a certain degree x of needs satisfaction were achieved while a higher degree $y > x$ would have been attainable. Therefore, people apply the so-called economic principle. In general terms, the economic principle recommends that the goal at hand be achieved at the maximum level possible given the means available. This is known as the maximum principle.

The economic principle can be formulated from another perspective as well. The minimum principle requires that a goal be achieved to a given level using the minimum amount of resources.

A situation in which the economic principle is fulfilled is called an "efficient" situation. Efficiency implies the absence of any wasting of goods. In contrast, a situation where goods are wasted is termed "inefficient".

In what follows, each kind of behaviour which is based on the economic principle is called economic behaviour (or rational behaviour). Every agent behaving economically is called an economic agent. Who are the economic agents we will have to deal with?

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3.2 Economic Agents

In economics, it is common to distinguish between different kinds of economic agents. In the present section, we are dealing with "consumers" and "firms".[1] Consumers are economic agents who demand consumer goods[2] and supply factors of production. Firms are economic agents who supply goods and demand both factors of production and investment goods. It is the purpose of microeconomic analyses to describe the economic behaviour of individual consumers and firms.[3]

First of all, human individuals who are endowed with needs are seeking to satisfy their needs by consuming goods. Therefore, in economic theory they are designated as consumers. As a synonym, the term private household is often used. It seems plausible to expect consumers to obey the economic principle, that is, to achieve the highest possible degree of satisfaction of needs given the amount of goods available. Alternatively, consumers will try to achieve a given level of needs satisfaction through minimum consumption of goods.

In Sect. 2.3 above it was argued that, in most cases, goods have to be produced. Agents conducting productive activities are called firms. Firms use investment goods (machines, tools, buildings, etc.) and labour services to produce, firstly, consumer goods; and secondly, investment goods used by other firms in order to produce goods.

Usually, firms are not represented by single human individuals. However, firms can be interpreted as institutions, where an institution is defined as a bundle of norms. Within a firm, many people (who act as consumers during their leisure time) come together to produce certain goods. Their actions are coordinated by a bundle of norms comprising regulations with regard to working time, division of labour, prevention of accidents, and earnings. The task of these norms is to generate a level of cooperation which meets the economic principle. With a given quantity of inputs, a maximum output is to be produced. Or, a given level of output is to be produced with a minimum quantity of inputs, respectively. The reason why firms try to act economically is that otherwise profits are not maximized. It is consumers that expect firms to maximize their profits as they are lending their capital to them. If the profits of firms are not maximized, consumers' capital income is lower than it could be and this, in turn, affects consumers' capacity for buying consumer goods and, hence, satisfying their needs.

[1] In more advanced macroeconomic analyses, two further types of economic agents are taken into consideration, namely the "state" and "foreigners". The role of the state will be discussed in Sect. 3.5 below.

[2] This assumption serves to simplify our analysis. In reality, private households are contributing to an economy's investment expenditure through the purchasing of new houses (see Mankiw 2010, p. 27).

[3] The way of proceeding (typical) within microeconomics will be discussed in more detail in Part II below.

Moreover, it can be assumed that people, in their role as employees, act economically as well. They try to obtain maximum earnings given their skill and effort level. According to the minimum principle, a given level of earnings is to be achieved by minimum effort (and maybe skill as well).

If there are, in our simplified picture of a market economy, just two types of economic agents, what happens when consumers and firms meet on the market?

3.3 The Circular Flow

In the presence of millions of consumers and tens of thousands of firms, to answer the question concluding the last section taking into account every single detail would ask too much of human cognitive capacity. Therefore, economists try to develop simplified representations of an economy and call them "models". Figure 3.1 presents a sketch of a model which can serve to help us understand the *structure* (not every single detail) of interactions between the economic agents mentioned in Sect. 3.2 above.

The circular flow delineated in Fig. 3.1 portrays the structure of real and monetary transactions between the various sectors of an economy. Individual consumers do not appear in Fig. 3.1 at all. However, all of the individual consumers, maybe millions of them, have been *aggregated* into a consumer sector, which appears as a rectangle on the right-hand side. Aggregation is a tool commonly used in macroeconomic analyses, which will be presented in more detail in Part III below. Although individual consumers differ significantly as to their needs structure and intensity, aggregation is justified by the fact that they all conduct similar types of activities. They buy consumer goods and sell factors of production, namely labour and capital (i.e., savings).

The thousands of different firms have also been aggregated into a firm sector, i.e., the rectangle on the left-hand side. This is because firms conduct similar types of activities, even though they differ significantly. They buy factors of production, they buy investment goods and they sell their products.

Figure 3.1 depicts these activities as interactions between the consumer sector and the firm sector. Consumers and firms meet on three macroeconomic markets, which appear as ellipses in Fig. 3.1. At the bottom we have the capital market, in the middle the labour market is shown and at the top is the goods market. The macroeconomic capital market is an institution which coordinates the aggregate amounts of savings supplied and funds demanded for the purpose of investment. The macroeconomic labour market is, in turn, an institution which coordinates the aggregate amounts of labour supplied and demanded by virtue of the wage rate. Finally, the macroeconomic goods market is an institution which coordinates the aggregate amounts of goods supplied and demanded.

From sector to sector there are arrows drawn. The dotted arrows represent real flows from one sector to the other, while the others stand for monetary flows. One of the real flows is the transfer of consumer goods (like bicycles or the advice of a tax consultant) from the firm sector to the consumer sector. Each real flow is accompanied by a monetary flow in the opposite direction. In the case of consumption, this is consumption expenditure.

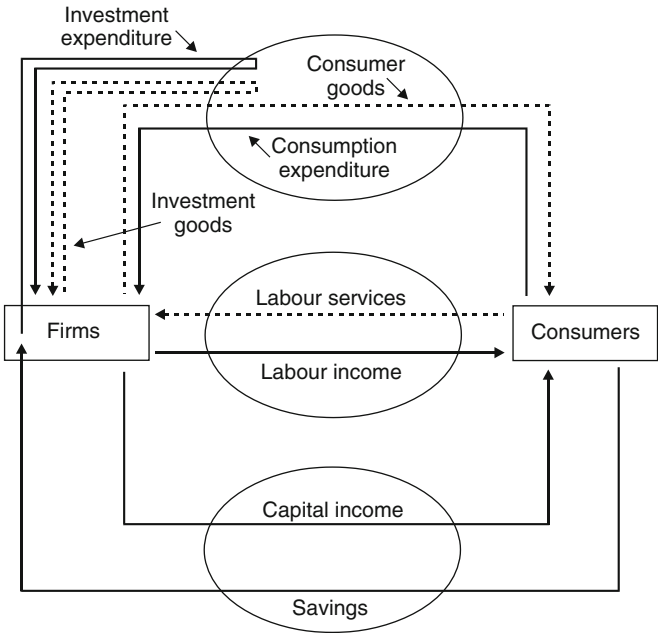

Fig. 3.1 The circular flow

Via the labour market, labour services are transferred from the consumer sector to the firm sector. Accordingly, labour income flows in the opposite direction. Finally, firms sell investment goods (machines, tools) to other firms on the goods market. The corresponding real transfer originates in the firm sector and flows back to the same sector. Of course, firms buying investment goods have to pay for these goods. The payment appears as investment expenditure in Fig. 3.1. The investment expenditure is financed out of the consumers' savings, which are offered on the capital market to firms seeking to buy additional investment goods. In turn, via the capital market consumers receive capital income (e.g., dividends) from firms demanding capital in order to buy investment goods on the goods market.

Using the structural framework depicted in Fig. 3.1, the transactions between the two private sectors can be monitored and their development can be described. Their volume can be quantified and documented in so-called national accounts. The task of quantification is usually conducted by national statistical offices in detail. Their annual, quarterly or maybe monthly reports show, e.g., whether investment expenditure, consumption expenditure and consumers' income (the sum of labour and capital incomes) have been higher or lower in the last period than in the periods before.

Besides mere monitoring, economists try to explore the mutual interdependencies between various economic indices and to find reasoning for the previously observed developments, based on data collected by statisticians. Ultimately, economists try to forecast the development of economic activity by using the observations made in the past.

However, economists are in no way satisfied by simply monitoring, reasoning and forecasting economic activity. Instead, they want to answer questions like this one: Is it "good", or is it "bad" if investment expenditure was higher in the last period than in the period before?

3.4 Positive and Normative Economic Analysis

Up to now, a mere *description* of what can be observed in reality has been developed. Humans are observed to strive for the satisfaction of their needs, goods are perceived to contribute to the satisfaction of human needs, production is conducted to make goods available, and so on. However, no statement has been made at all concerning whether the observations documented above can be judged to be "good" or "bad". This kind of analysis, which is restricted to mere observation, documentation and attempts at explanation of economic reality without making any value judgements, is called a "positive" analysis.

In contrast, each analysis that poses questions concerning "good" or "bad" is called a "normative" analysis, because a norm is needed to separate "good" outcomes of economic activity from "bad" ones. While Chap. 2 as well as Sects. 3.1, 3.2, and 3.3 above give examples of pure positive argumentation,[4] the remainder of Chap. 3 will outline the principles of a normative analysis of the economic process.

For economists thinking in the tradition of mainstream economics, the satisfaction of the needs of human individuals is the most important norm. Of course economists are not the only group of people interested in human needs, however. Managers, for example, are too and, consequently, Maslow's "pyramid" of needs can very often be found in marketing textbooks as well. But there is an important difference. For a manager, human needs are just an *intermediate* goal. They have to be explored and respected in the context of corporate decision making as a prerequisite to achieving a firm's primary goal – profit maximization. From the economist's point of view, however, human needs represent the *primary* goal in itself. Economists, at least those thinking in the tradition of free market economics, seek to make a contribution to the highest possible degree of satisfaction of human needs. This goal dates back to Jeremy Bentham, who in 1776 postulated that "it is the greatest happiness of the greatest number that is the measure of right and wrong" (Bentham 1988, p. 3).

There are two normative cornerstones of mainstream economics to be mentioned in connection with the notion of needs.

The first one is the postulate that only *human* needs are to be taken into consideration. At the centre of the analysis we find the human individual and nothing else. This is an *anthropocentric* point of view.

The second corner stone is the postulate that only human individuals themselves can judge the character and the intensity of their own needs. No religious, political

[4] Nonetheless, the mere choice of human needs as our point of departure clearly represented a normative act.

or scientific authority can claim this judgement for itself. This is called the postulate of *consumer sovereignty*. In free market economics, the needs of a human individual are accepted as they are felt by that individual. Of course, those needs which would require breaking laws or violating moral obligations in order to be satisfied are excluded from the postulate of consumer sovereignty.

Several secondary goals have been deduced from the postulate of the satisfaction of human needs. According to a widely acknowledged classification by Musgrave (1959, p. 5), there are three norms guiding economic thinking: the criteria of efficiency, justice and stability.

The notion of efficiency has been already discussed in Sect. 3.1 above, where it was observed that humans facing scarcity will try to act economically. In what follows, the meaning of efficiency from a social point of view will be discussed.

Efficiency implies non-existence of resource wasting. It can be achieved by behaviour which fulfills the economic principle. In contrast, if resources are wasted, economists use the terms inefficiency, market failure or misallocation. The notion of "allocation" refers to a certain assignment of productive resources to certain productive activities, and of consumer goods to individual consumers. An allocation is socially undesirable if it flouts the economic principle, i.e., if the maximum level of satisfaction of human needs that could be attained given the available resources is actually not achieved. Imagine an allocation characterized by the fact that a great proportion of labour and capital is allocated to the production of black and white TVs. Obviously, this would be inefficient because in modern times, black and white TVs don't fit people's needs at all. Resources would need to be reallocated to the production of colour TVs.

Inefficiencies arise in the case of collective goods, which are characterized by non-excludability of use and non-rivalry in use. The provision of collective goods on the basis of private action entails the well-known problem of *free riding*. If a potential user knows that he cannot be excluded from using the good after it has been provided, and if he knows that he, using the good, will not in any way prevent others from using the good, this potential user will refuse to make any contribution to the provision of the collective good. Instead, it will be rational to wait for all the other potential users to contribute and to consume the good free of charge, once it has been provided. Since all potential users will feel this incentive, nobody will make any contribution and the collective good will not be provided at all, even though each individual would benefit from it. The needs that could be satisfied by the provision of the collective good remain unsatisfied.

Inefficiencies arise due to the good's characteristics in the case of open access goods as well. Anyone who has ever enjoyed a buffet will know this. Because there is non-excludability as regards the meal provided coinciding with rivalry in terms of who gets what, many guests overload their plates. They are obviously not able to eat all they take and a great proportion of the meal must be thrown away – an obvious case of wasting goods.

From a social point of view, the requirement that firms should obey the economic principle can be deduced from the primary goal of satisfying consumers' needs as well. The reason for this is that if a firm wasted investment goods (i.e., used them in an inefficient manner), the amount of consumer goods produced would be smaller than possible. This obviously implies that the degree of satisfaction of consumers' needs would be smaller than possible as well.

Even an efficient allocation of resources can be socially undesirable if it is interpreted as unjust. If the needs of a small minority are well satisfied while the majority is starving, a society can be severely destabilized. Note that, in aiming at the "greatest number", Bentham already implicitly introduced a certain concept of justice.

Unfortunately, in comparison to efficiency, it is much more complicated to define the criterion of justice. The central question is whose needs should be better satisfied than they were before, and who, in turn, should sacrifice. We owe one of the most famous theories of justice to John Rawls (1971), who argued that justice should be interpreted in the sense of equity. But, obviously, there are many competing interpretations of justice; maybe as many as there are human individuals living on earth.[5]

Finally, the term instability refers to any deviation of the actual utilization of the productive capacity from its normal utilization, maybe due to fluctuations in aggregate demand for goods. The problem of instability is captured by the term "business cycle", which is defined by cyclical divergences of productive capacity and actual production. During a business cycle there are recessions, i.e., phases characterized by actual production falling short of the productive capacity. Aggregate demand is low and, consequently, firms reduce their production. As a consequence, the factors of production are underemployed. Many people become unemployed, such that their income shrinks. Unemployed people are not able to maintain the level of needs satisfaction they were used to. In contrast, a boom is a phase of a business cycle characterized by actual production exceeding the productive capacity. Aggregate demand is high and the factors of production are fully employed. Eventually, production cannot be enhanced any further, such that the demand for goods may exceed the maximum production level. This leads to inflation. Inflation impedes the functioning of the price mechanism (which will be discussed in detail in the subsequent section) and misallocations, i.e., inefficiencies will occur. As was argued earlier, inefficiencies prevent the maximum level of satisfaction of human needs from being achieved.

If the outcome of economic activity is not compatible with the norms of efficiency, justice, or stability, what can be done?

[5] See Sen (2009) for a recent discussion of the idea of justice.

3.5 Economic Policy

3.5.1 The Choice of Economic System

In principle, a society and politicians acting on behalf of that society's people can choose from a variety of economic systems. If the satisfaction of human needs is the primary goal, the question arises as to which of the economic systems serves best to fulfill the norms of efficiency, justice and stability. In the present section, we will restrict ourselves to the efficiency criterion.

In what follows, alternative economic systems will be compared on the basis of two questions:

1. Which goods should be produced, and in which amounts, i.e., which factors of production should be used, in which amounts, in which productive sectors?
2. After question 1 has been answered and the outcome of production is available, which individual should get which good, in which amount?

Within every economic system, both problems are addressed using a system-specific *allocation mechanism*. By this term we mean a mechanism that guides both productive resources to various productive sectors and the outcomes of productive activity to various consumers. Based on the allocation mechanism and on who owns the resources available we will distinguish between three alternative economic systems: firstly, a system of solidarity; secondly, a bureaucratic system; and thirdly a market system. It will be shown that the central problem is generating information concerning the nature and intensity of the needs of the individual members of society. It is crucial to solve this problem since, if the maximum level of satisfaction of human needs is to be achieved, the strongest needs should be served first and the weakest needs should be served last, if at all possible. Hence, it is of central importance to distinguish between the "strong" and "weak" needs of perhaps millions of human beings.

A system of solidarity is an economic system characterized by both private ownership of resources and an allocation mechanism in the form of an appeal to the common sense of individual members. A moral authority, be it a religious, scientific or political one, tells people to take into account not only their own needs, but also the needs of their fellow people when deciding where to allocate their own factors of production. When people decide whether to buy a share in a firm producing weapons or in a firm producing energy using regenerative resources, they should consider whether their fellow individuals have a desire for military or environmental protection. The decision to work as a pop singer or a farmer should also be based on one's perception of the needs of one's fellow people.

After production has taken place, everyone can take what they need. But again, there is an appeal to common sense. Everyone should leave enough goods that all other individuals can take what they need most as well.

Such a system of solidarity must fail in the attempt to achieve the maximum level of satisfaction of human needs. The first reason is that it is questionable whether people are sufficiently altruistic. If egoism on the part of some individuals is too strong, then these individuals will grab what they can carry. As a consequence,

others fear that they might not be able to satisfy at least their strongest needs and will grab and carry as well, before others can do so. Eventually, for a great number of individuals there is nothing left at all. Consequently, a lot of strong needs are left unsatisfied.

This does not necessarily mean that altruism completely disqualifies as an organizing principle of human relationships. Even in modern market economies, which explicitly rely on the individual's self interest (see below), there is room left for altruistic behaviour, such as for example, in the field of honorary posts, in the relationship between parents and children, and in the willingness to donate to the victims of earthquakes and flooding all over the world. As a *general* principle of organizing human relationships, however, it seems to be too weak.

The second reason is that, even if all individuals were sufficiently altruistic, it would be impossible for a human individual to obtain all the information on the character and intensity of the needs of all other individuals that would be necessary to obey the appeal to common sense. Thus, individuals are simply not able to make the "right" decisions.

A bureaucratic system is an economic system characterized by public ownership of resources and by an allocation mechanism in the form of governmental planning. The allocation is conducted exclusively by a central authority. This institution decides which amounts of which goods will be produced. When the output is available, the same institution decides which individual will be supplied with which amount of which good. The goal of maximum satisfaction of human needs will not be attained in a bureaucratic system either. The first reason for this is that the actors within the bureaucratic apparatus might attempt to misuse their power, i.e., to pursue their self-interest first. If the bureaucrats satisfy their own less important needs before the strongest needs of their people, the goal of maximum needs satisfaction for society as a whole is missed. The second reason is that, even if the bureaucrats solely were striving for the well-being of their people, even for a great ministry equipped with thousands of employees, it is impossible to collect all the information required concerning the intensity of various needs of millions of inhabitants.

If bureaucrats don't know about the great variety in the needs of their people, they will fail to decide on the allocation of the productive resources in a manner that suits all different needs. Uniformity of the goods supplied will be the consequence and the goal of maximum needs satisfaction will not be attained. A third reason this goal might not to be attained is that, in bureaucratic systems, often the allocation of produced goods to the individuals is based on criteria other than productive performance (maybe, membership of the "right" political party, party-line and conformity). However, if people cannot influence their share of production by productive effort, their motivation in production will be affected. The cake that is baked will be *a priori* smaller than it could be with highly motivated people and this will inevitably affect the level of needs satisfaction in society.

The disadvantages of a bureaucratic system do not imply, however, that there are no bureaucratic elements to be found in modern market economies at all. On the contrary, there are many fields, even in market economies, which are strongly

influenced by public bureaucracies. For example, in many economies both the educational sector and the healthcare system are highly regulated. Actually, there might be good reasons for introducing carefully directed regulations even within the context of a market system. As will be explained in the following Sect. 3.5.2, certain regulations are justifiable if market outcomes are inefficient, unjust, or unstable.

A market system is an economic system characterized by private ownership of resources and by an allocation mechanism in the form of the price mechanism. Prices are more suited to tackling the information problem than the two allocation mechanisms discussed before. This can be demonstrated by an example. Imagine that a firm invents a new mobile phone which, by virtue of its functionality, makes all prior mobile phones seem insignificant. Many people feel a strong desire to buy the new phone, and because their desire is strong, they are willing to pay a lot of money for it. Other producers will observe the high willingness to pay and will imitate the new phone, because they see a chance to enhance their profits. They will establish new capacities to produce the new type of phone by attracting additional factors of production. Firms will induce an inflow of labour and capital to the new sector of production by bidding higher factor prices; namely, wages and dividends. By this mechanism, the price system generates and processes information concerning the intensity of human needs. Prices of consumer goods and of the factors of production will pull the factors of production to those sectors where consumer goods are produced which meet the actual needs of consumers best. Therefore, the task of achieving a maximum level of satisfaction of human needs is better fulfilled than in the context of the two systems discussed before.

Note that this result is attained on the back of individual self-interest instead of altruism, which was needed in the system of solidarity. Moreover, as compared to the bureaucratic system, it is based on individual (i.e., decentralized) instead of bureaucratic (i.e., centralized) decision making. These two features of a market system were first elaborated by Adam Smith. His book "An Inquiry into the Nature and Causes of the Wealth of Nations" (Smith 1776) marks the birth of the theory of the market economy and the ideas developed therein live on in the programs of liberal political parties in many countries. Smith claimed *individual freedom of choice* to be the dominant pillar of a market economy. He argued that the decentralized pursuit of individual self interest would bring about the most desirable state of an economy. This state, which is called "market equilibrium", will be analyzed in more detail in Sect. 6.5 below. There it will turn out that the price mechanism (which Smith called the "invisible hand") is able to coordinate decentralized and free individual decisions and to harmonize the (though often competing and even conflicting) self-interest of the numerous individuals in a market economy.

To summarize, because the market system has advantages in generating and processing information about human needs, a society seeking to maximize the satisfaction of human needs has good reasons for choosing to organize economic life as a market economy, as a necessary condition for achieving the primary goal. However, will a market system always ensure efficiency, justice and stability?

3.5.2 Interventions in the Economic Process

In the theory of the market economy the conviction prevails that governmental interventions in the economic process should be principally avoided. The reason for this is that governmental interventions must affect the functioning of the price mechanism. For example, governmental regulation of prices obviously must destroy the ability of the price system to signal the strength of individual needs and to allocate the factors of production so as to firstly satisfy the strongest needs. A market equilibrium could not be reached under governmental price regulation, but any other state of the economy is less desirable from a social standpoint than the market equilibrium itself (see Sect. 6.5 below).

Unfortunately, choosing the best economic system available is not sufficient to ensure the maximum level of satisfaction of human needs. Not all of the outcomes of market processes are socially desirable. The reason is that there are certain deviations from the ideal of a "perfect market", which cause inefficient, unjust or unstable outcomes. In such cases, it may be found to be justifiable for the state to intervene in the economic process. This is, in addition to choosing the best system, another aspect of economic policy.

According to the three criteria of efficiency, justice and stability, there are three branches of economic policy that intervene in the economic process: allocative, distributive and stabilizing interventions.

Allocative policies. By allocative policies we mean the use of policy measures to achieve an efficient use of resources. Because of the free riding problem which occurs in connection with the provision of collective goods, many collective goods are provided by governments and individual contributions are enforced via taxes. For many countries, this holds for the collective goods "safety from exterior threats", "schooling" and "highways". Another field of allocative policies is defined by the problem of market power. A lot of policy instruments have been developed to regulate monopolies and to stimulate competition, defined as a situation in which various agents supplying/demanding the same good try to attract the same set of buyers/sellers. One of these instruments is the control of mergers by public authorities to prevent monopolies actually being created in the first place.

Distributive policies. This term stands for the use of policy measures to achieve a just distribution of income and wealth between individual households or factors of production. In the nineteenth century, "pure" market economies created an extremely unequal distribution of income and wealth. The prosperity of industrial entrepreneurs was in sharp contrast to the impoverishment of what Karl Marx called the proletariat. In order to reduce the inequality of distribution, many modern market economies are endowed with mechanisms of redistribution like progressive income tax, inheritance tax and transfer payments.

Stabilizing policies. These are defined as use of policy measures to maintain a normal rate of utilization of the productive capacity. Market economies are affected by the periodical occurrence of business cycles. There is unemployment during recessions and inflation in booms. Both of these problems are addressed by policy measures taken by governments and central banks, the latter representing state-run institutions exclusively issuing domestic currency and seeking to avoid inflation.

For example, during the financial crisis in 2008 and 2009, many governments raised their expenditure to build new infrastructure or to create incentives for consumers to increase their consumption expenditure. The purpose was to stabilize aggregate demand, in order to avoid a rise in unemployment. At the same time, central banks all over the world lowered interest rates in order to stimulate investment activities.

It has to be noted that governmental interventions in the economic process often restrict the individual freedom of choice discussed above, which is fundamental to the existence of a market economy. For example, an inheritance tax robs the concerned individual the chance to decide on the use of a part of his or her income. Instead, the government decides on the use, maybe by using the tax revenue to introduce a transfer payment in favour of the poor members of society.

This restriction of individual freedom is the reason why every governmental intervention must be carefully justified on the grounds of at least one of the three normative criteria explained above, namely efficiency, justice, or stability. A precondition for any governmental intervention is to prove that one of these criteria is violated. Otherwise, the concept of individual freedom of choice predominates and there is no justification for the government to intervene.

In this context, it seems appropriate to introduce the term of a "merit good". Consider the intertemporal allocation problem of a young man or woman at the beginning of his or her work life. The decision has to be made on which proportion of current income to consume, on the one hand, and which proportion to save, on the other. The savings of the work life period can ensure that, after retirement, the standard of living remains the same as during work life.

In many countries (for example in continental Europe) governments assume that, with regard to future consumption, individual preferences are "defect" because people are myopic. Governments expect that individual savings in the present are not sufficient to maintain the working period standard of living into retirement. Therefore, the intertemporal allocation of individual income is assumed to be inefficient. In this case, future consumption becomes a "merit good", i.e., a good the future benefits (or "merits") of which consumers are not able to correctly perceive in the present period. Consequently, governments invalidate the principle of consumer sovereignty – which has been introduced in Sect. 3.4, above – at least locally, by introducing a public pension scheme and forcing people to contribute. Another example of a merit good is education at school. Governments assume that neither children ("we don't need no education"[6]) nor their parents ("teacher leave them kids alone") are able to judge, from a present perspective, the future merits that education will have for the children during their work life and, consequently, introduce school attendance.

It should be noted, however, that within the theory of the market economy the principle of consumer sovereignty represents the rule, while merit goods are the exception. In modern industrialized societies, many controversies emerge from the question where the limits between these two principles should be drawn.

[6] Readers who are either much younger or much older than the authors might not recognize that this is taken from Pink Floyd's *The Wall*.

Review Questions

1. Please describe the two flips of the coin called the "economic principle"!
2. What is meant by the term "inefficiency"?
3. Who are the agents that are behaving economically?
4. How can the structure of interactions between the private sectors within a closed economy be best sketched?
5. What is the difference between a "positive" and a "normative" analysis?
6. Please explain the differences between a system of solidarity, a bureaucratic system, and a market system!
7. Which problem arises if the attempt is made to establish a ranking of all needs of all members of a society?
8. Please discuss the advantages and disadvantages of a system of solidarity, a bureaucratic system, and a market system in managing the problem of scarcity!
9. In which respects is it possible, according to Musgrave, to justify governmental interventions in the economic process?
10. What is a "merit good"?

Exercises

1. Please find an example for an intervention in the economic process with the purpose of ensuring an efficient resource use!
2. Please apply the economic principle to the planning of:
   (a) A first semester student;
   (b) A taxi driver;
   (c) A doctor.
3. Please answer the following question with regard to the circular flow: on which markets do consumers and firms interact? Which kinds of real and monetary flows are crossing which market?
4. Please delineate the normative foundation of a free market economy!
5. Please explain the allocative functioning of the price mechanism in a market economy! How does it ensure a maximum level of needs satisfaction? In answering this question, please consider a firm which has developed a new and very attractive product!

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Integration of the Natural Environment: Socially Undesirable Utilization of Natural Goods

4

4.1 Introductory Remarks

In Chaps. 2 and 3 above, the natural environment was not mentioned at all. In the present chapter, the relevance of the natural environment for economic thinking will be discussed in some detail. In order to do this, we will pick up some of the notions dealt with in prior chapters, namely those of goods, production, the circular flow, normative analysis and economic policy. In doing so, we will use these notions as analytical tools to formulate economically meaningful statements concerning the natural environment. This procedure will help to reveal that the discipline of environmental economics rests on the foundations of general economics.

4.2 Natural Goods

Numerous natural resources make a direct contribution to the satisfaction of human needs and, therefore, can be interpreted as consumer goods. Their contribution to the satisfaction of human needs can be considered within Maslow's framework of various levels of needs.

There are many natural commodities that directly satisfy humans' needs at the basic level. Humans cannot survive without breathing clean air and drinking clean water. As opposed to commodities, services have been defined, in Sect. 2.2.2 above, as actions of other humans that satisfy human needs. In the context of the natural environment, however, the notion of a service has to be reinterpreted, because there are services of the natural environment that do not constitute human actions. For example, people are warmed by the permanent flow of "good" sunrays and protected from "bad" rays of the sun by the ozone layer. Thus, in addition to certain commodities, the natural environment provides services as well, which directly satisfy basic human needs:

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> [T]here has been increasing recognition that continuing economic growth and human welfare are dependent upon the services provided by the environment. These services include the provision of raw materials and energy used to produce goods and services, the absorption of waste from human activities, and the basic roles in life support and the provision of other amenities such as landscape. (UN 2003, p. 1)

At the level of safety needs, natural caves gave shelter to the Stone Age people and the ozone layer still protects people from radiation.

It is much harder to find any example of natural resources which directly contribute to the satisfaction of human belongingness and love needs, or esteem needs. This is because at these levels of Maslow's needs hierarchy, human relationships seem to be decisive. However, at the level of self-actualization needs, many stocks of animal and plant species need to be interpreted as consumer goods as well. The population of a seldom and endemic butterfly species living in a Brazilian jungle far away from civilization contributes neither to the satisfaction of people in North America or Europe's basic needs (butterflies don't represent food), nor to their safety needs. However, the knowledge of the sheer existence of this population may indeed contribute to the satisfaction of human needs, even in the Western world; we might call this the need for an intact natural environment. This is the so-called existence value of certain stocks of natural resources.

The classification of goods summarized in Table 2.1 of Sect. 2.2.3, above, is of special importance for natural goods and for the agenda of environmental and resource economics. The classification developed there was based on the criteria of excludability of use and rivalry in use. Many natural goods can be classified as private goods, which are characterized by excludability and rivalry. Natural gas may serve as an example. If the price is not paid, the pipeline can be locked, as Russia has proved occasionally. This means that excludability is at hand. Furthermore, if a given amount of natural gas is used in the oven of family A, family B can't use this amount to produce heating, so we have rivalry.

A natural club good (excludability, non-rivalry) may be a beach accessible only via a certain hotel. Only this hotel's customers have access to the beach, while other potential users are refused entry. There is no rivalry among the hotel's customers concerning the beach (again, if we do not take into account overcrowding).

Some severe environmental problems may arise where natural goods can be characterized as collective goods (non-excludability, non-rivalry) or as open access goods (non-excludability, rivalry). The natural collective good most frequently discussed at present is the purity of the atmosphere. By substantially reducing greenhouse gas emissions, global climate stabilization could be achieved. No person in the world could be excluded from the corresponding benefits. In addition, there is non-rivalry, because the fact that climate stabilization would be enjoyed by people in Asia would not prevent humans in Africa from enjoying it simultaneously.

Sea fish are an important and severely endangered natural open access resource. With regard to the access to the *stocks* of fish living in the oceans, there is non-excludability, because no fisherman can be prevented from casting out his net outside territorial waters. However, each ton of fish *caught* by fisherman A cannot be harvested by fishermen B, so there is rivalry as regards the harvest.

4.3 Production Based on Natural Resources

Many natural resources are used as factors of production and constitute, in the terminology developed in Sect. 2.3 above, investment goods. Fossil fuels, wood, metals and water are productive factors in the production of energy, furniture, in the metalworking industry and in agriculture. They contribute indirectly to the satisfaction of human needs enabling the production of consumer goods like electricity, chairs, cars and crops.

Two problems may arise from the productive use of natural resources. First, the stocks of the natural resources used as productive factors become depleted and may decline over time. Eventually, those stocks may even be exhausted. Exhaustion may severely restrict human economic activity. This was the kind of argument that the Club of Rome provided in its famous report "The Limits to Growth" some decades ago (see Meadows et al. 1972). Second, the stocks of other natural resources not involved in production at all are used up as well. The most threatening example is that of greenhouse gas emissions into the atmosphere caused by burning fossil fuels. Both problems are important issues within natural resource economics.

4.4 The Circular Flow and the Natural Environment

In Fig. 3.1 of Sect. 3.3 above, nature doesn't appear at all. It might be possible to integrate natural factors of production into the circular flow. In this case, however, nature would play a subordinate role. It would appear merely as a supplier of raw materials for human economic activity.

In sharp contrast to this view, some ecological economists suggest that human economic activity is embedded within the natural environment and crucially dependent on numerous services provided by nature. Therefore, the economic system created and operated by mankind must be viewed as subordinate to nature and not the opposite way round. This point of view is illustrated in Fig. 4.1.

The arrows in Fig. 4.1 represent the diverse interdependencies between the natural and economic systems. Those arrows coming out of the economic system may stand for waste emissions or for changes in landscape caused by productive activities. The arrows going into the economic system may represent the extraction of productive factors from their stocks, which are part of the natural environment (wood, minerals). However, the most decisive feature of Fig. 4.1 is the interpretation of the economic system as a subsystem of nature. There are certain services of nature without which human economic activity could not take place at all. The ozone layer in the atmosphere may serve as an illustrative example, again: without its protective functions human life would not be possible on earth.

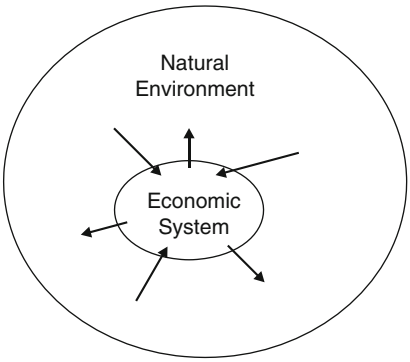

Fig. 4.1 Systems hierarchy (see, for example, Daly and Farley 2011, p. 51)

4.5 Normative Analysis: Efficiency, Justice, and the Natural Environment

The normative analysis developed in the following deals with the norms of efficiency and justice. The third criterion, stability, is not discussed in environmental and resource economics.

The efficiency criterion is violated in the case of natural collective goods and natural open access goods. The reason is that in both cases, certain incentives emerge for potential users to systematically overuse those resources.

The purity of the atmosphere is an important natural collective good. A look at the problem of greenhouse gas emissions reveals the environmental relevance of the free riding position. Effective climate protection would require substantial contributions from all members of the global community. Unfortunately, however, free riding is still quite a common position in this field.

Given a natural open access resource, the incentive for overusing it is of a somewhat different nature. If a rational fisherman knows that he cannot harvest a ton of fish which has already been harvested by his colleague, he will try to catch exactly this ton of fish before his competitor can do so. If all the fishermen act in the same way, a race starts which can't be won in the long run – either by the fisherman or by the fish. Recently, an expert workshop led by the International Programme on the State of the Ocean (IPSO) strongly alluded to the devastating consequences of, inter alia, overfishing for marine life and concluded that "[t]he extinction threat to marine species is rapidly increasing" (Rogers and Laffoley 2011, p. 7). Consequently, the workshop participants recommended that fishing effort be reduced significantly and that a global system of marine protected areas be established (ibid, p. 8). But overfishing is only one of the stress factors threatening marine life. In addition, the workshop revealed some important interdependencies between different stress factors affecting the oceans, including the fact that a certain proportion of carbon dioxide emissions is becoming dissolved in the water. This is leading to increasing acidification of the oceans further threatening marine species.

Besides natural collective goods and natural open access resources, one of the most important issues discussed in environmental economics, which involves a violation of the criterion of efficiency, is the problem of external effects. External effects emerge whenever the degree of satisfaction of human beings' needs is restricted by market activities of other individuals, who do not account for the effects on the well-being of those not involved in the market transaction. If external effects occur, the resulting market allocation is socially undesirable because the economic principle is violated, i.e., resources are wasted. The problem of external effects will be discussed in detail in Chap. 7 below.

Another branch of environmental and resource economics which is of growing importance deals with violations of the criterion of justice. In modern times, varying degrees of scarcity co-exist. While in developing countries people often have no chance of satisfying their basic needs, people in developed countries, whose basic needs are fairly well satisfied, are looking for ever new forms of self-fulfillment. It was the famous report "Our Common Future" of the so-called Brundtland Commission (WCED 1987) which took up the position that the uneven distribution of opportunities between humans living today is closely related to the problem of environmental degradation. Moreover, the Brundtland Report emphasized that present economic activity is diminishing the opportunities open to future generations and put on the agenda the problem of justice between generations. This problem led the Brundtland Commission to recommend sustainable development, defining it as:

> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:
>
> - the concept of "needs", in particular the essential needs of the world's poor, to which overriding priority should be given; and
> - the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs. (WCED 1987, p. 43)

This citation reveals that, like the whole argumentation developed in Chaps. 2 and 3, the Brundtland Commission was concerned exclusively with *human* needs. This was a purely anthropocentric point of view. Human beings alone were treated as the measure of all things. In opposition to this there are, however, some ecological economists who claim that animals are endowed with needs as well, and maybe even plants. In doing so, these economists take an ecocentric position. The well-being of non-human nature is brought into the focus.[1]

[1] A classical formulation of an ecocentric position is Aldo Leopold's one: "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise" (Leopold 2001, p. 189).

4.6 Economic Policy and Environmental Protection

Especially in the field of allocative policy, there are, in many countries, various interventions in the market process in order to ensure efficient use of natural resources. In principle, politicians can choose between direct regulations of behaviour, charges on environmentally harmful behaviour, and tradable permits.[2] To give just one example, the latter instrument has been implemented by the European Community on the basis of the Kyoto Protocol to improve the provision of the collective natural good climate stabilization. Firms within some specified sectors of production are obliged to buy permits initially distributed by public authorities if they intend to emit carbon dioxide.

As regards the goals of justice and sustainability, concrete policy interventions are still seldom to be found. The problem seems to be that it is hard to reach a consensus about the appropriate definitions of "justice" and "sustainability". As an exception, the Government Pension Fund of Norway should be mentioned. The Norwegian government invests the revenues from exploiting Norwegian stocks of fossil fuels into buying shares in firms all over the world. The purpose is to ensure that future generations of Norwegians can enjoy a standard of living comparable to that of their ancestors when the stocks of fossil fuels are exhausted in a few decades' time.

Review Questions

1. In which ways does the natural environment directly contribute to the satisfaction of human needs?
2. Which components of the natural environment are used as productive factors?
3. What is meant by a "service" of the natural environment?
4. Please discuss the relevance of the problem of "free riding" in the context of using the natural environment!
5. Which problem arises with regard to the utilization of the natural resource "sea fish"?
6. How can the interrelationship between the economic system and the natural environment be described?
7. Are there any cases in which the criterion of efficiency is violated with regard to the use of natural resources?
8. Is the norm of "justice" relevant in the context of the use of natural resources?
9. Which policy measures can be adopted to ensure an efficient use of natural resources?
10. Please explain the goal of the Norway's Government Pension Fund!

[2] See Chap. 7 in Part II, below. A more detailed analysis can be found in Endres (2011).

Exercises

1. Please find an example for a natural resource that exhibits the characteristics of a "collective good", and please describe the causes and consequences of free riding!
2. Please explain the special importance of the criteria of "excludability of use" and "rivalry in use" in the context of an economic analysis taking into account the natural environment!
3. Please explore the multiple problems that arise from the productive use of tropical wood!
4. What is the meaning of an "existence value" of a natural resource stock? On which level of Maslow's hierarchy of needs might it be located?
5. Is the norm of "justice" relevant to environmental and resource economics?

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Summary to Part I and Looking Ahead

5

The present Part I began with the observation that human beings are restricted, in all their attempts to satisfy their unlimited needs, by the limited availability of goods. This phenomenon was called scarcity. Humans oppose scarcity by acting in conformity with the economic principle. Based on rational behaviour, the negative consequences of scarcity can, in principle, be addressed better within a market system than in other forms of economic systems. However, given some special circumstances, market processes fail to produce outcomes that meet the goal of the greatest degree of satisfaction of human needs. In those cases, the application of economic policy measures is justified. The very special case of market failure, which constitutes the core idea behind the present text is the socially undesirable utilization of natural goods in the context of a market economy.

In Part II, which follows, some of the issues dealt with above will be examined more closely. In Sects. 6.2 and 6.3, the economic agents introduced in Sect. 3.2 above, namely consumers and firms, will be our focus again. The "economic behaviour" of consumers and firms will be examined more carefully. Subsequently, in Sect. 6.4 we will explore in a positive sense what happens when consumers and firms, acting economically, meet on markets. The normative flip of the coin will be presented in Sect. 6.5, raising the question of which conditions are required for market outcomes to meet the primary goal of economics introduced in Sect. 3.4 above: to achieve the best degree of satisfaction of human needs. It will be shown out that market outcomes often, but not always, help to achieve this primary goal. The latter case, called "market failure", will be discussed in Chap. 7, with special reference to the causes and consequences of inefficient use of environmental resources in an unregulated system of markets. Departing from the introductory remarks on economic policy made in Sect. 3.5 above, some possible policy devices that may serve to ensure efficiency in the use of environmental goods will be sketched in Chap. 7 below.

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Part II

Microeconomics and the Natural Environment

Fundamental Concepts of Microeconomics 6

6.1 Objectives and Methods of Microeconomics

Microeconomics is an impressive (and bold) architecture of thought. Its objective is most ambitious: it attempts to describe, explain and evaluate almost everything that is going on in the world as far as human behaviour is concerned.[1] To achieve this goal (or to at least come as close as possible) microeconomics takes a multi dimensional approach providing

- a theory of rational individual decisions,
- a theory of conflict resolution and coordination,
- a theory of the evaluation of resource allocation,
- a theory of public regulation.

Given this set of dimensions, microeconomics is fairly *comprehensive*. It is also quite *general*. Let us see what the term "general" means in this context, and take the first of the four bullet points presented above, the dimension of individual decision making, as the example for our explanation.

The decisions of a baker are certainly different from the decisions of the manager of a basket ball team, and the two afore mentioned decisions are certainly different from the decision of a couple to get married. However, when we said that microeconomics attempts to provide a theory of individual decisions, above, we did not mean that microeconomics provides different theories for the decisions of bakers, sports club managers and fiancés. On the contrary, microeconomics tries to identify features of decision making that are *general* in the sense that they are common to all kinds of rational decision making, irrespective of who the decision maker is and what the decision is about. Based on this general approach microeconomics serves as the basis of many different fields of applied economics, such as environmental economics, industrial organisation or the economics of the family.

[1] Describing and explaining constitute the *positive*, evaluating the *normative* part of microeconomics. See Sect. 3.4, above.

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Let us now elaborate on each of the four dimensions of microeconomic theory mentioned above.

- Microeconomics as a theory of rational individual decisions

It is an essential feature of human life that each autonomous individual takes many decisions every day. This is a burden and a privilege, at the same time. There are fundamental and trivial decisions. An example (of the former) is that most of the honourable readers of this text, at a certain point in their lives, may have decided to enrol on an environmental studies programme of a university. Instead, they could have decided to enrol on a different programme or not to go to university at all. Another example is a family deciding on whether to buy a new car instead of travelling abroad in their vacations.[2]

These decisions (and all others), have an important feature in common: the decision maker must choose between alternatives. "Alternatives" means that realising one possibility implies that the other possibility cannot be chosen. The decision in favour of a new car, for example, implies that the vacations abroad cannot be realized. (At least, this is so in the case of the family playing its part in our example.) As regards the decision to enrol in a certain university program the possibilities to do the one and leave the other are rather limited. Some people might go for two university degrees, simultaneously, but this is the maximum you can do, in most cases.

The reason for the necessity to choose and therefore being forced to decide is that the realisation of an alternative uses up resources. Once these resources are consumed for one alternative they cannot be used for the realisation of the other alternative. It is impossible "to have your cake and eat it". These resources can be of completely different kinds for different decisions. For example, the resource that forces you to decide between buying the car and going away for vacation is money. The resource that forces you to decide between different university programmes is money too, but in addition, it is time.[3]

Of course, the fact that the decision in favour of a certain alternative uses up resources wouldn't be worth mentioning if resources were abundant. It is the *scarcity* of resources, as discussed in Sect. 2.4, above, that adds a painful touch to decision making: realizing one alternative comes at the cost of not being able to realize the other alternative. The alternative foregone is interpreted to be the cost of the alternative chosen, in economics.[4] It is called "opportunity cost".

So if microeconomics is a theory of individual decision making, this is a consequence of the central theme of scarcity that we have discussed in Part I, above. Since economics focuses on the painful aspect that the decision to realize a

[2] The wish to have a new car, and to travel abroad in the vacations are "needs" in the sense of Sect. 2.1, above.

[3] These two resources are related to each other, even if the saying "time is money!" somewhat overstates the case.

[4] If there are several alternatives forgone, it is the best of these which counts as the opportunity cost.

certain alternative uses up scarce resources, it is easily understood what a criterion for "prudent decision making" is: in the economic view, a necessary condition for a decision to be prudent is that it does not use up more resources than absolutely necessary to achieve the purpose of the decision. Decisions like this do not imply any waste of scarce resources. They are termed "efficient" in economics, as has been explained in Sect. 3.1, above. Aiming to behave efficiently, people shopping for a car or deciding upon their vacations will try to find out which offers provide the best value for their money. Analogously, students try to find out which university programme will provide the best return on the invested money and time.

Of course, the idea of achieving a certain goal efficiently does not say anything about what this goal might be. Indeed, the criteria according to which a car is chosen and the relative weights of these criteria in the decision making process might be quite different for different individuals. For some people fuel efficiency might be most important. For others, size, speed, or prestige effect may be crucial. Similarly the decision to pursue environmental studies might be driven by different motives. Among these motives might be the prospects of future earnings ("Environmental experts are rich!"), personal preferences ("Environmental science is so fascinating!") or the feeling of moral obligation ("Environmental experts contribute to a better world!").

With regard to the goals individuals try to achieve, microeconomics is quite open-minded. Microeconomics presumes that individuals strive to attain as much satisfaction as possible. In the microeconomic terminology they are trying to "maximize their utility". What and how high this utility is, completely subjective. It is defined by each individual decision maker, and not by the economist who analyses the individual decision making. Microeconomics assumes that each individual agent possesses a web of tastes which enables him/her to rank alternatives according to how desirable they seem to him/her personally. This set of rankings is called "preferences". The autonomy of an individual decision maker to define his/her own preferences is called "consumer sovereignty" in the microeconomic literature even though it does not apply to consumers only, but to any decision maker.

However, there is an important exception to the rule that microeconomics is unspecific about the goal of the individual decision maker, leaving the definition of "utility" quite open. This exception applies if the decision maker under consideration is a *firm*. A firm is an economic unit combining productive factors, like labour and capital, to produce commodities and services to supply them to consumers (and other firms). In the case of firms we generally take it for granted that the utility they strive to maximize is *profit*. We will elaborate on this in Sect. 6.3, below.

We have explored some general features of microeconomics as a theory of individual decisions. We will apply these general insights in Sects. 6.2 on the consumer and 6.3 on the firm, below. Before we do that let us examine a few general observations on the second dimension of microeconomics, mentioned above:

- Microeconomics as a theory of conflict resolution and coordination

  Humans are social beings. On the one hand, each individual competes with other individuals for scarce resources. On the other hand, no individual can cope without cooperating with other individuals.

Art work 1 David Dalla Venezia, No. 269, Oil on Canvas, 2000
This might be the illustration of three economics textbook authors (they all look alike!) struggling on whose name will appear first on the cover. Obviously, they are using brute force as a means of conflict resolution. Alternative mechanisms of conflict resolution would be the seniority principle, or – sometimes it's as simple as that – the alphabet. An alternative (and possibly more serious) interpretation would be that the painting illustrates the internal creative struggle of the artist. Interestingly, this kind of a conflict, the conflict within one and the same person, is dealt with in the arts, philosophy, as well as in poetry and prose, but not in mainstream economics. In economics, it is assumed that the decision making process of any individual does not use up emotional (or any other) resources, but is conducted "costlessly". When we talk about "conflict", in economics, we are most certainly referring to conflict between different individuals

Conflict resolution and coordination were no hot topics for *Robinson Crusoe*, at least in the time before he met *Friday*. Sparse as the resources on his island were, they were all his – at least that's what he thought, initially. However, there was no one with whom he could share the tasks of life.

Modern societies are designed in sharp contrast to the Robinson Crusoe scheme. People compete with each other for all kinds of objects of desire, like consumer products, jobs, organ transplantations, and grants to cover the costs of university environmental studies programmes. Moreover, labour is strictly divided between people who specialize in narrowly defined tasks. For example, there are environmental scientists who know most everything about the greenhouse effect but who do not know how to bake a bread, let alone how to drive a nail straight into a piece of wood. This is no problem: working on how to meet the need of society for energy without burdening the earth with excessive greenhouse gas pollution, they earn money. They can use this money to pay people who know to bake bread and to work on the nails if this is what needs to be done.

This may sound trivial but it is not. On the contrary, we are talking about a fundamental problem every society must solve. The problem consists of two elements.

The first is that society must provide a mechanism for the solution of conflicts in cases where the goals of different individuals are not compatible with each other. This is a social "must" no matter what the conflict is about: if two people want to have a unit of a certain good, it must be decided who prevails, no matter whether this unit is the last slice of bread, or the last student slot in an environmental studies programme.

The second aspect of the problem with which we are dealing here is that where ever the goals of different individuals are compatible with each other, society must provide a mechanism which makes people cooperate together like the different organs in a healthy body. This means, for example, that the decision of a consumer to buy a certain good can only be realized if this decision is complemented by firms (or other institutions) producing this good. Your decision to learn about environmental sciences and to get a qualification which makes you fit to enter the labour market for environmental specialists leads to nothing, except your frustration, if your decision is not complemented by universities' decisions to offer environmental studies programmes.

Art work 2 Theater Bonn, Germany, FRIDA KAHLO, 2003. Director and Choreographer: Johann Kresnik (Photo: Thilo Beu). There are many wonderful photos particularly from Dance and Opera on Thilo Beu's webpage, http://www.thilo-beu.de/
In economics, we certainly acknowledge the utmost importance of coordination among individuals for their well-being. However, we take a rather prosaic look at it. The scene from the ballet shown above reminds us that there are poetic (if not romantic) alternatives. Here's the authors' understanding of utmost romance: we believe the photo shows a (somewhat farsighted) couple coordinating in jointly reading *Economics for Environmental Studies*. And don't they look happy?!

The problems we are dealing with are about how scarce goods are assigned among the people who want to lay their hands on them: is David's or Susan's application successful when the last student slot in the prestigious environmental

studies programme is assigned? The problem is also about how scarce productive resources are allocated to competing uses: does the university of Nobel City decide to stage an environmental studies programme or would it rather extend its famous medical school? A certain amount of scarce goods assigned to competing consumers (and a certain amount of scarce productive resources assigned to competing uses) is called an *allocation*, in economics.

Of course there are many possible ways to solve conflicts between individuals rivalling for scarce resources. Using the terminology that has just been introduced we might just as well say: there are many *allocation mechanisms* which may be applied. A mechanism which has a particularly long tradition in the history of human-kind is brute force. However, in the process of societies' evolution human kind became aware that different mechanisms for the regulation of conflicts have different potentials to contribute to human welfare. In this respect, brute force fared pretty badly compared to other mechanisms.

Therefore, microeconomics does not pay much attention to brute force as an allocative mechanism.

As for conflict resolution, there are many allocative mechanisms which might be considered to arrange cooperation.[5] Among these possibilities is the order of the king (of the queen!). Another mechanism is a central allocation plan designed by a national bureaucracy. Thirdly, the democratic process might decide on how to coordinate individual behaviour by majority voting. Moreover, social traditions and informal agreements may play a role in coordinating.[6] Finally, coordination might be arranged by the market mechanism.

There is not much economic analysis nowadays on monarchical rules or on central bureaucratic planning, but there certainly was, a while ago. However, there is a lot of microeconomic work on voting procedures, social traditions and informal agreements. This is done in special branches of microeconomics, called *public choice, social choice* and *institutional economics*. In the present introductory text, however, we do not pay much attention to these specialities but rather concentrate on mainstream ("bread and butter") economics. There, the focus is on the market mechanism and governmental intervention as the most important means of allocating scarce resources both in the process of conflict resolution and in the process of coordination.[7]

Let us deal with the market first (and leave government intervention to the final part of this section).

Under certain conditions, this mechanism is thought to be quite effective in managing the two social problems mentioned above, conflict resolution and

[5] Various allocation mechanisms have been briefly explained in subsection 3.5.1, above.

[6] An example of coordination by social tradition is the (admittedly somewhat old-fashioned) "ladies first" rule, coordinating the behaviour of two people of opposite gender who are about to pass through the same door. Even though it might be considered to be not completely politically correct, the rule has an impressive success rate in preventing people from bumping into each other.

[7] See subsection 3.5.2 on economic rationales for governmental intervention. In the context of environmental problems, market failure due to externalities is the most important one. These issues will be dealt with in subsection 6.5.3 and Chap. 7, below.

coordination. We will elaborate on this in Sect. 6.4, below, dealing with "the market". In the present section we make some general observations on how the market mechanism might be able to meet the need for coordination and for the solution of conflicts.

To do so we will consider an extremely simple example. Imagine that the firms in a certain market have decided to produce 50 units of a certain good, X. We won't worry about how this decision was made. This kind of a question is postponed to Sect. 6.3 on "the firm", below. On the other side of the market there are assumed to be 100 consumers and each of them would love to have exactly one unit of this product. Of course, this example is highly artificial. This might be considered to be a drawback. On the other hand, it has the advantage of being most simple. It is the simplest means of demonstrating the point at issue here: how the market mechanism can contribute to solving the two problems involved here, the one of coordination and the one of conflict resolution.[8]

In the context of this example, the coordination problem is restricting the total quantity demanded by the consumers to the total quantity of supply provided by the firms. The aspect of conflict regulation is how to decide which ones among the 100 consumers are the "lucky winners" who will receive the unit of the product in question. In a market system, the issue is not decided by a lottery but by the market price. We are looking for the level of the price for good X which cuts back the aggregate demand of the consumers to 50 units and simultaneously identifies the 50 consumers who will buy the product. This special price which equates the total quantity demanded to the total quantity supplied is called the *equilibrium price* in economics. Obviously, this price cannot be 0. As the example has been constructed, each consumer would want one unit if the product was given away for free and then the total demanded quantity would be in excess of the total quantity supplied. Excess demand is at a level of 50 units in our example if the price is 0. Let us assume the price is one monetary unit (dollar, euro, yen . . .). Then, each consumer is forced to think about it thoroughly (or fulfil the task using his/her intuition). Since the budget from which the monetary unit (let it be dollar hereafter) must be taken is limited, the question is: is a unit of good X worth the dollar? To answer this question the consumer must consider other possibilities to spend the dollar and compare the utility that this dollar generates if spent on good X with the utility this dollar provides if spent on any other good, Y.[9] On the basis of this kind of an internal evaluation process, a certain number of consumers (say, five consumers) may decide not to spend the dollar on good X but instead on an other good (or put it away into a savings account). Then, the

[8] Choosing the simplest way to make our point meets the requirement of *efficiency*, one of the most important concepts in economics, as explained in Sect. 3.1, above: we choose the way in which we achieve our didactical goal such that it confines the time our readers must devote to this issue to its minimum level. You see: we treat your time budget as a scarce resource which has to be allocated efficiently. So the rule for prudent decision making that has been explained in the previous subsection also holds for decisions in the process of economic theory building, and of textbook writing.

[9] Not being able to buy a dollar's worth of Y is the opportunity cost of buying a dollar's worth of X.

discrepancy between the quantity demanded and the quantity supplied has already somewhat narrowed compared to the situation with a price of 0, but is still at 45 units. Obviously the equilibrium price for X is higher than 1 dollar.

Assume that at a price of 43.50 dollars there are 51 consumers left who think, based on an assessment of their needs and their budgets, that good X is worth buying. Then, the equilibrium price is the lowest price at which one additional consumer can be induced to refrain from buying X. If at 44 dollars just one of the remaining 51 consumers decides to leave the market, then 44 dollars is the equilibrium price: at that price, the total quantity demanded is exactly equal to the total quantity supplied. At the same time this price draws the line according to which it is decided which of the 100 people interested in X, in the first place, actually receive it and which don't. Obviously, the people who prevail are the ones who are able to demonstrate the intensity of their needs for X by paying the equilibrium price. If all consumers had a budget of the same size, then the people with the highest intensity of need for X would be the ones who in fact received a unit of X. If different people have different sized budgets, this is not so simple. The willingness to pay depends on both, the intensity of the preference for the good and the size of the budget.

Of course, a prerequisite for the workability of the mechanism described above is that all people participating in the process respect the rules of the market mechanism as a means of coordination and conflict resolution. There must be a consensus in the society that scarce goods are allocated using the price mechanism, at least as far as goods like X are concerned. An alternative would be that goods are stolen. Another possibility is that they are distributed by the government according to a catalogue of criteria defined by a bureaucracy. A third possibility would be allocation by waiting in line. All of these procedures play a certain role in most societies. Microeconomics can be applied to analyse what's going on if any of these allocative schemes is applied. However, the focus of microeconomics is on the market mechanism (and on governmental intervention).

- Microeconomics as a theory of evaluation of resource allocation

Under the first bullet point of this introduction into the objectives and methods of microeconomics, we presented some observations on how microeconomics stylizes individual decisions: economic agents are taken to choose among alternatives, striving to achieve their goals as well as they can in light of the fact that their resources are limited. We call this behaviour *rational*, in microeconomics. What these goals are is left (almost[10]) completely down to the individual decision makers themselves.

[10] There are some basic requirements on the preferences of individual decision makers which somewhat attenuate the generality of the observation made above. However, we do not follow this line of thought here. See, e.g., Varian (2010), p. 35/36. Moreover, not all individual goals are socially accepted. There are certain constraints on individual goals defined by the law, but also by ethical principles, as well as the customs of a particular society. Notably, microeconomic analysis can also be applied to illegal behaviour. See the groundbreaking (1968) work of Economics Nobel Prize Laureate Gary Becker and, for a more recent exposition, Chaps. 11 and 12 in Cooter and Ulen (2004).

This approach is *positive*, in the sense explained in Sect. 3.4, above: it is used to describe, explain (thereby, hopefully helping to understand) and even to forecast individual behaviour. However, the approach does not say whether individual behaviour is good or bad.

An analogous statement holds for what has been said under the previous bullet point. Here, we have explained how the market mechanism might coordinate the decisions of different individuals and how it might resolve conflicts about the allocation of scarce resources among those individuals. This is also *positive analysis*; we did not say whether the market mechanism does a good job in terms of coordination and conflict resolution.

Many microeconomic analyses are confined to the positive approach but there is also an important branch of microeconomics which is *normative* (see Sect. 3.4 and subsection 3.5.2, above). Here, microeconomics tries to assess whether a certain situation is "good" or "bad". This evaluative analysis is not used very much in the area of individual decisions. Modern microeconomics does not teach people about what is good for them. The idea that individuals are entitled to decide upon their own goals, the principle of *consumer sovereignty* mentioned above, does not leave much room for microeconomic value judgements.

This is completely different where the results of social mechanisms (like the market mechanism) are concerned. There the question arises of whether the results of this mechanism in terms of conflict resolution and coordination are good or bad from the point of view of society as a whole.[11]

Of course, to assess whether a job is done well you need a criterion with which you can measure the quality of the performance. To find such a criterion is much more complicated when the quality of a situation is to be evaluated from the point of view of society as a whole than it is from the point of view of a single individual. As has been mentioned above, the issue concerning the individual decision maker is solved by microeconomics in a stunningly simple way: the decision maker is his/her own judge when it comes to assessing what is good and what is bad. However, when it comes to assessing situations from the point of view of society, we cannot get away as easily as that. The reason is that society is not a single comprehensive decision unit ("a person"), but consists of many different people. As we have observed above, each of the many members of society might follow his/her own personal goals and there may be considerable conflicts between these goals. In light of this fact, it is a difficult philosophical question when we ask how criteria might be designed according to which different situations may be assessed from the point of

[11] When we talk about "society", it must be mentioned that it consists of human beings only. Animals and all kinds of vegetation do not "count" as members of society in mainstream economics. This may be heartless but it is not as heartless as it sounds at first hearing. It does not mean that animals and vegetation are not respected and have no value from the point of view of economics. They are and they do have value, but only in so far as respect and value is attributed to them by human individuals. So animals and vegetation play a role in economics but it is a secondary role as granted by human beings in the context of an anthropocentric approach. (See Sects. 3.4 and 3.5, above, on anthropocentrism and ecocentrism.)

view of society as a whole. It is this issue which we courageously tackle in this subsection.

Compare two different allocations a certain society might be able to realize, A and B. To illustrate this, imagine that society enjoys a certain provision of consumption goods which are sold in private markets and also enjoys a certain level of environmental quality, in allocation A. In allocation B, consumption is a little lower than in A and environmental quality is somewhat higher. The question is: which allocation is better for society? In the common terminology of microeconomics you could reformulate this question to ask: is the *welfare* of society higher or lower in A than it is in B? A subsequent question is: in which situation (A, B or a third alternative C) is the welfare of society maximal? The allocation for which the welfare of society is maximal is called the "socially optimal" allocation.

Microeconomists have been working on these questions for quite a while (and very hard too). We will deal with the answers they have come up with in subsection 6.5.1, below. In this introductory section we work with the idea that good old Jeremy Bentham proposed in 1776, and which was referred to in Sect. 3.4, above. According to this somewhat cryptic but also plausible concept, an allocation is *socially optimal* if it provides the greatest happiness to the greatest number of members of the society under consideration.

This leads us to the fourth (and last) dimension of microeconomics.

- Microeconomics as a theory of public regulation

Microeconomics uses the idea of social optimality to assess the results that are produced if a society uses a certain allocation mechanism, e.g., the market mechanism. If this mechanism produced results ("equilibria") that were socially optimal, this would be a strong case in favour of the allocation mechanism under consideration leaving things as they are. On the other hand, if the equilibria produced by the allocative mechanism a society applies do not meet the criterion of social optimality, the question arises as to whether the welfare of society can be improved by governmental intervention. It is important to note, however, that "governmental intervention" is a very comprehensive term, incorporating many forms of governmental intervention. Microeconomics tries to analyse the properties of different forms of governmental intervention and to find designs that best meet the objective of maximizing social welfare.

Ooophs! This sounds awfully philosophical. Is it still economics? Yes, it is, as will become apparent when we apply these concepts in the subsequent sections.

To give you a preliminary idea of how this might work, consider environmental problems. A doctoral degree in environmental economics is not needed in order to observe that an unregulated market mechanism will not be able to secure natural resources for this and future generations. It is a safe guess that governmental intervention will be needed to protect the natural environment, and that this protection will improve social welfare. However, there are obviously different forms of governmental intervention that benefit the environment and society. Wherever the readers of this book may be located, each will know – from their home country – examples of different kinds of environmental policy instruments.

These include environmental taxes, environmental subsidies, various emissions trading programmes, requirements to apply environmentally sound technologies, and many other forms of environmental regulation. An important economic question is to evaluate these different kinds of environmental policy instruments in terms of their effectiveness and their potential to enhance social welfare. We will briefly deal with these issues in Chap. 7, below, where we discuss the microeconomics of environmental policy.

6.2 The Consumer

We will turn now to one of the main actors of any market economy: the consumer. The consumer is an economic agent, supplying such things as labour and capital in the market for productive factors, as well as demanding in the market for consumer goods items such as refrigerators and haircuts.[12] In discussing the economics of the consumer we apply microeconomics predominantly as a theory of rational individual decisions, in the sense explained in the preceding section. In this section we identified the scarcity of resources to be the reason for the necessity to decide among alternatives.

Let us apply this idea to the role of a consumer supplying labour. The resource which is scarce in this context is time. Each consumer must decide how to allocate his/her time budget to alternative activities all of which need time to be performed. Economically, the most crucial of these activities are work, leisure, and education. The most important benefit from work is money (as far as traditional microeconomic theory is concerned). The most important benefit from leisure is fun, hopefully.[13] The most important benefit from education is to improve the chances of making more money by working in the future.[14] Microeconomics stylizes the decisions of consumers to divide their scarce time budget optimally among the three competing uses in the sense that the total utility derived from spending the time is maximized. The situation in which a consumer spends his/her time in the utility maximizing manner is called the *equilibrium* use of time. Naturally, this equilibrium may look different for different consumers. It depends upon the relative utility a consumer

[12] Additionally, a consumer might operate in money markets, borrowing and lending. However, we do not pay very much attention to this dimension of consumer decisions. In the context of environmental issues it is not as consequential as the activities of consumers in markets for physical resources. The present textbook is designed to present economics as it is most useful to environmental studies.

[13] The German philosopher Johann Friedrich Herbart (1776–1841) said: "Boredom is the biggest sin!". This is understandable from the point of view of microeconomics because a lifetime is definitely limited. Interestingly, the economic quest for efficiency, often sneered at to be a low "purely mercantile" issue, can be interpreted as a high moral obligation.

[14] Most of our readers know that education is a lot of fun, too – isn't it? However, we do not deal with this aspect in the above brief exposition.

derives from competing allocations of time. All other things being equal, a consumer with a strong preference for consumption goods supplies more labour to the market, in equilibrium, than a consumer who does not care very much for the material world and likes best to sit meditating in the sun (weather permitting). Another determinant of the equilibrium usage of time is the wage rate. All other things being equal, more labour will be supplied (and less leisure enjoyed) the higher the wage rate.[15] If the wage for an additional hour of work is $50, a greater proportion of our cherished readership would be happy to sacrifice an hour of leisure compared to a situation with a wage rate of $5. Similarly influential for the structure of the equilibrium time budget is the extent of the wage increase that can be achieved by attaining a higher professional qualification. If a certain education is very profitable in this sense, more people will decide to invest their precious time by partaking in educational programmes where they can attain the respective qualification. Moreover, the specific time an individual may need to finish the educational programme under consideration depends on several factors, particularly the intellectual capacity of the respective individual. So the equilibrium allocation of the time budget will turn out to be different for people with different endowments of intellectual (and other[16]) resources.

Having sketched the decisions of the consumer supplying in the factor market as utility maximizing management of his/her time budget, let us now turn to the role of this economic agent demanding consumer goods. Here, the necessity to decide among competing alternatives is predominantly rooted in the scarcity of money. In order to receive a consumer good legally, one has to pay the price and, like it or not, the budget of each consumer is (more or less) limited. Resultantly, each consumer has to decide how best to divide his/her scarce budget between consuming and saving. Simultaneously, he/she must decide on which of the very many alternative commodities and services to buy as well as in which of the many alternatives he/she should save or invest. Of course, if savings already exist at a certain point of time, the consumer might decide to increase his/her budget available for consumption by reducing the stock of money saved. However, we leave savings aside in the subsequent analysis and concentrate on consumption.[17] Analogously to what has been said for supplying labour, microeconomics stylizes the decision of the consumer buying goods to be one of utility maximization. The consumer is assumed to spend his/her money optimally in the sense that he/she buys the bundle of goods for which the utility that is extracted from spending the limited budget is higher than it is for any other bundle that could be alternatively purchased with this budget. This

[15] If the wage rate gets "very high", this relationship might be turned upside down. The same holds true for "very low" wage rates. See, e.g., the section on the "backward-bending" labour supply curve in Varian (2010), pp. 174–178.

[16] If you inherit a huge fortune you probably won't worry so much about putting in a lot of work to earn money.

[17] Since saving is assumed to be zero in most introductory microeconomic analyses, the terms "budget" and "income" are used as synonyms.

utility maximizing bundle of consumption goods constitutes the *equilibrium demand* of a consumer. Of course, the structure of equilibrium demand is generally different for different consumers. This is so, because the preferences of different consumers differ. Some consumers are prepared to pay up to 200 dollars to see a soccer match, others couldn't care less. Moreover, the budgets of different consumers differ widely.

Calculus Club: Session 1

In this digression we address those of our readers who are familiar with the mathematical method of *calculus*. Occasionally during our exposition we call this subset of readership together to an imaginary "club session", where we use some mathematical language to make the point. So this section is more appropriately geared to people who take the environmental engineering perspective as the focus of their environmental studies, rather than to those predominantly interested in environmental law or philosophy. We hope that the members of the latter group share our assessment that the discrimination we practise hereby is a mild and tolerable one. The contents of the "calculus club sessions" are strictly supplementary (and thereby optional). The argument can be fully understood by everyone skipping the sessions. However, mainstream economics is a social science that heavily relies on the use of mathematical methods. In the main parts of this book we do without but it would be unwise to completely ignore the didactical potential of mathematical methods; thus, we address those readers who are somewhat familiar with this language.

Having said that, the members of the Calculus Club may consider a consumer buying two goods X and Y with quantities x and y. The utility he/she derives from consuming these goods is represented by a twice differentiable utility function

$$U = U(x, y).$$

According to an intuitive (even if somewhat old fashioned) interpretation, this function quantifies the satisfaction the consumer derives from consuming the goods. According to a modern (and somewhat prosaic) interpretation, U is just an index function attributing the higher numbers to the dependent variable the more the consumer under consideration likes the bundle of goods, which is represented by the independent variables. So if a consumer prefers a certain bundle $(\bar{x}, \bar{y})$ to a bundle $(\hat{x}, \hat{y})$, then

$$U(\bar{x}, \bar{y}) > U(\hat{x}, \hat{y})$$

follows.

(continued)

The first partial derivative of this function for any of the two variables is assumed to be positive, the second derivative for any of the two variables is assumed to be negative. The second cross derivative may be positive, negative, or zero. The first partial derivative is called *marginal utility*, in economics. Its economic interpretation is the utility generated by the consumption of a small additional amount of the product under consideration. Strictly speaking (after all, we are talking calculus here), the unit is indefinitely small.

Assume that the amount of money the consumer spends for consumption is m and the prices of the two goods are p_X, p_Y. Then, all the combinations of x,y the consumer might buy are given by the equation

$$p_X x + p_Y y = m.$$

We call this equation the consumer's "budget constraint".

From all the combinations of the two goods for which the consumer is able to pay with his/her budget, he/she is assumed to choose the one providing the highest utility. This decision rule is formalized by maximizing the utility function under the budget constraint.

$$U(x, y) = \max!$$

$$s.t.$$

$$p_X x + p_Y y = m$$

The tuple of consumption quantities solving this constrained optimization problem (let us call it (x^*, y^*)) constitutes the equilibrium demand of the consumer under consideration.

Above we have characterized the concept of equilibrium supply (of labour) and demand (of commodities and services) of a consumer, as stylized by microeconomic theory. This has been done verbally for all of our readers and in somewhat more formal terms for the subset of our readers familiar with calculus (confined to the case of demand). We have also argued that the structure of equilibrium supply and demand might vary with the level of all kinds of determinants. In the case of equilibrium demand, the consumer's preferences and budget as well as the product prices have been mentioned.

Above, we tacitly assumed that these determinants do not change. We did not introduce any movement in terms of salary, prices of other goods, etc. This kind of an approach, describing equilibria under the assumption that the determinants of those equilibria are unchanged, is called *static analysis*.

Obviously, however, the size of each of the aforementioned determinants may change over time. That stated, the question arises as to how the consumer's equilibrium might react to changes in the determinants.

This part of microeconomic theory, analyzing how equilibria vary with varying sets of determinants is called *comparative static analysis*.[18]

Answering questions related to comparative static analysis is at the core of microeconomic theory of the consumer. However, microeconomics does not pay equal attention to each kind of aforementioned determinant.

Among the three determinants most important for equilibrium demand (preferences, product prices, and income), changes in the first receive almost no attention from mainstream microeconomics. Explaining changes in the preferences (the utility function) of consumers has been almost completely surrendered by mainstream economics to the realm of other behavioural and social sciences, such as psychology and sociology. On the other hand, the explanation of changes in prices and the consequences of such changes for equilibrium demand are central to economic analysis.[19] Changes in income and their effects on equilibrium demand play an equally considerable role in economics. In the context of the present section, we concentrate on how changes in prices affect an individual consumer's equilibrium demand.

We posit a situation in which a certain consumer achieves his/her equilibrium in consumption. Here, with given preferences, prices, and income, the consumer buys the equilibrium quantities of the available commodities and services. Unless the level of one of the determinants changes, the consumer would not want to change this situation.[20] (If we imagine that consumption takes place in different time periods – for the sake of higher plausibility –,[21] with one decision on the equilibrium demand in one period, the consumer would not want to make a different consumption plan for the next period from that which he/she has made in the previous period.)

Now assume that the price of one of the goods in the consumer's equilibrium basket increases, all other things being equal. Then, the old (pre-price change)

[18] There is a third kind of method, in addition to static and comparative static analysis. Here, microeconomics observes the trajectory along which the variable to be explained (e.g., the quantity demanded) changes in the process of moving from one equilibrium to another (or even to no other equilibrium at all). This kind of a method is called *dynamic analysis*. We do not pay very much attention to it in the microeconomic part of this book. However, dynamic analysis plays an important role in the macroeconomic part, particularly in Sects. 9.2 and 10.1.

[19] There are some (well, obviously) *extremely smart* remarks on the division of labour between economics and other social sciences in the (1993) article by Economics Nobel Prize Laureate Gary Becker.

[20] Indeed: not wanting to change behaviour given the circumstances is the "heart of the matter" in the microeconomic concept of *equilibrium*.

[21] To imagine different periods here is helpful to get the idea. However, strictly speaking, there is no *time* at all in the concept of static analysis. Acknowledging the passage of time in economic modelling belongs to the realm of dynamic analysis.

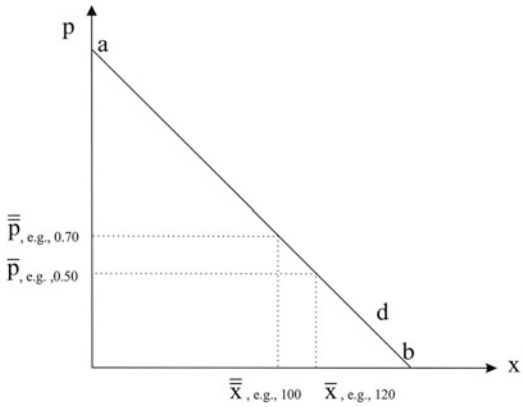

Fig. 6.1 The individual demand curve

equilibrium cannot be upheld. The income is just not high enough to pay for the initial consumption bundle after the price of one of the elements of this bundle has gone up. It is unavoidable that the consumption level of at least one of the goods purchased by the consumer must go down, given that the price of one of the goods goes up. It is most plausible that the equilibrium quantity of the good whose price has risen actually decreases as a reaction. For example, if you imagine that the price of apples in the market increases, with all other prices remaining as they are, it is quite plausible that many consumers may revise their consumption plans: some might buy pears instead.

This inverse relationship between the price of a good and the quantity of this purchased good is often referred to as the *law of demand*. However, this is neither a law from which no deviation is possible – as is the case with natural laws – nor is it a law in the sense that deviators are punished (in the sense of criminal law). The law in the economic sense is a general observation which holds true in most cases but from which there are occasional deviations.

Of course, what has been said above for an increase in the price of a certain good can be generalized for any price change in any good.

A graphical illustration of this idea is the *demand curve* of an individual consumer, *d*. For every given price the curve indicates the corresponding quantity that the consumer under consideration demands in equilibrium. It is presented in Fig. 6.1.

For any given price observable from the ordinate of the graph, the curve shows the quantity demanded by the consumer for which this demand curve holds at the abscissa.[22] In the example, at a price of \$0.50 the consumer purchases 120 units of the good *X* in equilibrium. In case of a price increase to \$0.70 the quantity demanded drops to 100 units.

[22] The abscissa is the horizontal, the ordinate is the vertical axis.

Putting it in more general terms you might say that at a price of $\bar{p}$ the equilibrium quantity demanded by the consumer under consideration is $\bar{x}$. If the price increases to $\bar{\bar{p}}$, equilibrium demanded quantity drops to $\bar{\bar{x}}$. The law of demand is respected in that $\bar{\bar{p}} > \bar{p}$ and $\bar{\bar{x}} < \bar{x}$ hold.

The demand curve is the graphical representation of the *demand function*, $x = d(p)$. The equation for the demand function is illustrated in Fig. 6.1 as $x = 170 - 100p$. From the way we wrote this equation and the way we interpreted the demand curve, we note p is the independent variable and x the dependent. Considering this, the illustration of the demand function in Fig. 6.1 is somewhat unusual, because it would be more conventional to plot the independent variable on the abscissa, and the dependent on the ordinate. Well, economists sometimes make an exception. The exposition presented here is very traditional, and economists have gotten so used to it that they do not even realize anymore that it is unconventional. As long as the curve is monotonically decreasing, however, it doesn't really matter which way you position the independent and the dependent variable.[23] Indeed we will use an interpretation below where the quantity is understood to be the independent variable of the demand function and the price to be the dependent.

In our example, the demand curve is assumed to be linear. This is done solely for convenience. The demand curve can take any shape: all that is required is that it is downward sloping, obeying the "law of demand", as was discussed above.

There are two points on the demand curve that are immediately eye-catching: these are the points at which the curve intersects the abscissa and the ordinate, respectively. Each of the two has its own economic interpretation which might be worth noting.

Consider the intersection of the demand curve with the ordinate first, a. If the price is at a level of a, the quantity demanded is 0 (and stays at 0 for any price higher than a). Since a is the lowest price that prevents the consumer from buying X, a is called the "prohibitive price".

At the other end of the demand curve you find the quantity, b, where d intersects the abscissa. b is the quantity the consumer demands if X is given away for free. (In order to make the consumer ask for more, you would have to pay him/her!) Quite descriptively, b is called the "satiation quantity".

Interpreting the demand curve, you should always keep in mind that illustrating how the quantity demanded of a certain good depends upon the price of this good does not say that this price is the only determinant of this quantity. Instead, all other determinants are assumed to be constant in the process of interpreting the demand curve.[24]

[23] Please remember that the property of being monotonically decreasing is assured by the *law of demand*.

[24] Academic economists sometimes love to show off their high level of education. A well established trick to make an impression is to occasionally intersperse some Latin terminology. So instead of saying "all other determinants assumed to be unchanged", you might say "*ceteris paribus*".

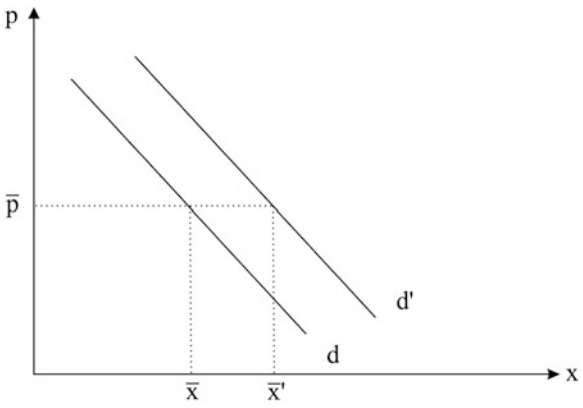

Fig. 6.2 Comparative static analysis of demand as income increases

When the demand curve is written as $x = d(p)$, this is shorthand for the values of all the variables affecting the demanded quantity of X beyond the price (p) of X being assumed to be constant. These variables are not explicitly mentioned in the equation. However, they are nonetheless "silently kept in the economist's mind".

Among these other determinants are the prices of all other goods and the income of the consumer. Importantly, the preferences of the consumer are assumed to be constant but this goes without saying in mainstream economics.

According to what has been said above, we read the reaction of a consumer in terms of his/her demanded quantity for a certain good along the demand curve if the price of this good changes. We "move along a given demand curve", observing different points along its course.

However, what happens if one of the other determinants of the demand for the good under consideration (other than the price of this good) does not sit still, as we have assumed in defining the demand curve? Then, the demand curve shifts. To see this, we apply some comparative static analysis, as referred to above. Consider a change in income. Normally, we expect that for every predetermined price of X, the quantity demanded, x, by a certain consumer increases when his/her income, m, increases. If X is a "normal" good in this sense, the demand curve shifts "to the north-east", i.e., from $d(p)$ to $d'(p)$ if the income of the consumer whose demand curve we analyse increases from m to m'.[25] This kind of a shift is illustrated in Fig. 6.2.

It is not important whether the shift shown in the figure is a parallel one. All that matters in the present context is that the new demand curve $d'(p)$ indicates a higher equilibrium demanded quantity for every price, compared to the initial curve $d(p)$.

[25] A positive relationship between the quantity demanded at a predetermined price and income is plausible but might not hold for every good. Think of the market for used shoes. Goods for which demand goes down as income goes up are called *inferior goods* in economics.

In Fig. 6.2, for any price of $\bar{p}$, the demand is at $\bar{x}$ given income is at m and at $\bar{x}'$ if income is at m'. $m' > m$ and $\bar{x}' > \bar{x}$ hold.

Above, we have presented a little exercise in comparative static analysis: one of the determinants assumed as being constant in the static analysis of the demand curve has been allowed to vary. This determinant is income.

Of course, analogous comparative static analyses can be applied with respect to all other determinants of the quantity demanded which are assumed to be constant in the consideration of a demand curve.

An issue very often discussed in economics is what happens to the demand curve of a certain good X, if the price of another good, Y changes. Depending on how the two goods are related to each other in terms of their suitability for satisfying the consumer's needs, an increase in the price of Y may stimulate or attenuate the demand for X. In the former case the demand curve of X would shift outward (to the north-east), whereas in the latter case it would shift inward (to the south-west). A case where the demand for X increases as the price of Y increases might be observed if X and Y are two different kinds of TV sets with comparable quality. Then, X and Y are said to be *substitutes* in microeconomic terminology. A case where the demand for X decreases if the price of Y goes up might be observed if $X$and Y are hardware and software. (An old-fashioned example is bread (popcorn!) and butter.) In this case, X and Y are called, in microeconomics, *complements*.[26]

For now, we will take a hiatus from comparative static analysis and return presently to the static analysis of the demand curve, taking a look at it from a different perspective.

In the interpretation of the demand curve, presented above, we have always taken the price to be the independent variable and the equilibrium quantity demanded to be the dependent variable: given a certain price the consumer wants to buy a certain quantity. So the curve was read "from the ordinate to abscissa". This is appropriate in the present context, explaining the decisions of a consumer as an important agent in the market.

However, it is also possible to interpret the demand curve by reading it "from the abscissa to the ordinate". This is a nice little exercise in mental flexibility. Moreover, it will turn out to be useful in Sect. 6.5. There, we proceed from describing what is going on in the market (positive analysis, see Sect. 3.4, above) to its evaluation (normative analysis, as is also dealt with in the section referred to above).

Consider the point on the demand curve shown in Fig. 6.1, as has been interpreted above, with the price being 0.50 and the quantity 120. (In more general terms the price/quantity combination is $(\bar{p}, \bar{x})$.)

[26] Our honourable readers are invited to graphically illustrate the comparative static analysis of demand for X as the price of Y increases. They might proceed analogously to what we have done in Fig. 6.2 referring to an increase of income. They might also distinguish the case of substitutes from the case of complements.

How about letting price and quantity switch the roles as independent and dependent variables? Then, we arrive at the following interpretation: if the consumer has bought a quantity of 120 ($\bar{x}$), then the price he/she has been willing to pay *for the last unit* of X is 0.50 ($\bar{p}$). Why? Try to prove the opposite: to do that, claim first that the willingness to pay for the last unit is lower than 0.50 ($\bar{p}$). Wrong! If it were true that the consumer was not willing to pay 0.50 ($\bar{p}$) for the last unit, then he/she would not have bought it. After all, we assume that the consumer strives for utility maximization. Second, what if one claims that the willingness to pay for the last unit is higher than 0.50 ($\bar{p}$), at a quantity of 120 ($\bar{x}$). Wrong! If the willingness to pay were higher than 0.50 ($\bar{p}$) at a quantity of 120 ($\bar{x}$), then a consumer would still buy this last unit at a price which is a little higher than 0.50 ($\bar{p}$). However, he/she doesn't, which can be seen in Fig. 6.1. If you observe a price which is a little higher than 0.50 ($\bar{p}$), then equilibrium demanded quantity drops below 120 ($\bar{x}$). It can't be otherwise because the consumer operates under the law of demand.

Of course, what we have argued for one point on the demand curve (0.50, 120), ($\bar{p}$,$\bar{x}$) can be just as easily argued for any point on that curve. For each predetermined quantity you can read the consumer's willingness to pay for the last unit consumed from the demand curve. In the usual microeconomic terminology (inspired by calculus) we call the last unit *the marginal unit*. So the demand curve can be interpreted as the *marginal willingness to pay*-curve. It must be mentioned that our little mental exercise of exchanging the roles of p and x as the independent and dependent variables, respectively, was made possible courtesy of the law of demand: if the curves were not running monotonically you could not transform the unique mapping of prices into quantities into a unique mapping of quantities into prices.[27]

For the benefit of terminological clarity economists do not shy away from any effort and thereby created a special word for the demand curve as interpreted above: if we read the demand curve such that the quantity is the independent and the price the dependent variable we speak of the *inverse demand curve*. Take the example we used above. If $x = 170 - 100p$ is the initial demand curve,[28] then $p = 1.7 - x/100$ is the inverse demand curve. In general terms, if the direct demand curve is $x = d(p)$, then the inverse demand curve is $p = d^{-1}(x)$. Very often, however, the "-1" in the exponent of the symbol of the function, "d", is not written. There, the authors trust that the readers will understand from the context, whether it is the direct demand curve or the inverse demand curve that is referred to. We partake in this tradition of "expository sloppiness" in the notation of graphs. There, a curve labelled "d" might sometimes be interpreted as being the direct demand curve, and sometimes to be the inverse demand curve. We do that in order to economize in

[27] To see why, imagine that the demand curve is U-shaped instead of being monotonically downward sloping. After completing this exercise, you might immediately forget about u-shaped demand curves; they violate the law of demand!

[28] The initial demand curve (the one where p is the independent and x the dependent variable) is sometimes called the *direct demand curve*.

terms of the number of graphs being used and believe that the likelihood of thereby creating misunderstandings is negligible.

6.3 The Firm

Having dealt with the consumer as the first main actor in the drama of microeconomics we are now going to turn to the second, the firm (there is no one to stop these dedicated authors and their enthusiastic readers!). The firm is an economic decision maker buying in the markets for productive factors, labour, and capital, and selling in the markets for commodities and services. Accordingly, the firm is the counterpart of the consumer who has been defined to sell in the first and to buy in the second market.

It is worth noting that markets for commodities cannot always be distinguished from markets for productive factors, by looking at the physical properties of the product under consideration. For example, electricity is certainly bought by firms as well as by consumers. So if electricity is demanded by a household then the market for electricity is perceived as a market for a consumer good. On the other hand, if electricity is demanded by the firm, electricity is perceived as being bought in the market for productive factors. Resultantly, the same entity can be interpreted from different perspectives and it is predominantly the context of the discussion (of the economic model under consideration) that matters in terms of terminology.

In discussing the role of the consumer we treated his/her supply in the market for productive factors only in passing and spent most of our efforts on explaining the consumer buying in the market for commodities and services. For the firm we follow a complementary pattern. For simplicity, we take it to the extreme, completely ignoring the role of the firm in the market for productive factors. We concentrate exclusively on how the firm acts in supplying commodities and services to the market. Just as we have done with regard to the consumer, we use microeconomics as a theory of individual rational decisions dealing with the firm.

So what does a firm have to decide, operating as a supplier in the market for commodities and services? Obviously, in order to be able to supply, the firm has to produce. So the decisions of the firm are related to the questions of *what*, *how much,* and *how* to produce. According to what has been said about the objective of the firm, in Sect. 6.1 above, the firm strives to find the answer to these three fundamental questions that maximizes the firm's profit. The firm's profit is defined to be the difference between the revenue the firm receives from selling its products in the market, and the costs that are generated by the fact that the firm has to pay for the inputs used to produce the firm's output.[29] (The terms "output" and "production" are used as synonyms in microeconomics.)

[29] In reality you might not be exactly sure what these revenues and these costs are going to be. In this introductory exposition, we ignore problems of uncertainty, to keep things simple.

For simplicity, we do not deal with the decision of the firm on what to produce.[30] We focus on the decisions of a firm that has already decided to produce a product, X. Regarding the question as to how to produce, we can be quite brief in the present context. Generally there will be more than just one method of production for the good under consideration. If you compare how a certain product, e.g., steel, is produced at one point of time in different countries, or at different points of time in the same country you will realize that different productive methods are used. These productive processes are particularly distinguished from each other according to how much labour and capital is used to produce one unit of the product (say, one ton of steel) and what kinds of labour and capital are used. Typically, you find more capital and less labour being used if you compare recent production methods to earlier ones. The same tendency is revealed if you compare production in industrialized countries to production in developing countries. So a firm that plans to produce X must choose which of the available production processes to use. The decision rule is quite clear: it follows from the profit maximization objective of the firm. Since costs reduce profits by definition, the firm selects the productive process with which it is able to produce at minimum cost. *Cost minimization* is a prerequisite of profit maximization. Which one of the many available production processes qualifies to be cost minimal depends on the prices the firm has to pay for the various inputs used and on the *productivity* of these inputs within the context of a specific production process.[31]

Cost minimization as a rule governing how to produce holds independent of how much is produced. Accordingly, our statement that each firm chooses to apply the cost minimizing mix of available production processes is true, independent of what level of output the firm decides to produce. Putting this into mathematical terms we can derive the *total production cost function*. As the dependent variable, this function indicates the minimum amount of cost, C, which is incurred for any level of production, x, as the independent variable. The total cost function is written as $C = C(x)$. By specifying this function for (small) additional units of production we arrive at the *marginal production cost function*, $MC(x)$.[32]

Since the cost function is defined for any level of output you cannot answer the question what the *profit maximizing* quantity, x^*, might be, using the cost function

[30] Also, the terms "production" and "supply" are used as synonyms. This is so, because we ignore that the firm may put part of its production into storage (or may throw it away). Everything produced is assumed to be brought to the market. Moreover, nothing brought to the market is taken out of storage.

[31] The *average* productivity of an input is the amount of output produced per unit of this input. If the level of output is denoted x and the level of labour is denoted l, then the labour productivity is x/l. A related concept is the *marginal* productivity of an input. It indicates by how much output increases as the quantity of this input used in the production process is increased by one (small) unit. *Calculus Club mini session*: marginal productivity of labour is $\partial x/\partial l$.

[32] *Calculus Club mini session:* the marginal cost function is the first order derivative of the total cost function.

only. However, using this function definitely contributes to the solution of the puzzle.

Stay tuned:

Put yourself into the shoes of the owner of a firm. Before production actually starts you sit down and consider the options. Applying the method established in microeconomics to identify the profit maximizing quantity of production, you take the "piecemeal" approach. You conduct a little "thought experiment" by considering an arbitrarily chosen level of production, $\bar{x}$, and you ask the following question: if I produced $\bar{x}$, would the last unit produced make a positive contribution to my profit? To answer this question, you compare the revenue this last unit generates with the cost that has to be spent for the production of this unit.[33] The revenue generated by the last unit is called *marginal revenue,* while the cost generated by this unit is called *marginal cost*. The difference between the two is *marginal profit*.

Consider the case where the marginal revenue is higher than marginal cost; in this case, the last unit under consideration obviously contributes to the profit of the firm, meaning marginal profit is positive. Then, it is worthwhile to increase production by one further unit. If this also provides positive marginal profit then further expansion of your production plan is warranted.

If, on the other hand, the marginal profit of the production unit under consideration is negative you will refrain from producing it, assuming you strive for profit maximization. So according to this reasoning a positive marginal profit is a signal to the profit maximizing firm to expand the quantity it plans to produce, whereas a negative marginal profit is a signal to reduce planned output. Accordingly, the profit maximizing quantity is defined by zero marginal profit. For the last unit supplied marginal revenue equals marginal cost. Here, the firm does not have any incentive to change its plan (i.e., the firm is in equilibrium). As the owner of the (albeit imaginary) firm, you are "there", once you have identified the level of production which meets the equilibrium condition "marginal revenue = marginal cost". It has been a long day then, but it was definitely worth it!

We briefly explained the concept of marginal cost, above. In order to operationalize the equilibrium condition "marginal revenue = marginal cost", we must be somewhat more specific with regard to revenue. Revenue is defined to be the product of price and quantity of the good sold. In the simplest setting, these two variables determining revenue are independent from each other. Here, the price for the product is determined in the market, as has been sketched in the previous section and as will be elaborated in the coming section. The firm can supply any quantity of the product at this ruling price. However, it cannot affect the price in any way. Instead, it has to take it as it is. Therefore, the firm is often said to be a *price taker*. Specifically, the price is independent on how much the individual firm supplies to the market. Moreover, the market price is the same for all firms within the industry producing the good under consideration, X. This setting is quite plausible if the firm

[33] Again, we ignore uncertainty.

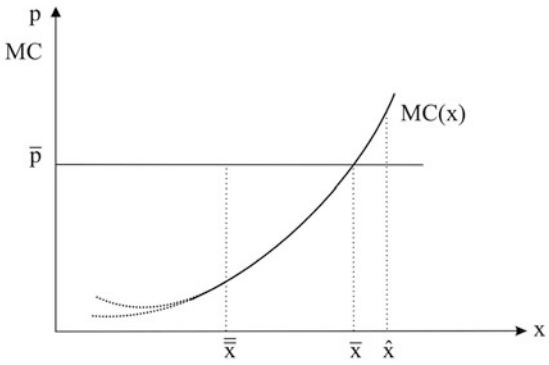

Fig. 6.3 Equilibrium output decision of a perfectly competitive firm

under consideration is very small compared to the totality of firms producing the same good. Consider a single farmer supplying to the world coffee market. You might also think of worldwide market places on the internet. Price comparison sites and online selling portals accumulate offers from very large numbers of suppliers for many different products. Regardless where the merchant is located, he/she is able to sell to customers throughout the world. Therefore, there are hundreds and thousands of companies offering the same product, meaning these firms have to accept the lowest price on the platform used as a reference price for their own price. A market structure which is characterized by this feature, where an individual producer is "a drop in the ocean", is called *perfect competition*.[34] If a firm operates in a perfectly competitive market, the marginal revenue is identical to the market price: selling an additional unit of output generates revenue which is exactly equal to price.[35]

Other kinds of market structures considered in microeconomics are *monopoly* and *oligopoly*. In the former market structure the firm under consideration is the only one supplying in the market. Consequently, it can exercise considerable influence over the market price. The latter market structure catches the case where a few firms operate in a market where each of them has certain influence on the market price and each of them must be on the guard, observing what the other firms do. However, we will concentrate on the simplest case of perfect competition and ignore monopoly and oligopoly.

Using the assumption that the market price is independent of the quantity supplied by the firm under consideration, we can illustrate graphically what we have said on the nature of profit maximizing output (Fig. 6.3).

[34] Within the context of the present section ("the firm"), we have emphasized above that firms are price takers in a perfectly competitive market. For the sake of the completeness of the definition of a perfectly competitive market, let us add that consumers are also assumed to be price takers in this market structure.

[35] Closer inspection (from which we refrain here) reveals that this statement does not hold for other market structures than perfect competition. See, e.g., Varian (2010), pp. 439–445, 497–506.

In this figure, the price $\bar{p}$ is drawn as a horizontal line as a consequence of the fact that it does not depend on individual firm output, x, which is measured on the abscissa. The curve $MC(x)$ illustrates the marginal cost of the examined firm producing x. The dashed parts of the curve indicate two alternative shapes of the curve. They illustrate that it is not essential for the argument explained above how the curves run "far away" from the point where the marginal cost curve intersects with the price line.[36] At this intersection, the equilibrium condition "price = marginal cost" is met. The quantity for which the equality holds is called $\bar{x}$ in the figure. So, $\bar{x}$ is the answer to the question of how much a profit maximizing firm will produce. This level is contingent on the price for X being $\bar{p}$, a market structure of perfect competition (implied by the fact that $\bar{p}$ is constant), and by the given values of the input prices and of technology (implied by the shape of the marginal cost curve).

The figure can be used to graphically illustrate the "piecemeal approach", so as to identify the profit maximizing output level (which has been verbally explained above). Take the production quantity $\bar{\bar{x}}$ as the first example. At this quantity level, price exceeds marginal cost, i.e., marginal profit at $\bar{\bar{x}}$ is positive. Flowing from this, production is too low at $\bar{\bar{x}}$, i.e., the production plan has to be extended to serve the goal of profit maximization. On the other hand, at production level $\hat{x}$ marginal profit is negative. As a result, the production plan has to be contracted in order to move into the direction of the profit maximum. Obviously, for this kind of an argument to be valid the marginal cost curve must be upward sloping in the vicinity of its intersection with the price line.[37]

[36] This is an example of the fact that the logical relationships dealt with in microeconomics are often more general than suggested by the graphical illustrations used to visualize these relationships. Another example was mentioned when we discussed the comparative statics of demand as income increases, using Fig. 6.2. There, we mentioned that the demand curves have been drawn to be parallels for simplicity only. The effects of changes in income on the quantity demanded at a given price also hold for (downward sloping) demand curves not parallel to each other.

[37] Not so obvious? To solve the puzzle, you might draw a figure with $\bar{p}$ as the horizontal price line and add a *downward sloping* marginal cost curve. Then, denote the quantity for which your marginal cost curve intersects the price line as $\bar{x}$, as we did in Fig. 6.3, above. Equipped with these analytical instruments you might find out what happens to the firm's profit if it increases output a little, going from $\bar{x}$ to $\hat{x}$, or decreases output a little, going from $\bar{x}$ to $\bar{\bar{x}}$. You will see that profit goes up for both deviations from $\bar{x}$. *Calculus club mini session:* If marginal cost decreases in the region of its intersection with the price line the second order condition for a profit maximum which will be derived in the subsequent calculus club is violated. In fact, the firm's profit is at a *minimum* at $\bar{x}$.

Calculus Club: Session 2

Just as we did in the previous section for the consumer we can summarize what we have just said about the firm in somewhat more formal terms:

The profit of the X-producing firm, Π, is defined to be revenue, R, minus cost, C. Revenue and cost are both written to be functions of output, $R(x)$ and $C(x)$. Revenue is defined to be price times quantity sold, i.e., $R(x) = px$ holds. Since we consider the market structure of *perfect competition,* the price cannot be affected by the individual firm, such that p is a constant. Given that the profit maximization problem of the firm can be written as

$$\Pi = px - C(x) = \max!$$

The first order condition is

$$\partial\Pi/\partial x = p - \frac{\partial C}{\partial x}(x) = 0.$$

Since the derivative of the cost function is the marginal cost function, MC the first order condition can be written as

$$p = MC.$$

The solution to this first order condition is x^*.

The second order condition is

$$\partial^2\Pi/\partial x^2 < 0,$$

i.e.,

$$\partial MC/\partial x > 0.$$

The first order condition given above is the formal expression for the intersection of the marginal cost curve and the price line in the figure. The second order condition is the formal expression for the requirement that the marginal cost curve is upward sloping in the vicinity of the solution.

We have sketched the output decision of a profit maximizing firm. In the process of this analysis the determinants of the profit maximizing level of production have been assumed to be constant. These determinants are the price of the output as well as the marginal cost curve. In turn, the determinants of the latter, input prices and technology, have also been assumed to be constant.

Just as we have done through the analysis of the consumer in the previous section we can now analyse how the firm adjusts its output decision if these determinants

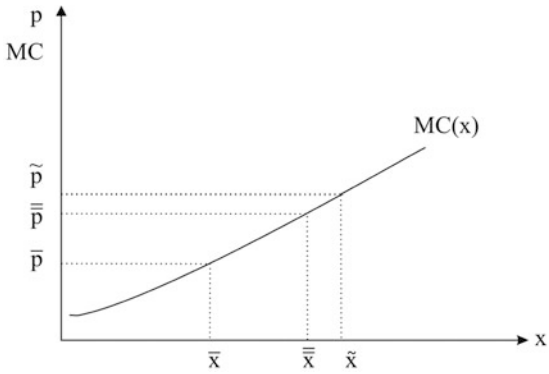

Fig. 6.4 Equilibrium supply for alternative prices

change. We focus on how changes in the output price affect a firm's equilibrium supply. Therefore, we choose the counterpart to the analysis of a consumer where we analyse how changes in the product price affect the decisions of the consumer in terms of demand.

The rules according to which the firm chooses the quantity supplied do not depend upon the level of output price p. However, the quantity that meets the equilibrium condition "price = marginal cost" changes if the price changes. This can easily be seen in Fig. 6.4 where the equilibrium supply of the firm is shown for alternative prices, $\bar{p}, \bar{\bar{p}}, \tilde{p}$. For each of the alternative and predetermined prices the quantity supplied can be read off the (increasing part of the) firm's marginal cost curve.

Dealing with the consumer in the previous section we defined the *demand curve* to be the curve indicating the quantity demanded by the consumer at each price for the product under consideration. Analogously, the *supply curve* is the curve indicating the quantity supplied by the firm under consideration at alternative product prices. In general terms, this is written as $x = s(p)$ and called the *supply function*. An example is $x = 2p$.

It follows from the brief analysis given above that the supply curve is generated by the increasing part of the marginal cost curve of the firm.

We say "is generated by" instead of "is identical to" for the following reason: in our definition of the supply function the price is the independent and the quantity the dependent variable. In the marginal cost curve, the quantity is the independent variable and the marginal cost the dependent. So the marginal cost function, $MC = MC(x)$, is not identical to the direct supply function, $x = s(p)$ but identical to the *inverse supply function*, $p = s^{-1}(x)$.[38] An example is the marginal cost

[38] In the previous chapter we noted that the monotonicity of the demand curve is a prerequisite for the transformation of the direct demand function into the inverse demand function. Analogously, going from the direct supply function to the inverse supply function requires monotony. This requirement is met since for the constitution of the supply curve we use the monotonically increasing part of the marginal cost curve only.

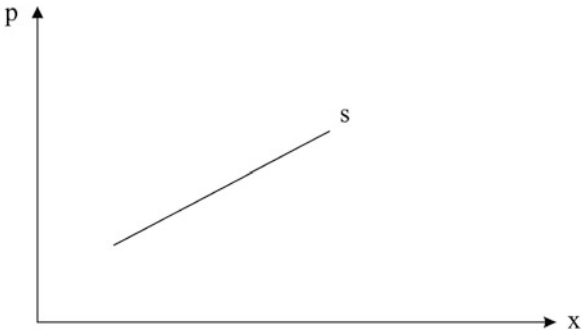

Fig. 6.5 The supply curve of the firm (at one time, this is an exercise in economics just as it is an exercise in minimal art)

function $MC = x/2$.[39] The corresponding inverse supply curve is $p = x/2$. This function is the inverse of the direct supply function mentioned in the example given above, $x = 2p$.

In analogy to what we have said in the section about the consumer, we use the symbol "s" for supply in the graphical illustration not distinguishing between the direct supply function, $s(p)$, and the inverse supply function, $s^{-1}(x)$. The curve illustrates the relationship between price and quantity in the context of supply and it will be always clear which of the two variables is taken to be the independent and which to be the dependent.

As a result, we redraw the relevant part of the marginal cost curve and label it s for supply.[40] If you read the curve "from the ordinate to the abscissa", working with p as the independent variable you are dealing with the direct supply curve. If you read "from the abscissa to the ordinate", instead, using x as the independent variable you are considering the inverse supply curve (Fig. 6.5).

Above we have taken the quantity of a certain good X supplied by an individual firm to be determined exclusively by the price of this good. The relationship between these two variables has been graphically illustrated by the supply curve. Of course, this mapping of prices to equilibrium quantities for the individual firm is analogous to the price-quantity mapping for the consumer elaborated in the discussion of the demand curve. This analogy is no big surprise because, obviously, the consumer demanding X and the firm supplying X have to be (and will be!) brought together in the market. We deal with this in the next section.

[39] This is a particularly nice one because it is monotonically increasing. Sometimes U-shaped marginal cost curves are used. An example is $MC = x^2 - 10x + 30$.

[40] The generality of this statement is attenuated by the fact that maximal profit might be negative for the firm if the price is too low. At these prices the equilibrium supply is 0 and the marginal cost curve of the firm, even if increasing, is not part of the supply curve in this area. These considerations are relevant for U-shaped marginal cost curves, as the one mentioned in footnote 27, and are further differentiated if you distinguish between "long run" and "short run" analysis. However, we do not deal with these issues here and refer instead to the literature. See, e.g., Varian (2010), pp. 398–402.

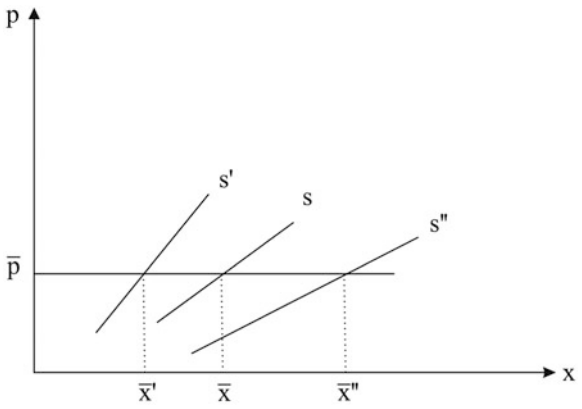

Fig. 6.6 Comparative static analysis of the individual supply curve

Before we do that let us briefly observe an additional analogy in the economics of the consumer and the firm. If we recall our discussion on the consumer, we will note that showing the demanded quantity depending on the price of the good under consideration does not say that the price is the only determinant for the equilibrium quantity demanded. This applies equally to the firm: introducing the supply curve as an analytical tool showing how the price of a good determines the quantity supplied in equilibrium by a firm does not suggest that the quality supplied is determined by the price of the good under consideration exclusively. Writing $x = s(p)$ is just a shorthand where the determinants of x, other than p, are assumed to be constant in the course of the analysis and therefore are not made explicit. Analogously to what has been said explaining the demand curve in the previous section, however, these other determinants are silently treasured in the economist's mind.

Let us now briefly deal with these other determinants of the quantity supplied.

Obviously, how much a firm will be willing to supply in terms of X depends on the cost of producing X. This intuition is wonderfully compatible with our earlier observation that the supply curve mirrors the marginal cost of production. However, the cost of production is not invariably determined by the laws of nature. On the contrary, it depends on factors which are subject to human decisions and might thereby change. An important issue in this case is the prices for the inputs that the firm uses in the production process. All other things being equal it is clear that production cost will increase if the prices for labour and/or capital increase.[41] If this happens, both the marginal cost and supply curves shift upwards. This is illustrated in Fig. 6.6 by the shift of the supply curve from $s(p)$ to $s'(p)$.

[41] Microeconomics contributes to a better world by stimulating the dialogue among different generations: ask your grandparents what happened during the world wide "oil crisis" in the year 1973. (A contemporary worry is what might happen to the cost of all kinds of electronic devices if the prices for rare metals go up.)

Another determinant of production cost, in addition to input prices, is technology. Technology changes over time as a result of research and development activities. Technical progress may take many forms. One of these forms induces production processes to economize on the inputs used for production. If the cost of production decreases due to a shift to modern technology, the marginal cost curve shifts downward, which in turn results in the same outcome for the supply curve. In the graphic above, we illustrate the supply curve for the advanced technology by $s''(p)$. (Input prices are supposed to be at what they were as "embedded" in the initial supply curve, $s(p)$.) You can read from the graph the impact changes in the determinants of production cost will have on a firm, with respect to its willingness to supply at a predetermined price. Given the price is at $\bar{p}$ the firm produces a quantity of $\bar{x}$ in equilibrium in the situation where input prices and technology are at their "old" levels. Given that input prices are at the "new" (higher) levels but technology is as it used to be, the equilibrium quantity supplied by the firm at $\bar{p}$ goes down from $\bar{x}$ to $\bar{x}'$. On the other hand, if input prices stay at their "old" levels and cost saving technical progress is introduced, then equilibrium quantity supplied at $\bar{p}$ goes up from $\bar{x}$ to $\bar{x}''$.[42]

6.4 The Market

> As a child I'd asked my Mom why was this so? Why the trains didn't stop in Mt. Ephraim any longer?
>
> Mom laughed. "Oh, ask me! As if I'd know."
>
> Then, for Mom always pondered our questions to her, even those she couldn't answer: "I think it has to do with the economy, Nikki. 'Supply and demand.' You can ask Dad, he will know."
>
> I was reluctant to ask Dad such questions. He'd squint at me suspiciously as if, at school, I'd already learned the answer and was testing him. Or, worse, he'd provide such a long and complicated answer I couldn't make sense of it. "Supply and demand" was what it all boiled down.
>
> Joyce Carol Oates, Missing Mom, New York (Ecco/HarperCollins Publishers), 2005, p. 256

Above, we have dealt with an individual consumer and an individual firm, respectively. The market we are about to discuss is an institution that arranges the coordination of decisions of these two kinds of agents, as has been explained in Sect. 6.1. Generally, however, markets do not coordinate one firm with one consumer but many firms with many consumers. This is particularly so in case of perfectly competitive markets, which is the specific kind of market structure to which this analysis has been chosen to be confined. So in order to explain the

[42] At this general level of discussion it is not clear what happens if input prices increase and technology improves, simultaneously. Then, the "new" supply curve will shift to a position somewhere between s', and s''. Whether, compared to the "old" equilibrium quantity, $\bar{x}$, the "new" quantity increases or decreases depends upon which of the two countervailing effects prevails.

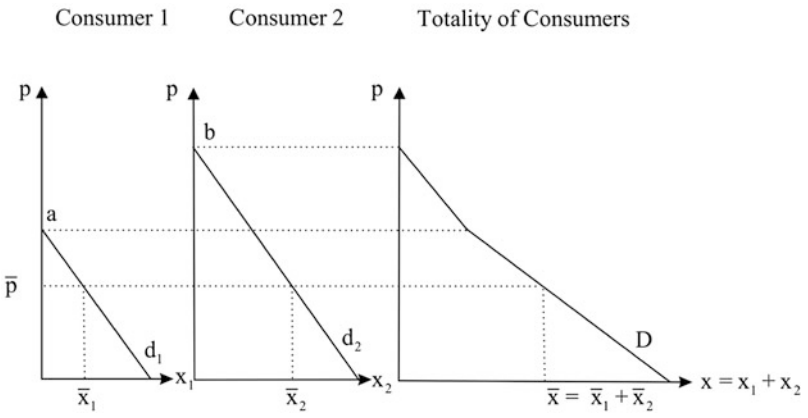

Fig. 6.7 Deriving the market demand curve by horizontal aggregation of the individual demand curves

market mechanism we must first extend the analysis of the consumer as well as the analysis of the firm from one decision maker to many.

Achieving that goal is facilitated by the fact that the analysis given for the consumer and the firm, above, was not meant to apply to one specific individual only. On the contrary, it was meant to be a general statement that respectively applies to all consumers and to all firms. Therefore, the idea of how the totality of the consumers behave in the market is generated by the idea that all the individual consumers behave as the "typical" consumer scrutinized above. The same idea analogously holds for the firm.

Let us be specific on this analytical step from one individual agent to the totality of agents of this kind and firstly address individual consumers. For those, we have explained how equilibrium demand is determined. Specifically, it was shown how the quantity of a product demanded by *an individual consumer* depends upon the price of this product, all other determinants assumed to be constant. The graphical illustration of this economic concept has been introduced as the *demand curve*. So if we want to explain how the demanded quantities of all consumers of X taken together depends on the price of X we somehow have to "add up" all the individual demand curves to arrive at the market demand curve. The market demand curve would then indicate how the quantity of a product demanded by *the totality of consumers* depends on the price of this product, all other determinants assumed to be constant. The kind of "adding up" necessary to go from the individual demand curve to the market ("total") demand curve, is done by a procedure called *horizontal aggregation,* as explained below.

For graphical simplicity we take the case where there are only two consumers constituting the demand side of the market, even though the argument is meant to apply to the case of many consumers (Fig. 6.7).

In the section on "the consumer" (6.2), we dealt with the decision of a single agent. The demand curve of this individual was labelled "*d*". Now that we extend the analysis to cover two consumers we need a somewhat extended notation. We

denote the demand curve of the first decision maker "d_1"and of the second decision maker "d_2". If we make a statement which refers to the demand curve of either of the two consumers, we write "d_i". The "i" is a general expression which might take on the form of one, or of two.[43] To distinguish the *individual* demand curve from the preceding section, dealing with one consumer only, "d", from the *total* demand curve in this section we write the latter with a capital, "D".

To understand the procedure of horizontal aggregation mentioned above, take any arbitrarily chosen price, $\bar{p}$, as an example. Given this price the demanded quantity of consumer 1 is $\bar{x}_1$ and the demanded quantity of consumer 2 is $\bar{x}_2$. You can read these individual demanded quantities from the individual demand curves of the two consumers, $d_1(p)$ and $d_2(p)$, respectively. So in order to arrive at the total demanded quantity, given the price $\bar{p}$, the individual demanded quantities must be added up. Total demand at $\bar{p}$ is $\bar{x}$ with $\bar{x} = \bar{x}_1 + \bar{x}_2$. Consequently, a point with the coordinates $(\bar{p}, \bar{x})$ is a point lying on the total demand curve, $D(p)$, for the product X.

Of course, the logic of this procedure in attaining information on the total quantity demanded does not depend on the level of the price. Instead of $\bar{p}$ we might have just as easily chosen any other price level. Accordingly, what has been said about the point $(\bar{p}, \bar{x})$ on the demand curve can be said for any other point on this curve. Generally, the total demand curve is constructed by adding up the quantity values of all of the individual demand curves for any price value. Since the quantity values to be added up are read from the abscissa, this procedure is called the generation of the total demand curve by "horizontal aggregation" of the individual demand curves.

Please note that even though the two individual demand curves in the figure are linear, the aggregate demand curve has a kink. This is due to the fact that the prohibitive price, b, of the second consumer is higher than the prohibitive price of the first consumer, a. So for prices between these two prohibitive prices, consumer 1 does not contribute any quantity demanded in the process of horizontal aggregation of the two individual demand curves. For prices between a and b, the aggregate demand curve is identical to the individual demand curve of the second consumer. It is only if the prices used for the horizontal aggregation are lower than a that positive quantities demanded by the first consumer are added to the demanded quantities of the second consumer.

Analogously, the market supply curve is derived from the individual supply curves of all of the firms operating in the market under consideration, which is also achieved by horizontal aggregation. Because of the analogy, we present only the graphical illustration, leaving comments brief.

We illustrate the supply curves of the two firms, $s_1(p)$ and $s_2(p)$. Then, we arrive at the total (aggregate) supply curve, $S(p)$, by horizontal aggregation. For each given price, the individual equilibrium supply quantities of the two firms are added up; their sum is the total quantity supplied. The combination of the predetermined

[43] In more formal terms we may write $i \in \{1, 2\}$.

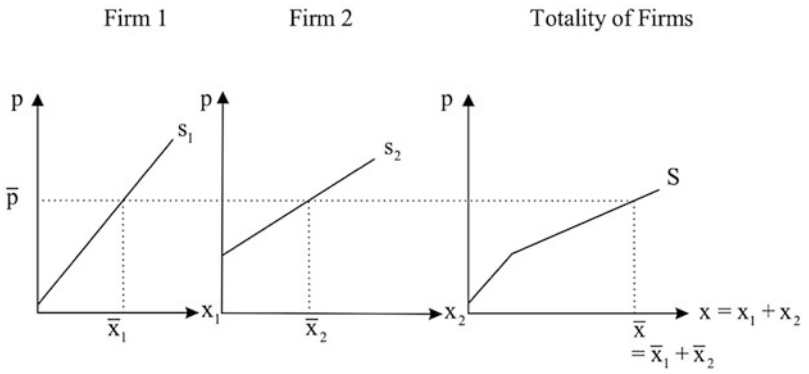

Fig. 6.8 Deriving the market supply curve by *horizontal* aggregation of individual supply curves

price and the corresponding total quantity supplied is one point on the total supply curve. Combining all of the points generated by this procedure ("drawing a line through those points in the graph") constitutes the total supply curve, $S(p)$ (Fig. 6.8).

Now we have designed all the pieces to be able to put the puzzle together. To illustrate how demand meets supply in the market, we draw the two previously derived curves, $S(p)$ and $D(p)$, into one diagram. This diagram is probably the most often drawn graphic in economics classes and textbooks.[44] Some have said that it constitutes the *totem* of the "tribe of the econ", the members of the economics profession (Fig. 6.9).

It is immediately obvious that the point where the two curves intersect requires special attention. Given the price is at p^*, the total quantity demanded and the total quantity supplied are identical to each other at x^*. In this situation the market is said to be in *equilibrium*. p^* is the *equilibrium price* and x^* is the *equilibrium quantity*. It should be recalled that the individual demand curves underlying the market demand curve and the individual supply curves underlying the market supply curve have been derived from utility maximization of each consumer and from profit maximization of each firm, respectively. Resultantly, it holds that in the market equilibrium each consumer maximizes utility and each firm maximizes profit, simultaneously. In addition, these equilibria of the individual agents are compatible with each other.[45]

To further highlight the idea of market equilibrium, let us briefly consider a situation of disequilibrium. To do so, imagine a price above the equilibrium price at, say, $\bar{p}$. Given this price, utility maximization of the consumers would lead to a market

[44] It is also one of the "famous figures and diagrams" beautifully explained in Blaug and Lloyd (2010). The authors did the right thing to put the supply and demand diagram referred to above right at the beginning of their gallery of fundamental economic illustrations.

[45] In this situation every agent is able to realize his/her plan.

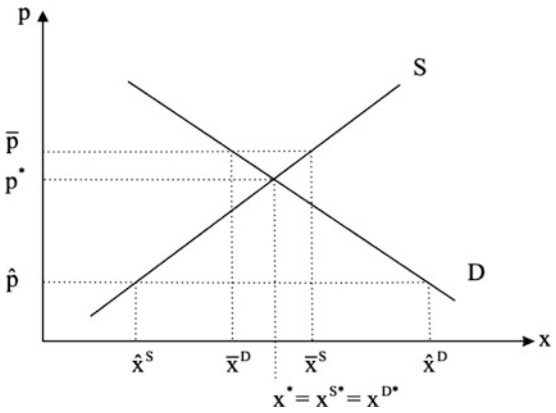

Fig. 6.9 Market equilibrium

demand of $\bar{x}^D$ units of the good under consideration. On the other hand, the production plans of all the firms would lead to a total quantity supply of $\bar{x}^S$. However, the plans of the consumers to maximize their utilities and the plans of the firms to maximize their profits are not compatible with each other, given the price is at $\bar{p}$. $\bar{x}^S$ is bigger than $\bar{x}^D$, such that firms are not able to sell $\bar{x}^S - \bar{x}^D$ units of the product at the price of $\bar{p}$. This situation in which the producers would be sitting on parts of what they would have produced is called *excess supply*. It is intuitive that a situation of excess supply might generate a downward pressure on the price, i.e., in the direction of the equilibrium price. This would stimulate the incentive to consume and simultaneously attenuate the incentive to produce, thereby narrowing excess supply. Under ideal conditions, the process would go on until equilibrium is achieved.[46]

The analogous argument holds if we observe a price below the equilibrium price, at, say, $\hat{p}$. Given $\hat{p}$, the quantity demanded in this market would be higher than the quantity supplied, resulting in a situation of *excess demand*, $\hat{x}^D - \hat{x}^S$. Here, the utility maximization and profit maximization decisions of the agents would not be compatible with each other in that the consumers would not be able to buy the quantities they are planning to, at this price. It is "plausible" that the price would increase in this situation and thereby would move into the direction of the equilibrium price. Consequently, quantities demanded go down and quantities supplied go up, narrowing excess demand (ideally) until it vanishes and thereby equilibrium is achieved.[47]

[46] Among the ideal conditions mentioned above is the requirement that all agents are fully aware of ruling prices. Moreover, it is a prerequisite that no governmental intervention prevents prices from reacting to divergences between the quantity supplied and the quantity demanded.

[47] The economic models presented above have been confined to static and comparative static equilibrium analysis. Therefore, strictly speaking, the speculations about how prices would move starting from a situation of disequilibrium violate the limits of our analysis. Therefore we intentionally use the soft term "plausible" in the passage to which this footnote refers.

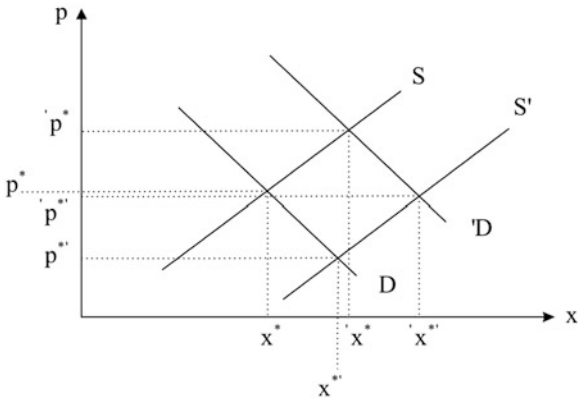

Fig. 6.10 Comparative static analysis of the market equilibrium

We have argued that it is plausible to expect the price to move towards the equilibrium price if the price is too high or too low in the initial situation, i.e., at $\bar{p}$ or $\hat{p}$ in the illustration presented above. In case this is true, the equilibrium under consideration is said to be *stable*. However, the stability of market equilibrium is not a natural law. There may be cases where actual prices are driven further away from the market equilibrium price if the starting price is not identical to the equilibrium price; in such cases, the market equilibrium is said to be *unstable*.[48]

In the main part of the analysis given above, we have commented on the market equilibrium in terms of a *static analysis* (enriched with just a glimpse at economic dynamics). Supply and demand curves did not change in the process of the analysis. However, in respectively dealing with the individual consumer and the individual firm, we previously briefly discussed *comparative static analysis*. In the case of the consumer we used an increase in income as an example to show that the demand curve might shift. In the case of the firm we used changes in the prices of the inputs to the production process, as well as advances in production technology, as two examples to show that the supply curve might shift. Of course, these insights can be transferred from the level of the individual decision maker to the level of the market. Essentially, this suggests that if the income of all consumers changes, the market demand curve shifts. If input prices change or production technology improves, for all of the firms, the market supply curve shifts. We illustrate this with the supply curve moving from $S(p)$ to $S'(p)$ and the demand curve moving from $D(p)$ to $'D(p)$ (Fig. 6.10).

You can see that the downward shift of the supply curve due to technical progress (taking the demand curve as it is, at $D(p)$) induces a decrease in the equilibrium price from p^* to $p^{*\prime}$ and an increase in the equilibrium quantity from x^* to $x^{*\prime}$. An outward shift of the demand curve from $D(p)$ to $'D(p)$ due to an increase in income (leaving the supply curve at $S(x)$) induces an increase in the equilibrium price from p^* to $'p^*$and an increase in the equilibrium quantity from x^* to $'x^*$. If we take the changes in demand and supply to occur simultaneously, i.e., we

[48] The question of the stability of market equilibria is a key topic of *dynamic* economic analysis.

assume that the supply curve shifts from $S(x)$ to $S'(x)$ and the demand curve shifts from $D(x)$ to $'D(x)$ "at the same time",[49] then, equilibrium price changes from p^* to $'p^{*'}$ and equilibrium quantity changes from x^* to $'x^{*'}$. Please note that it cannot be said in general terms whether the new equilibrium price is above or below the old one. This is due to the fact that the two changes introduced have countervailing effects. The improvement in production technology creates a tendency to bring the price down. On the other hand, the increase in income creates a tendency to drive the price up. The net effect depends upon which of these countervailing powers is stronger. Analogous reasoning holds for the effect of simultaneous changes in the demand and the supply curve on the equilibrium quantity.

6.5 Basic Issues in Welfare Economics

6.5.1 The Concept of Social Optimality

In the previous sections we dealt with the principle actors on the stage of microeconomics, consumers and firms, and with the script according to which these actors play together, the market mechanism.

This was all positive analysis: we described how individual decisions and their coordination are stylized in microeconomics. We did not ask whether the results of these decision and coordination processes are good or bad for society as a whole. In the present section we are going to consider this normative issue. Doing so we take up what we briefly touched on in the paragraph on "microeconomics as a theory of the evaluation of resource allocation" in Sect. 6.1, above. There, we promised that the idea of operationalizing the general concept of social welfare would be elaborated on in subsection 6.5.1. So now is the time to deliver!

The measuring rod with which it may be assessed what is good or bad for society as a whole is called a *social welfare criterion*. If social welfare goes up according to such a criterion, this is taken to be good for society, and vice versa.

One very popular social welfare criterion has been around for a particularly long time: it was introduced by the Italian sociologist Vilfredo Pareto (1848–1923), and to honour his contribution it is called the *Pareto criterion* in the microeconomics literature. It says that an allocation A is better than an allocation B for society as a whole if in A at least one member of society is better off than in B, and no other member of the society is worse off in A than in B.[50]

[49] We put this expression in quotes because, strictly speaking, there is no time in the model that we use here. To allow for that, we need a dynamic model but the one under consideration is static. So of any two activities it is not possible that one happens "first" and the other happens "second", nor can they happen "at the same time". However, it supports intuitive grasp on what is going on in the model if we talk about it using terms from daily "colloquial" language, even if they are not strictly appropriate.

[50] Whether the particular individual is better off in A or B is decided by this very individual. This follows from the principle of consumer sovereignty, referred to above.

Take a group of people sitting in a (class)room together. The group in this little example substitutes for "society" in the general exposition given above. The window in the room is closed, which we notate as allocation A. Now consider changing to allocation B, which is identical to A, except for the window being open. If, in the first situation, some members of the group (at least one of them) want the window to be opened and no one objects, it is a Pareto improvement to open the window (to go from A to B).

Developing the idea a little further, this criterion does not only allow us to say which one of two alternative allocations is better for society as a whole. In addition, it allows us to identify allocations which cannot be improved from the point of view of society as a whole. An allocation which cannot be improved in this sense is called *Pareto optimal*. In a Pareto optimal allocation it is not possible to introduce any change by which the utility of at least one member of society is increased without making any other member of society worse off.

According to the experience of the authors, the Pareto criterion is plausible and acceptable to most people. Of course, students with whom we discussed the acceptability of the Pareto criterion are not representative of the world population (and the students of other economists who had the same experience aren't either). Still, the acceptance that we have observed is not very surprising. After all, there are similarities between deciding whether a certain reallocation of resources is an improvement for society as a whole according to the Pareto criterion and to deciding this issue by unanimous vote: if, as a result of a certain reallocation, some people would enjoy higher utility levels and no other people would suffer from a deterioration in their utilities, then you might expect that the people who would benefit from the change would vote in favour of the reallocation and others would not vote against it, say abstain.[51] However, it must be conceded that the Pareto criterion is not "value free". After all, the criterion implies that the welfare of society is nothing more than the welfares of the individual members of society. This value judgement is called *normative individualism*, in economics. Even though this is quite a common perception, you cannot prove anybody wrong who believes otherwise.

The fact that the Pareto criterion is widely (even though not "mandatorily") accepted is one of its advantages. On the other hand, the criterion is not very powerful in its ability to help societies make decisions between alternative allocations. This is so because an awfully high number of allocations meet the criterion of Pareto optimality.[52] Without referring to complicated proofs, this is intuitively clear when you recall the analogy between the Pareto criterion and unanimous voting. There are very many situations from which it is impossible to deviate by a unanimous decision of the members of the society under consideration. All of these situations are Pareto optimal.

[51] The assumption underlying this expectation is that each individual votes according to his/her own self interest. This implies that the people who are not affected by the reallocation do not envy the ones who benefit.

[52] Strictly speaking there are an infinite number of allocations. See intermediate microeconomics textbooks for deeper analysis. Examples are Eaton et al. (2011), Varian (2010).

To illustrate the point from our earlier example, imagine a situation where the group enters the classroom and the window is closed, i.e., the starting situation is *A*. It might happen that at least one member of the group wants the window to be opened but there is at least one other member of the group objecting. Then, the starting situation with the closed window is Pareto optimal. Obviously, it is not possible to change the situation and make at least one member of the group better off without making another member of the group worse off.

Alternatively, imagine the group entering the room and finding the window open (starting at situation *B*). It is not contradictory to the story told above that at least one member of the group wants to have the window closed but at least one other member objects. If this is the starting situation, it is Pareto optimal because you cannot go from *B* to *A* making at least one member of the group better off without making at least another member worse off. Our example therefore illustrates a case where the choice is between two allocations that are both Pareto optimal. Obviously in such a situation the Pareto criterion is not a very helpful social decision rule.

There have been attempts to broaden the set of situations which can be ranked according to their social desirability by modifying the Pareto criterion. The essence of these approaches is that we take a look at reallocations from which some members of society gain and others loose. There, the winners would vote in favour of the reallocations and the others would vote against it. So the change under consideration could not be assessed using the Pareto criterion. To overcome this problem you would look at *how much* the people who benefit from the change would win and *how much* the people who suffer would loose. According to the *Kaldor-Hicks criterion,*[53] the change would be a social improvement if what the people benefiting won would be enough to compensate the losers and still leave a positive net improvement for the ones who would benefit from the change in the first place. Please note that, according to this criterion, it is not a prerequisite that the compensation actually takes place. All that is required for the reallocation to qualify as a social improvement is that compensation is possible. (If the compensation does, indeed, take place we are back to the original Pareto criterion.) Therefore the Kaldor-Hicks criterion is often termed a criterion of *potential* Pareto improvement.

A related approach to assessing the desirability of alternative allocations from the point of view of society is the *social welfare function*. This one comes in different variants.

The most simple type is the *utilitarian social welfare function*. Here, the welfare of society is defined as the sum of the utilities of the members of society. All of these individual utilities contribute to social welfare with the same weight. A generalization of this simple concept of aggregation is the *Bergson-Samuelson welfare function*.[54] Here, social welfare is the weighted sum of individual utilities.

[53] Nicholas Kaldor (1908–1986), British economist; John R. Hicks (1904–1989), British economist, Economics Nobel Prize 1972.

[54] Abram Bergson (1914–2003), US-American economist; Paul E. Samuelson (1915–2009), US-American economist, Economics Nobel Prize 1970.

This creates some leeway for societal welfare judgements. For example, the utilities of the "weaker" members of society might enter into the aggregation with a higher weight. Obviously, the Bergson-Samuelson welfare function contains the utilitarian welfare function as a special case – the one where all the weights are equal to 1. An obvious problem is that defining the weights is difficult and opens up considerable room for all kinds of discrimination. A third prominent type of a social welfare function is the one designed by the US-American philosopher John Rawls (1921–2002) in his monumental work "A Theory of Justice" (1971). Here, social welfare is determined by the utilities of those members of society who are worst off, only. As you might already have suspected, this special view of justice has been highly controversial in the literature.

Comparing the Pareto criterion to the social welfare function approach, we might note that it is an advantage of the latter that all alternative allocations can, in principle, be ranked according to their social desirability. Conceptually it is thereby possible to identify a unique socially optimal allocation (provided it exists). This implies the possibility of arriving at very definite suggestions as to where a society should move. As we have argued above, this is impossible using the Pareto criterion. However, as very often in life, "there is no such thing as a free lunch": using the social welfare function approach we have to pay a price for enjoying the described advantage. We must assume that we can cardinally measure the utilities of all the individual members of a society in the same dimension. Consider the utilitarian welfare function as an example. In order to add up all the individual utilities to arrive at a number for social welfare, it must be possible to measure utilities just as you measure distances in yards or metres. The problem is (and this is a considerable problem, indeed) that such a quantitative measure of the utilities of different people does not exist.

You might suppose that, in light of this impossibility, microeconomists would have given up on the idea of a social welfare function. Far from it! Microeconomists do not give up that easily. Instead, they have been looking for a measuring rod which might be substituted for the unattainable goal of measuring utility cardinally. What microeconomists have come up with is *willingness to pay*. Willingness to pay certainly meets the requirement of being quantifiable cardinally in one and the same dimension for different individuals. This dimension is money. Also, there is certainly a strong positive correspondence between the utility an individual expects to derive from a certain reallocation (e.g., by receiving a certain commodity) and his/her willingness to pay for this reallocation. For most people the willingness to pay for a certain good increases with the level of utility they expect to attain by consuming the good. However, even though they are closely related to each other, utility and willingness to pay are not the same. This is so because the willingness to pay not only depends on the preferences of an individual but also on the *ability to pay*, i.e., the size of the budget the individual has at his/her disposal. A wealthy person can articulate his/her utility much better in terms of willingness to pay than a poor person. So if aggregate willingness to pay is used as a proxy for social welfare, this basically applies the Bergson-Samuelson type of welfare function in a specification where the weight with which the utility of an individual enters the social welfare function increases with the income of this individual. This type of a social

welfare function is suggestive only in societies where there is a consensus that the income distribution is (well, more or less) just.[55]

Imagine that in a society there is a distribution of income that is understood to be just in a pragmatic sense. This does not mean that everybody in this society is happy with the distribution. It would be compatible with our understanding of a distribution "being just in a pragmatic sense" if most people thought that the effective distribution was somewhat unfair, in the sense that they themselves should have received a little more and the others a little less. However, the effective distribution is the result of market allocation and subsequent redistributional government policy. The redistributive activities of the government like progressive income taxation, the social welfare and education systems, and others have been decided upon by a democratic process. In light of this democratic legitimization it can be said that the society agreed upon accepting a certain distribution, even if some members of the society might have done so with clenched teeth. In such a situation it might be reasonable to use aggregate willingness to pay as a proxy to social welfare – unless you can come up with something better. This is then a powerful tool for evaluating different allocations according to their social desirability.

Armed with what we have just said, we are able to assess the results of individual decision making and its coordination from the point of view of society as a whole. This is what we do in the following subsection, applying the concept of social optimality which has just been operationalized to the performance of consumers, firms and the market mechanism, which were explained in the previous sections.

6.5.2 The Social Optimality of an Ideal Market Economy

6.5.2.1 Socially Optimal Output

In Sect. 6.4, above, we conducted a strictly *positive* analysis characterizing the equilibrium quantity, x^*, of an arbitrarily chosen good, X, which is provided in a perfectly competitive market. In subsection 6.5.1, above, we conducted a strictly *normative* analysis, pondering the concepts of social welfare and social optimality. Now we put the pieces together, and assess the social welfare properties of the perfectly competitive output quantity. Applying the concept of social optimality to the problem of what quantity of a certain good should be produced leads to the idea of the quantity that maximizes social welfare. The social welfare of production is the benefit this production yields for the consumers minus the opportunity costs of the resources used to produce the quantity of that good. Using this operationalization of the idea of social welfare, we heavily rely on the concept of *willingness to pay*, explained in the previous section.

[55] The understanding of what fairness (justice) is varies over time and across societies with different cultural backgrounds.

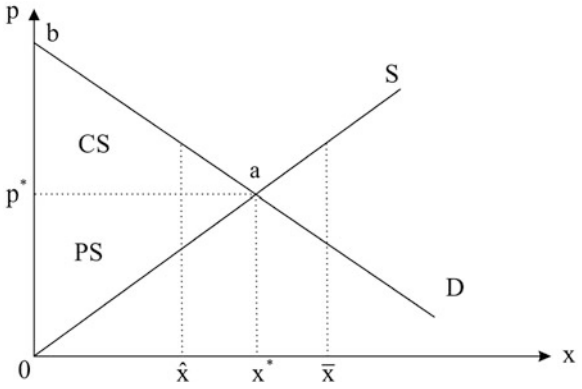

Fig. 6.11 Socially optimal and perfectly competitive level of production

It is plausible that these two elements, consumers' benefits and opportunity costs, are exactly the driving forces identified above as constituting the equilibrium of a perfectly competitive market.

The benefits to consumers are "caught" in the demand function. This is so because a monetary measure for these benefits is the willingness to pay of consumers. As has been explained in Sect. 6.2, marginal willingness to pay can be read off the inverse demand curve. So given that the ordinate value of each point on the inverse demand curve shows the willingness to pay for the last ("marginal") unit consumed, then the area under the demand curve illustrates total willingness to pay, i.e., the benefits from consumption.

Analogously, it can be argued that the inverse supply curve illustrates the opportunity costs of the resources used up by the production. This is so because the inverse supply curve is generated from the marginal cost curves of the individual firms. So at each point the ordinate value of the inverse market supply curve represents the production cost of the last ("marginal") unit produced. Accordingly, the area under the inverse supply curve is the total cost of the resources used for production (ignoring fixed cost).

Following the goal of social welfare maximisation, production of any unit under consideration is warranted if marginal willingness to pay is at least as high as marginal production cost. In the terminology of the graphical illustration used in this text, such as in Fig. 6.11, this means that the production of a certain unit of X is socially warranted if the ordinate value of the inverse demand curve is at least as high as the ordinate value of the inverse supply curve. This criterion for the social desirability of a certain unit of X is met for all the units between 0 and x^*, the level of output at which demand and supply curves intersect. This is exactly the perfectly competitive equilibrium. Take any other unit of production (say, $\bar{x}$, where $\bar{x} > x^*$), as indicated in the figure. For this quantity the benefit to the consumers is lower than the value of the resources used to produce this unit. In $\bar{x}$, the inverse demand curve is below the inverse supply curve. Therefore, this unit should not be produced

according to the criterion of social welfare maximization. Indeed, it is not produced in the perfectly competitive equilibrium.

On the other hand, if production would be at a level of $\hat{x}$, smaller than x^*, then the production of the last unit would be socially warranted. However, the possibility of increasing social welfare would not be exhausted. This is because between $\hat{x}$ and x^* there is plenty of room to produce units of the product for which the marginal willingness to pay is above marginal production cost. In the figure, the level of social welfare generated by the optimal and equilibrium production x^* is illustrated by the area between the inverse supply and the inverse demand curves, within the limits of 0 and x^*. This is the area $0ab$.

In the figure, you can also read how the social welfare generated is shared between consumers and producers. The total benefit enjoyed by the consumers from the socially optimal and perfectly competitive quantity x^* is measured by the area under the inverse demand curve within the limits of 0 and x^*, the area $0x^*ab$. However, to get hold of x^* in the market, consumers must pay the equilibrium price, p^* for each unit of the product. As a result, they spend a sum equal to p^*x^*, illustrated by the area $0x^*ap^*$ in the figure. Of course, this reduces their overall benefit. The net benefit they receive is the willingness to pay minus the sum actually paid, i.e., an amount of money represented by the area under the inverse demand curve and above the horizontal price-line within the limits of 0 and x^*, p^*ab. This net benefit the consumers gain from consumption is called *consumer surplus* ("*CS*" in the figure).

A similar argument can be made for firms. The benefit of producing is the revenue they attain in the market. What they get is identical to what the consumers pay (this is particularly so in the present model, since there is no one collecting taxes). Ergo, in the illustration, the benefit to the producers is p^*x^*, the area $0x^*ap^*$. On the other hand, the producers must pay for the scarce resources they use in the production process. This amount of money is illustrated by the area under the inverse supply curve between 0 and x^*, i.e., by $0x^*a$. The net benefit to the producers is graphically represented by the area between the horizontal price line and the inverse supply curve between 0 and x^*, i.e., by $0ap^*$. This net benefit is called *producer* surplus ("*PS*" in the illustration).

Consumer surplus and producer surplus add up to the social welfare generated by production. You might as well call the latter "social surplus". Consequently you might also say that in a perfectly competitive equilibrium the quantity produced is socially optimal, since for this quantity the sum of consumer and producer surplus is maximized.

The result that the equilibrium of a perfectly competitive economy is socially optimal (as far as shown here: in terms of output levels) is of utmost importance for economic theory. The result is therefore terminologically knighted with the expression "the first fundamental theorem of welfare economics".[56]

[56] Obviously, there would not be a "first" theorem if there were no "second" one (and possibly others). However, to discuss this would lead us astray from the convenient pathways of our

The result is somewhat surprising. After all, there is no economic agent in the model striving for social welfare maximization. On the contrary, each of the agents under consideration is exclusively interested in his/her own welfare. This individual welfare takes the form of utility in the case of a consumer and of profit in the case of a firm. Instead of being attained by the activities of a superior actor, e.g., a "social planner" the result is attained by the "invisible hand" of the perfect market guiding the individual actors.[57]

Moreover, the allocative mechanism of the perfectly competitive market does not need an outrageous amount of information to do the *Herculian* job of producing socially optimal equilibria. All that is required is that each individual actor knows the market prices of the goods under consideration (commodities, services, and productive inputs) and their qualities. Additionally, actors who are consumers need to know their preferences and budgets. Actors that are firms need to know production technology. It is worth noting that no individual consumer is required to know the preferences of any other consumer or the technology of any firm. No individual firm is required to be informed about the technology of any other firm or about the preferences of any consumer.

If the task of producing socially optimal output would have to be fulfilled by a central planning agency, this agency would have to look behind the foreheads of all the consumers to learn about their preferences and behind the walls of the firms to learn about technology. Certainly, the consumers and the firms would stage some resistance against this.

6.5.2.2 Cost-Effective Inter-firm Allocation

What we said above on the social optimality of equilibrium output in a perfectly competitive economy is what you generally see in introductory economic textbooks. Fine. However, the authors of the present text just love to coddle their readers. So here is an additional and somewhat more subtle argument contributing to a deeper understanding of the welfare properties of perfectly competitive equilibria. It will turn out to be useful when we consider the economics of environmental policy in Sect. 7.2, below.

We have argued above that a prerequisite for a firm to achieve its goal of maximizing profits is that it minimizes cost. This follows from the definition of profit as the difference between revenue and cost. No matter how much a firm decides to produce, without cost minimization there is no profit maximization. If a given quantity of a good is produced at minimum cost, production is said to be *cost-effective*.

This kind of reasoning can be transferred from the individual firm to society as a whole. As we have discussed above, a standard assumption in microeconomics is

introductory exposition. See, e.g., Estrin et al. (2008), pp. 468–476, Perloff (2007), pp. 318–321, Varian (2010), pp. 601–606.

[57] The *invisible hand* is a "crossover word" going right back to the cradle of modern economics, the work of Adam Smith (1776).

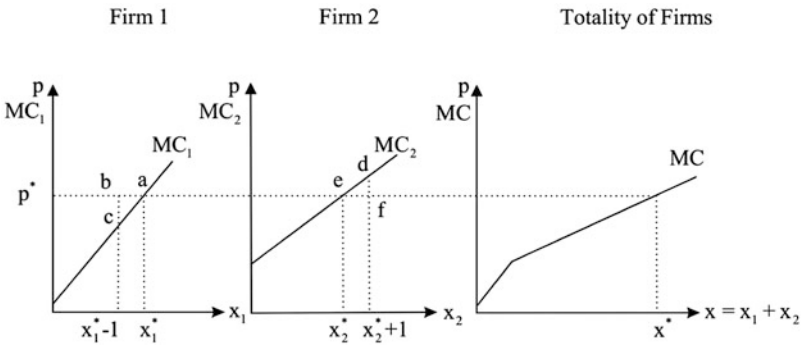

Fig. 6.12 Cost-effective inter-firm allocation

that society strives for welfare maximization. Welfare is defined as the difference between aggregate consumer benefit and aggregate cost.

A prerequisite for social welfare maximization is that the costs of production (represented in the inverse supply function in marginal terms) are minimized.

On the level of the individual firm this is no problem since each firm is interested in cost minimization, as has been explained above. However, the market supply curve is generated from individual supply curves by a special procedure: horizontal aggregation.[58] The question is whether this procedure satisfies the requirement of cost minimization. Wouldn't it be possible that the market mechanism makes the individual firms contribute to total supply in a manner that violates the cost minimization principle? Wouldn't it be possible to "assign" shares of total output to the individual firms where those shares are different from the distribution as generated by the market mechanism and in doing so arrive at the production of total output at lower cost?

We use Fig. 6.12 to illustrate.

Assume the equilibrium market price is at p^*. Then, equilibrium total supply is at x^*. To this total quantity, firm 1 contributes x_1^* and firm 2 contributes x_2^* units, where $x_1^*+x_2^* = x^*$ holds. However, (x_1^*,x_2^*) is just one of indefinitely many inter-firm allocations of the total supply of x^*. $(x_1^* - 1,\ x_2^* + 1)$ is an alternative allocation which sums up to exactly the same level of aggregate output, x^*. A question is whether the allocation (x_1^*,x_2^*) brought about in the perfectly competitive market equilibrium is the cost minimizing allocation.

Yes, it is!

To see why, we make a comparison between the cost of producing x^* with firm 1 contributing x_1^* and firm 2 contributing x_2^* with the cost of producing x^* with firm 1 contributing $x_1^* - 1$ and firm 2 contributing $x_2^* + 1$.

You can do that by staging a little thought experiment: imagine the allocation is (x_1^*,x_2^*) and you figure out that the total cost of producing x^* can be reduced by

[58] That's exactly what we did in Sect. 6.4, above. See Fig. 6.8.

changing the allocation to $(x_1^* - 1,\ x_2^* + 1)$. If total cost decreases as a consequence of this reallocation, then – gotcha! – the market equilibrium (x_1^*,x_2^*) cannot be a cost minimizing allocation.

So what are the consequences of going from (x_1^*,x_2^*) to $(x_1^* - 1,\ x_2^* + 1)$ in terms of total cost?

The cost reduction at firm 1 due to the decrease of this firm's production from x_1^* to $x_1^* - 1$ is illustrated by the area under the marginal cost curve of firm 1 between $x_1^* - 1$ and x_1^*, i.e., by the area $(x_1^* - 1)x_1^*ac$.

To compensate for the unit less produced by firm 1, in terms of the level of total output, firm 2 has to produce one unit more. The additional cost is illustrated in the figure by the area under the marginal cost curve of firm 2 within the limits of x_2^* and $x_2^* + 1$, i.e., by the area $x_2^*(x_2^* + 1)de$.

Obviously, the amount by which the costs of firm 2 increase is higher than the amount by which the costs of firm 1 decrease. Thereby, the sum of the costs the two firms have to bear, producing an aggregate quantity of x^*, increases by an amount graphically illustrated as the sum of the two triangles *abc* and *def*.

Deviating from the market equilibrium inter-firm allocation (x_1^*, x_2^*) to the alternative allocation $(x_1^* - 1,\ x_2^* + 1)$ would increase the cost burden society has to bear for the benefit of producing x^*. Therefore, the reallocation that we have considered would fail the cost-effectiveness test. Of course, we have analyzed only one of indefinitely many possible deviations from the market equilibrium inter-firm allocation. However, the principle that we used in discussing this example is perfectly general. Starting from the market equilibrium allocation you can take any reallocation. You will find that the result is always the same. Deviating from how the perfectly competitive market "assigns" the shares to which individual firms contribute to total equilibrium supply increases the burden society has to bear for the sake of production. So the inter-firm allocation of total output, as "arranged" in the perfectly competitive market equilibrium, is cost-effective. Thereby, an important prerequisite for social welfare maximization is met in equilibrium.

The deeper reason for the result graphically illustrated above, is that given that marginal cost curves are increasing, it is a property of the cost minimizing allocation that the marginal costs of different firms are equal to each other. The "trick" of the perfectly competitive market is that in its equilibrium this property of cost minimization is met. The mechanism that guarantees this is profit maximization, while also influential is the fact that an individual firm has no command over the level of the market price under perfect competition (and that this market price is identical for all of the firms producing the same good).

As we have argued in the preceding section (on the firm), a firm (let's call it "i") maximizes profit by choosing to produce the level of output for which its marginal cost is equal to the market price, $p^* = MC_i$.[59] This is true for each of the firms supplying in the perfectly competitive market. Since the market price is the same

[59] In our 2-firms-example, "i" might take the values of 1 or 2. Some highbrows might write $i \in \{1, 2\}$.

for all of these firms, marginal costs are identical across firms, in the competitive equilibrium. So $MC_i = MC_j$ holds for any pair of firms.[60] The equality of the marginal costs of the firms is a requirement for cost minimization and is simultaneously a feature of the perfectly competitive equilibrium.

Calculus Club: Session 3

The problem of cost-effective inter-firm allocation of a predetermined quantity of aggregate production, $\bar{x}$, has been dealt with above using verbal and graphical analyses. It can be laid out in formal terms as follows:

The objective is to minimize total production cost, $C(x)$, which is defined as the sum of firm-specific production costs, $C_1(x_1)$, $C_2(x_2)$. We do this for two firms here without any loss of generality. The formal expression of this cost minimization problem is

$$C = C_1(x_1) + C_2(x_2) = \min!$$

Production cost minimization is subject to the requirement that output produced by the two firms, x_1 and x_2, adds up to an aggregate output of $\bar{x}$. So the minimization has to be done under the constraint of

$$x_1 + x_2 = \bar{x}.$$

Consequently, the Lagrange function is

$$L = C + \lambda(\bar{x} - x_1 - x_2) = \min!$$

Writing the first order derivative of the total cost function, the marginal cost function, as MC, the first order conditions are

$$\begin{aligned} \partial L/\partial x_1 &= MC_1 - \lambda = 0 \\ \partial L/\partial x_2 &= MC_2 - \lambda = 0 \\ \partial L/\partial \lambda &= \bar{x} - x_1 - x_2 = 0 \end{aligned}$$

$$\rightarrow MC_1 = MC_2.$$

So the necessary condition for the cost-effective inter-firm allocation we are looking for is that marginal production costs are equal across firms.

Since the second cross dervivatives equal zero, the second order conditions are

[60] If "i" is one of the two firms in our example, "j" is the other one.

$$\partial^2 L/\partial x_1^2 = \partial MC_1/\partial x_1 > 0$$
$$\partial^2 L/\partial x_2^2 = \partial MC_2/\partial x_2 > 0\cdot$$

Accordingly, the extreme value characterized by the first order condition is indeed a minimum if it is located in the increasing parts of the two marginal production cost curves. Since, for simplicity, we assumed the marginal production cost curves to be monotonously increasing, above, this second order condition is always met.

6.5.2.3 "Benefit-Effective" Inter-consumer Allocation

Above, we have compared the cost-effective inter-firm allocation of a given level of aggregate production to the perfectly competitive inter-firm allocation. The result of the analysis is that they are identical.

Obviously, an analogous question can be posed regarding the manner in which a predetermined quantity of aggregate production is allocated to the consumers. What would be the "right" way to share total production among the consumers of the economy under consideration and how does this "right" scheme relate to the perfectly competitive scheme?

It may not be immediately clear what is meant through the nobly termed criterion for the allocation among consumers of "right". Every reader might have his/her attitudes and thoughts about this question. However, in the present context we are not dealing with personal attitudes and thoughts but with microeconomic theory.[61] Indeed, microeconomics offers an answer to this difficult question. All we have to do in order to find out is to be consistent with the general concept of social welfare maximization. Above, social welfare has been defined as the difference between aggregate willingness to pay and opportunity cost. We used this definition above to find out about the "right" inter-firm allocation of a certain aggregate production. There, the focus was on the cost side of the social welfare definition. In the present context, where we deal with the "right" allocation of a certain aggregate production among the consumers, we proceed analogously by focusing on the side of aggregate willingness to pay. Consequently, the "right" allocation among the consumers is the one that maximizes aggregate willingness to pay for the given production level because willingness to pay is a measure of the benefit from consumption.[62] With reference to the terminology used with regard to firms, terming the "right" inter-firm allocation as cost-effective, we call the inter-consumer allocation generating maximal aggregate benefit as a "benefit-effective" allocation.

[61] Nevertheless, every reader is cordially invited to compare his/her own attitudes and thoughts with microeconomic wisdom.

[62] However, we remind our cherished readers of our discussion of the caveats of this concept, as presented above.

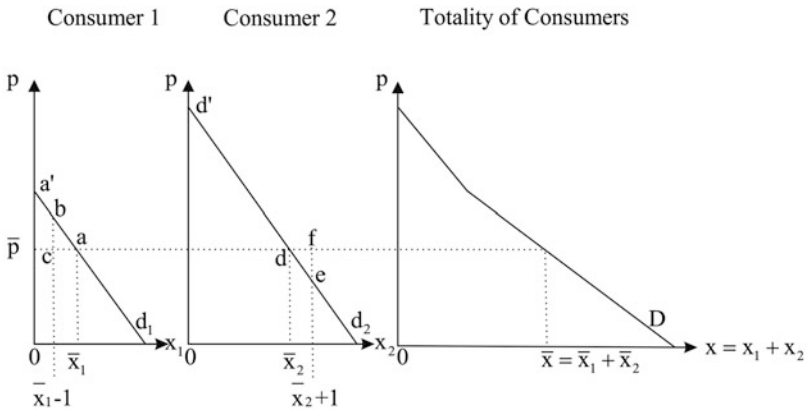

Fig. 6.13 "Benefit-effective" inter-consumer allocation

Also in perfect analogy to what has been said for the firms, above, the benefit-effective allocation is characterized by the requirement that marginal values for the agents under consideration have to be equal to each other. With regard to firms, these marginal values have been shown to be marginal costs. With regard to the consumers, it's each consumer's marginal willingness to pay for the good under consideration that has to be equal in the benefit-effective situation. To see this, take a look at Fig. 6.13.

Here an inter-consumer allocation is shown where the aggregate production quantity, $\bar{x}$, is shared among the two consumers in that consumer 1 receives a quantity of $\bar{x}_1$ and consumer 2 receives $\bar{x}_2$.[63] The benefit a consumer derives from consumption is measured by the area under the inverse demand curve in the relevant range. In the situation described above, the benefit to consumer 1 is illustrated by the area under the inverse demand curve d_1 within the limits $0\bar{x}_1$, i.e., by the area $0\bar{x}_1 aa'$. Analogously, the benefit of consumer 2 is illustrated by the area $0\bar{x}_2 dd'$.[64] It can be shown that this allocation, characterized by the marginal willingness to pay of the two consumers being identical to each other, generates the maximum benefit that can be "squeezed out" of total production, $\bar{x}$. To demonstrate this, follow the analytical line of reasoning explained above. You can show that aggregate benefit for the two consumers decreases if you deviate from the aforementioned allocation. As an example for such a reallocation let consumer 1 have one unit less and consumer 2 one unit more. Then, track down the consequences of this reallocation in terms of aggregate benefit. It is easy to see that what consumer 2 gains from having one unit

[63] Please remember that the total demand curve shown in Fig. 6.13 is the horizontal aggregation of the two individual demand curves shown in this figure. The procedure has been explained in Sect. 6.4, above, using Fig. 6.7.

[64] Please avoid a notational trap here: do not confuse the points on the demand curve, denoted "d", "d'", with the demand curve labelled $d_2(x_2)$

more is less than what consumer 1 loses from having one unit less, in terms of benefits. The total decrease in the aggregate benefit due to the reallocation under consideration is illustrated by the sum of the areas *abc* and *def* in Fig. 6.13.[65]

By taking any other reallocation starting from $\bar{x}_1$, $\bar{x}_2$, the result will be, in principle, the same: aggregate benefit goes down. So the "golden rule" for allocating a given amount of production among the consumers is to do it in a way that ends up with the consumers having identical marginal willingness to pay.

Obviously, this requirement is met by the perfectly competitive allocation. There, the equilibrium is characterized by the fact that each consumer buys a quantity at which his/her marginal willingness to pay equals the market price, and this price is the same for all the consumers. Accordingly, marginal willingness to pay is the same across consumers in equilibrium. From $\bar{p} = MWP_1$ and $\bar{p} = MWP_2$, $MWP_1 = MWP_2$ follows, where MWP stands for the marginal willingness to pay.

6.5.3 Market Failure

In the previous subsection we praised the social welfare properties of a perfectly competitive market. This kind of market is a useful analytical and didactical tool. However, it does not adequately represent the world in which we live. Instead, there are many systematic deviations between the assumptions underlying the perfectly competitive market model and what we have to cope with in the real world.[66] By introducing the concept of perfect competition in Sect. 6.3, we have already alluded to the fact that a market structure assuming that the individual firm does not have any control over the price of its product can only partly explain what is going on in real markets. Therefore, there has been considerable attention in microeconomics given to how the equilibria in markets with different structures, like monopoly and oligopoly, are constituted and what can be said about their social welfare properties. Another issue is that the perfectly competitive model requires that the agents acting in the market are very well informed, particularly about the quality of the products under consideration. In reality, however, it is very often much easier for the producers to find out about the properties of products they sell than it is for consumers to find out about what they buy. This *asymmetric* information distribution between consumers and

[65] This can be disentangled by an exercise in "geometrical accounting": by the consumption of the additional unit, consumer 2 gains a consumer surplus illustrated by the area $\bar{x}_2(\bar{x}_2 + 1)ed$. This is equal to the area $\bar{x}_2(\bar{x}_2 + 1)fd$ − the area def. Consumer 1, consuming one unit less loses consumer surplus illustrated by the area $(\bar{x}_1 - 1)\bar{x}_1ab$. This is equal to the area $(\bar{x}_1 - 1)\bar{x}_1ac$ + the area abc. So the change in total consumer surplus is illustrated by $\bar{x}_2(\bar{x}_2 + 1)fd - def - (\bar{x}_1 - 1)\bar{x}_1ac - abc$. Since the areas $\bar{x}_2(\bar{x}_2 + 1)fd$ and $(\bar{x}_1 - 1)\bar{x}_1ac$ are identical to each other, the total change in consumer surplus is $-def - abc$.

[66] Just one of the advantages of the perfectly competitive market model is that it provides a theoretically sound background against which many real world phenomena can be contrasted and analysed. Specifically, microeconomics investigates how equilibria and their social welfare properties are affected if we deviate from the assumptions underlying perfect competition.

producers has considerable consequences for the nature of market equilibria and their social welfare properties. These kinds of problems and how to cope with them is the focus of a special division of microeconomics: the economics of information.

Closer inspection reveals that market equilibria lose the amazing feature of being socially optimal if we deviate from the ideal market model sketched in the previous section, and allow for "distortions" such as market power and asymmetric information. Economists are often said to be brainless followers of the "free market ideology". Well, maybe some are (even though we hope it isn't true *at all*). Anyway, most of them are being strict judges: if markets do not meet the ambitious goal of producing socially optimal equilibria, then they are said to fail. *Market failure* is a key topic in microeconomics.

However important these and other issues may be for microeconomics and for the way markets operate in the real world, they are not at the core of our analysis. This is so because the concept of this book is to focus on problems directly related to the environment. Indeed, there is a deviation in real world markets from the framework of a perfectly competitive economy which is far more consequential for environmental problems, environmental policy, and the economic analysis of these issues than are the issues of market power and imperfect information. It is to this issue that we turn to for the remainder of this subsection: market failure generated by *externalities*.

The key to understanding this problem is that in the model of the perfectly competitive market, as sketched above, there are no agents other than consumers and firms. Moreover, all the relationships that exist between these agents are mediated by the market. Individuals interact with each other solely based on the price mechanism.

Obviously this stylisation is completely inappropriate if environmental issues are taken into consideration. Most of the effects that human activities have on the quality of air, water, soil, and biodiversity are not mediated by the market mechanism. Nevertheless, these natural resources are scarce. Consequently they should be at the core of economic analysis dealing with all forms of scarcity, be they recognized by the market mechanism or not.

This has important consequences for microeconomic analysis and for the social optimality of the market mechanism in particular. To see this we allow a third type of economic agent to enter the stage of microeconomic modelling, which has so far exclusively been occupied by consumers and firms. Somewhat ironically, we might call the third agent to be "the breather". Just as the traditional consumer, this agent wants to enjoy the consumption of a certain good but the object of his/her desire is not sold in the market place: Instead, it is clean air.[67]

[67] In reality, the breather is obviously not a third type of an agent. All individuals have to breathe, consumers and producers alike. So the different types of agents described in the economic model represent different roles that one and the same individual might take on. Of course, one individual playing more than one role, simultaneously, might also apply in the simple model that allows for consumers and firms only. All the individuals that act as producers are also consumers, although the opposite does not necessarily hold.

If the quality of the air deteriorates, the utility of the breather decreases. If the deterioration of air quality is a result of productive activity, the decrease in the utility must be counted as an opportunity cost of production. Using up clean air is a cost in economic terms, just as with using up any other scarce resource. Of course, to evaluate the worth of the clean air lost by production is more difficult than to evaluate the use of labour and capital. Regarding the latter, the prices for these productive factors in competitive markets are usually accepted as representing these values.

Regarding the utility individuals lose due to air quality deterioration, the same problems arise as those that were discussed when we dealt with the utility consumers derive from the consumption of commodities and services, as in Sect. 6.2, above. Consequently, the pragmatic idea to solve this problem is also the same: in microeconomics, the willingness to pay for clean air is taken to be a proxy for the utility people derive from clean air.[68] Please do not confuse this concept with the idea that people should have to pay for clean air. The former idea is not this kind (or any other kind) of policy recommendation, but a concept of evaluation. From the point of view of microeconomic analysis, it is a very welcome property of this concept of evaluation that it measures the utility from air quality (and the disutility from losing this quality) in monetary terms. This is a distinct advantage because the cost of reducing air quality can be added to other costs of production and can be therefore compared with the utility of production, which is also measured in monetary terms using the willingness to pay concept explained above.

Of course, what has been elaborated for the example of the utility loss the breather suffers if air quality deteriorates can be generalized to all environmental resources used up by human activity.

In general terms, we talk of *environmental damage* to denote all environmental resources which are used up (or the quality of which is reduced) by economic activity, irrespective whether what is affected is air, water, soil, or biodiversity. If we apply the willingness to pay concept to physical environmental damage, as briefly explained above, we arrive at a monetary number for environmental damage. When you read the expression "environmental damage" in economic texts, it usually refers to the monetary expression.

Just as has been done with the willingness to pay of consumers and the marketable resources used by the firms, microeconomics works with the assumption that the level of environmental damage relates to the level of economic activities and that this relationship can be expressed in terms of a mathematical function. In introductory economic essays like this one, these functions are presented in the simplified form of two dimensional graphs.

[68] An alternative measure would be the amount of money necessary to compensate the people for a certain loss in air quality. There has been a lot of discussion in the environmental economics literature about the relationship between these two evaluation methods: willingness to pay and the requirement to be compensated. See, e.g., Tisdell (2010). A particularly critical view is taken by Hahnel (2011).

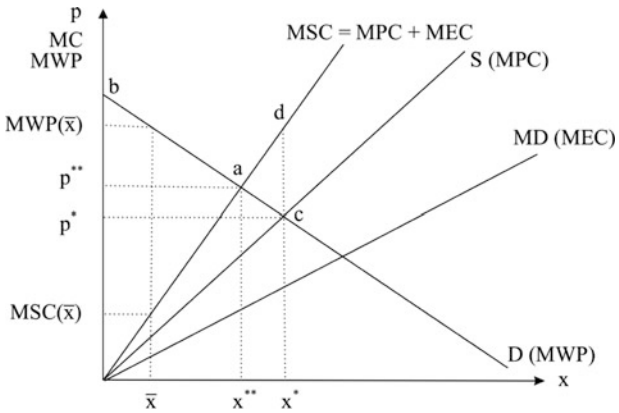

Fig. 6.14 Market failure due to negative externalities

To make things most easy, for a start, we assume that production generates emissions proportionate to the level of output. This means that for any unit of the good X produced, a constant amount, a, of a certain pollutant, E, is emitted. So the relationship is $e = ax$, where $e$is the level of pollution of type E emitted, and a is constant. These emissions generate environmental damage, D, depending on their level.[69] As has been explained for consumer willingness to pay and for the cost of production, we deal with environmental damage in marginal terms in microeconomic modelling. Ergo, we focus on how much damage is done by *an additional* unit of emission. In the simple model where emissions are proportionate to output, a statement on how much damage is done by an additional unit of emission is easily translated into a statement on how much damage is done by an additional unit of output. In analogy with the terminology used for willingness to pay and cost of production, additional damage is called *marginal damage*. Most often it is assumed that marginal damage increases with the level of emissions (the level of production): "it gets worse" with higher levels of economic activity. The reason for this assumption is a certain mathematical convenience on the one hand. On the other hand, it is ecologically quite plausible. For many pollutants the environment has a certain assimilative capacity. It can cope with a certain emissions burden quite well. The more this capacity is strained, however, the greater the damage to the assimilative capacity.

In Fig. 6.14 you find marginal damage integrated in the diagram illustrating a competitive market, as explained above. According to what has just been said, the marginal damage-curve (MD) is indicated as increasing with the level of production, x.

The inverse supply curve contains the marginal costs paid by the firms for the use of productive factors bought by them in input markets. The marginal damage curve includes the marginal cost of using environmental resources *not* bought in the

[69] We use the terms "emissions" and "pollution" as synonyms.

market in the production process. To terminologically distinguish these two kinds of marginal cost from each other, the marginal cost for the inputs bought in markets are called *marginal private cost* (MPC); the costs for the environmental resources not bought in private markets are called *marginal external cost* (MEC). They are "external" with regard to the market system. Society must bear, as a consequence of production, the sum of private and external costs. This sum is called "social cost". The social cost of an additional unit of production is called *marginal social cost*. In the graph, marginal social costs are illustrated by the MSC-curve. The MSC-curve is graphically constructed by adding up the MPC- and MEC-curves vertically.

The inverse demand curve contains the marginal willingness to pay of consumers for the product under consideration. Marginal willingness to pay is taken to be a measure for the benefits consumers gain from having a small additional unit of X.

We can use the figure to illustrate how the introduction of environmental issues (using the concept of external cost) affects the level of socially optimal output and the social optimality of the market equilibrium. The idea of socially optimal output has been explained to be one of maximizing the difference between the benefit of production yields for the consumers and the value of the resources used up in the process of production. This general concept does not change when we introduce environmental problems. However, the concept of resource use changes, in that the value of environmental resources has to be added to the value of resources bought in the input markets. Optimal output is defined as the maximization of the benefit to consumers minus social costs. Stating this in marginal terms, we find that the optimal quantity of production is defined by an equalization of the marginal willingness to pay and the marginal social cost. This condition is met at quantity x^{**} in the figure. For any unit of output between 0 and x^{**} marginal willingness to pay (represented by the respective point on the inverse demand curve) is higher than marginal cost (represented by the respective point on the inverse supply curve). This is shown for an arbitrarily chosen output level $\bar{x}$ in the figure. The contribution of production unit $\bar{x}$ to economic welfare is illustrated by the distance between the demand curve and the marginal social cost curve above $\bar{x}$, i.e., $MWP(\bar{x}) - MSC(\bar{x})$. Total welfare generated by the socially optimal production quantity x^{**} is graphically illustrated by the area between the two curves within the limits of 0 and $\bar{x}$, $0ab$.

There is a fundamental divergence between the situation illustrated in Fig. 6.14 and the one illustrated in Fig. 6.11. In the previous model, where all the relationships between the economic actors are market relationships, the equilibrium quantity provided by the perfectly competitive market for X is socially optimal, $x^* = x^{**}$. In the present analysis, allowing for environmental damage as an effect external to the market, the socially optimal level of production is smaller than the equilibrium level, $x^{**} < x^*$. The $(x^* - x^{**})$ units of X that are produced in the perfectly competitive equilibrium in excess of the socially optimal quantity can easily be seen as reducing social welfare. The value of scarce resources (whether being bought in the market or not) is higher than the benefit provided to its consumer, for each of these units. Therefore, according to the criterion of social

welfare maximization, these units should not be produced. This stated, they nonetheless are in the competitive equilibrium.

In this case, the market fails to produce a socially optimal equilibrium. Any situation where this occurs is called *market failure*. The reason for the market failure in the present context is that the environmental damage generated by production creates an *externality* (*external effect*), i.e., a consequence of economic activity not acknowledged by the market system.[70]

Diagnosing market failure and being unhappy about it does not mean that the market system as an allocative mechanism has to be thrown "onto the rubbish dump of history".

However, it is necessary (and intellectually attractive) to ponder what can be done to make amends. Specifically, it is here suggested that there is a role for the state (the government) to improve the situation. Microeconomists have been particularly interested in designing governmental interventions which improve the allocative results of the market system and do not hamper the socially beneficial allocative powers of this system. In furthering this idea, the question that pertains is: how do we design a smart system of governmental assistance for the *invisible hand* of the market? Answering this will be a subject of the next chapter. Obeying the concept of this book, we focus on environmental problems and the possibility of solving (or at least attenuating) them through sound environmental policies.

Review Questions

1. What are the general features of decision making of a baker, a manager of a basketball team, and a couple getting married?
2. Why is it necessary to choose between alternatives?
3. What might be the "opportunity costs" of reading this textbook (not to mention the benefits!)?
4. Which factors might influence an individual consumer's decision on how to divide his/her time between work, leisure, and education?
5. When deciding on the bundle of consumption goods to buy, what is the goal and what is the constraint of an individual consumer?
6. Can we expect that two consumers with identical budget, confronted with identical consumption goods and identical prices will choose an identical bundle of these goods?
7. What is the meaning and the purpose of a "comparative static analysis"?
8. Through what kind of thought experiment can a firm succeed in identifying its profit maximizing quantity of production?

[70] Externality is the most important cause of a market failure in the context of environmental economics. A related problem is generated by collective (public) goods, as referred to in subsection 2.3.3 and Chap. 4. However, please recall that we have pointed to other deviations from the "ideal" conception of a market system, which also lead to market failure, above. The most important ones are market power (particularly in the form of monopoly and oligopoly) as well as imperfect information (particularly in the forms of asymmetric information). These issues are dealt with in intermediate microeconomics textbooks like Varian (2010).

9. What is the meaning of "perfect competition"?
10. Starting from individual demand and supply decisions, how are "market demand" and "market supply" arrived at?

Exercises

1. Please find an example for a situation in which an individual consumer is forced to decide between alternatives!
2. Please elaborate the common features, as described in microeconomics, of the decisions made by
   (a) An electric power-supply company;
   (b) A cook;
   (c) A professional rugby player.
3. What are the functions of an allocation mechanism?
4. What is the difference between judging a market outcome as "good" or "bad", respectively, from an individual perspective, on the one hand, and a societal perspective, on the other?
5. Imagine that you have realized your individual equilibrium demand for pizza, on the one hand, and for burgers, on the other, given your income and the prices of both goods. Now assume that the price of pizza doubles, while the price of burgers remains constant, as does your income. How would you change your demand for pizza and burgers, respectively?

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A Sketch of Environmental Microeconomics 7

7.1 Internalizing Externalities

It has been explained in Sect. 6.3 that firms striving for profit maximization are anxious to minimize cost (by definition). Cost minimization is also a socially welcome project because it implies the minimization of resource use and thereby an important contribution to the social goal of softening the problem of scarcity. The problem for firms minimizing cost within a market system is that they are interested in minimizing the use of only those resources that they have to buy in the marketplace. Profit maximizing firms do not care about minimizing the use of resources they do not have to pay for, but can instead take out of the environment for free.[1] As a result of this, the aim of harmonizing the objective of society not to waste scarce resources and the objective of the firm not to do so, is only achievable when the market system forces the economic agents to behave economically by making them pay.

A competent diagnosis is the first step towards a successful cure, in medicine as well as in other areas of human life. Given that the problem of market failure due to externalities is generated by the fact that firms do not have to pay for using up environmental resources, then we just make them pay! This is the general idea underlying any environmental policy obeying the *polluter pays principle*.

Today, this principle comes in many different variants. The original idea is due to the work of the British economist *Arthur Cecil Pigou*. In his ground-breaking work (1920) Pigou suggested that the government should make the polluters pay for the

[1] We are talking about the firm as it is stylized in mainstream microeconomic models. It is not so easy in reality. Here, the manager of a firm might care for the environment because his/her conscience does not allow doing otherwise, or because doing otherwise would draw punishment from the consumers, or employees (or even his/her children at home at the breakfast table!). In this introductory textbook we ignore these real deviations from the standard model of the firm. We may do so without worrying too much about this omission because the standard model of the firm catches an important part of reality. If it were otherwise we would not suffer as much from environmental problems as we do.

A. Endres and V. Radke, *Economics for Environmental Studies*,
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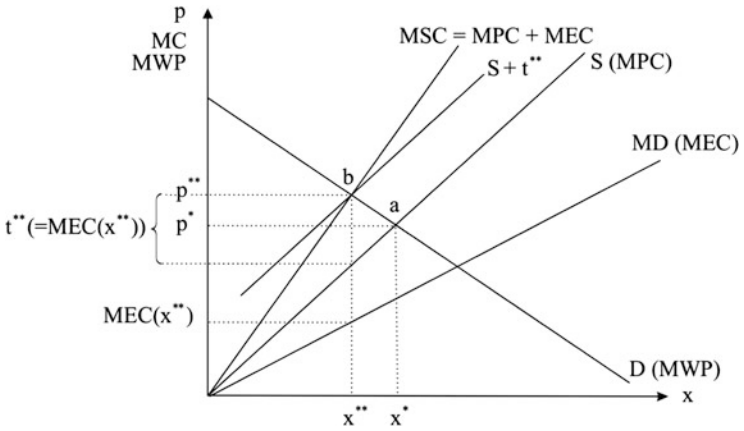

Fig. 7.1 Internalizing externalities with a Pigouvian Tax

environmental resources they use by taxing their emissions. To honour the originator of this idea the subsequent literature calls the special kind of tax the *Pigouvian tax*.[2] Here is how it is to be designed and what effect it is supposed to have.

The Pigouvian tax tries to do for *marginal external cost* what prices of the inputs bought in the factor markets do for *marginal private cost*: make the firms pay! Thereby, the firms are "persuaded" to acknowledge the scarcity of *all the resources* they use, when deciding upon the quantity to be produced. So the idea of the Pigouvian tax is to induce the firms to act upon environmental resources just as economically as they do with respect to resources bought in the market. If this succeeds, the market failure generated by externalities is corrected by the use of the Pigouvian tax. Then, externalities are said to be *internalized*. Given internalization, equilibrium output is driven down from the initially distorted level, x^*, to the socially optimal level, x^{**}.

In order to arrive at this attractive result the Pigouvian tax has to be designed correctly (Fig. 7.1).

Pigou's idea is to use a tax on emissions with a constant *tax rate*. The tax rate is the tax per unit of the pollution. To say it is constant means that the level of the tax rate does not depend on the level of emissions. In the simple model used above (and also used in the work of A.C. Pigou), the level of emissions is in proportion with the level of output. Pursuantly, the Pigouvian tax is constant per unit of output. In order to make the firms acknowledge the damage done to the environment by their production, the tax rate has to be equal to marginal external cost. However, we assumed that marginal external cost is increasing in unison with the level of

[2] The Pigouvian tax is the *Godfather* of all kinds of *ecological taxes* that are presently used in most industrial countries. See Dias Soares et al. (2010) for a recent overview. The authors emphasize that the numerous examples of environmental taxes from the many different countries discussed in their analysis are all part of the "Pigouvian approach" (p. 23).

production. On the other hand, the tax rate is supposed to be constant. To solve this apparent contradiction, it has to be indicated at which level of output marginal external cost is to be evaluated to determine the level of the tax rate. The answer is that the tax rate equals the marginal external cost evaluated at the level of socially optimal production, $t^{**} = MEC(x^{**})$.

Given that, the producers have to pay an amount of t^{**} for each additional unit they produce, on top of marginal private cost. Since the inverse supply curve equals the marginal private cost curve (in its relevant section), as explained above, imposition of the Pigouvian tax makes the inverse supply curve shift upward by an amount of t^{**}. So the inverse supply curve after the imposition of the Pigouvian tax is parallel to the pre-tax inverse supply curve, and the vertical distance between the two curves is t^{**}. The allocation for which the new inverse supply curve intersects the inverse demand curve, thereby constituting the new market equilibrium, features the property that marginal willingness to pay equals the sum of marginal private cost and marginal external cost, $MWP = MPC + MEC$. In other words, the feature of the market equilibrium transformed by the imposition of the Pigouvian tax is that inverse marginal willingness to pay equals marginal social cost, $MWP = MSC$. This feature has been explained as constituting the condition for socially optimal output, above. Thereby, a constant tax rate set at the level of marginal cost evaluated in the socially optimal situation is exactly what Dr. Pigou ordered in terms of his internalization cure for market failure. In the figure, imposition of the Pigouvian tax makes the supply curve shift from S to $S + t^{**}$ and thereby market equilibrium move from a to b. Thereby, the equilibrium provision of the commodity under consideration goes down from the uncorrected market equilibrium level x^* to the post-tax equilibrium level x^{**}, which just happens to be socially optimal. That does the trick! The market price increases from the pre-tax level p^* to the post-tax level p^{**}.[3]

It is sometimes said that "green taxes" inspired by the Pigouvian idea generate a *double dividend*: the first dividend is the welfare gain reaped by the internalization of negative externalities as explained above. The second dividend is generated if the government uses the tax revenue to reduce the cost of labour as a productive factor. This might be done by reducing the contributions of employers to the social insurance system. This is expected to have an employment stimulating effect. The double dividend hypothesis stylizes ecological taxes as silver bullets simultaneously fighting environmental destruction and unemployment. This stylization might increase the social acceptability of these kinds of taxes. However, closer economic analysis cautions against the double dividend story, suggesting that it cannot be taken at face value under all kinds of circumstances.[4]

[3] It may be noted that the tax rate drives a wedge between the price consumers pay (p^{**}) and the price producers receive ($p^{**} - t^{**}$). Market price increases due to the imposition of the tax, although the price increase ($p^{**} - p^*$) is smaller than the tax rate (t^{**}). So the burden of the tax is shared among producers and consumers in that consumers pay a higher price and producers receive a lower price compared to the situation without tax.

[4] See, e.g., Endres (2011, pp. 174–187), for a critical appraisal.

We have explained the Pigouvian tax as a means to internalize externalities. Even though this is still the most well-known internalization strategy, it is not the only one. In environmental economics textbooks (like Endres 2011, and Faure and Skogh 2003), focus is given to negotiations between polluters and pollutees, environmental liability law, and also to the Pigouvian tax. However, we do not deal with these further options in our introductory economic textbook.

7.2 Standard-Oriented Environmental Policy

7.2.1 Introduction

In the previous section we discussed the concept of internalizing externalities. The essence of the matter is to make the polluter pay for the value of the environmental resources used up for production. By definition this concept requires that the relationship between the level of emissions and the level of environmental damage is known, or can be at least assessed in a reasonable way. In mathematical terminology, this relationship is called the *damage function*. It must be emphasized that it is not enough to know a damage function that maps different levels of pollution to different units of different physical dimensions of damage, such as decreased visibility, corrosion of certain materials, or an increased incidence of certain illnesses, e.g., in the respiratory system. Instead, in order to act on the programme of internalization, different levels of pollution must be mapped to different levels of damage in terms of a single dimension – money.

However, there are many people who believe that environmental damage cannot be monetized, and if it could, it shouldn't be.[5] Of course, practical difficulties and ethical concerns vary among different forms of environmental damage. In particular, there is little opposition against monetizing damage such as the corrosion of machinery and buildings, but there is a lot against monetizing damage in terms of increased morbidity and mortality.

We do not deal with this controversy here. Instead, we ponder on the question as to the consequences for the economic approach, if we cannot assess the damage function, be it because of methodological or because of fundamental ethical reasons. Is this the end of *environmental economics*? To the relief of economists interested in environmental issues the answer is "no!" There are many ways to use economic methods to analyze environmental problems and to make recommendations on how environmental policy might be designed to use economic incentives for the benefit of the environment, even if we do not know the damage function.

To get the idea, it is useful to keep in mind what the role of monetizing externalities is, within the internalization framework. Firstly, the marginal external

[5] Issues of monetary valuation of environmental resources are discussed, e.g., in Hackett (2011), Tisdell (2010), and particularly sceptically so in Hahnel (2011). A practical application of these methods (to the cost of oil spills) is in Carson et al. (2004).

cost function has been used, jointly with the private cost function and the demand curve (indicating marginal willingness to pay), to determine the socially optimal level of pollution. In the simple model in which emissions are proportional to output, socially optimal output levels are simultaneously determined with socially optimal emission levels. Secondly, it was used to design the rate of the Pigouvian tax through reconciling the market equilibrium level of output with the socially optimal level of output.

Consequently, without the environmental damage function, the concept of social optimality (and socially optimal output and emission levels, in particular) cannot be applied in a framework where production uses up environmental resources.

Still, society (and policy makers) may take the level of pollution produced in the uncorrected competitive market equilibrium to be too high. Society may wish to reduce pollution even though it cannot specify the target level of this pollution reduction (as from the criterion of social optimality), as defined in microeconomics. So the target level has to be specified otherwise. Suppose that in the process of societal discussions, lobbying, and political decision-making, some target level of the emissions, e, of a certain pollutant, E, is defined. This target level, $\bar{e}$, is supposed to be below the level of emissions of the pollutant under consideration as it is generated in the uncorrected competitive market equilibrium, e^*, i.e. $\bar{e} < e^*$. According to that, society has determined a certain cut back of a certain pollutant by means other than microeconomic social optimization. However, defining the social target of emission reduction is not sufficient to qualify for a comprehensive policy programme regarding the pollutant under consideration. At least two additional problems have to be simultaneously answered by policy makers. The first problem is due to the fact that, in most cases, the pollutant is not generated by one firm only. Most often, emissions of the same kind are produced by many firms. These firms may or may not produce the same commodity. So in addition to determining the amount of pollution reduction, $e^* - \bar{e}$, necessary to arrive at the emissions target level, society must decide how the aggregate pollution reduction burden will be distributed among the firms emitting pollutant E. For the goals of aggregate emission reduction to be achieved, each individual firm has to take action such that the sum of all the firm-specific emission reductions add up to the aggregate emission reduction envisioned by society. Secondly, society must decide on how to induce the firms to follow the societal plan.

7.2.2 Cost-Effective Inter-firm Allocation of Aggregate Pollution Abatement

Beginning with the first issue, we see that in order to argue how a given aggregate emission reduction is to be distributed among the firms emitting the pollutant under consideration in a rational way, we first need a criterion according to which this issue should be decided. Taking the microeconomic view, the task to "produce" emissions reduction has a very important feature in common with all other kinds of production: it uses up scarce resources. Using scarce resources generates costs and,

following the microeconomic programme of social welfare maximization, costs must be minimized as a prerequisite. Even if the socially optimal level of pollution cannot be determined in the present framework, the idea of economically dealing with scarce resources requires that no such resources will be wasted, i.e. arriving at the target level of emissions must be achieved in a cost-minimal manner, for every point along that reduction journey.

In applying traditional microeconomic reasoning, the criterion for the determination of the emission reductions of the individual firms is cost minimization.

In general, different firms may incur different costs in curtailing their "production" of the same pollutant. This is so even in the simple model that we have used above with the level of emissions being proportional to output. There, the reason for differences in the cost of abating a certain pollutant is that the firms might produce different kinds of outputs. Then, the cost of output reduction (as a means of emission abatement) generally differs between X producing and Y producing firms. These costs are the reductions in consumer and producer surplus due to reductions in the level of X and Y, respectively.

Differences in the costs of firms in the abatement of pollution are even bigger in reality, and in a model that is somewhat "richer" than the simple one with emissions proportional to output used above. In this richer model, we allow for all kinds of possibilities in the abatement of emissions, in addition to output reduction. These possibilities consist of "end-of-pipe"-technologies like filters, substitution from high emission intensity inputs to low emission intensity inputs (e.g., coal of different sulphur content), or environmentally-friendly changes in the production methods (e.g., processes with higher effectiveness in combustion).

When we think about how a typical firm might decide between these different options of pollution reduction, we can apply what we have said in Sect. 6.3 on the theory of a firm. Since we assumed there (and continue to do so throughout this book) that firms strive to maximize profits, we conclude that they also strive to minimize costs. It has been argued above that cost minimization is a prerequisite ("a necessary condition") for profit maximization. Accordingly, each firm planning to abate a certain amount of pollution chooses to apply the cost minimizing mix of the available pollution reducing methods. This is true independent of the level of pollution the firm decides to abate. Putting this into mathematical terms we can derive a pollution *abatement cost function*. This function indicates the minimum amount of cost (as the dependent variable) incurred for any amount of pollution reduction (the independent variable). Specifying this function for (small) additional units of emission reductions we arrive at the *marginal abatement cost function*.[6] From the point of view of the economic theory of the firm, there is no difference between a production cost function (marginal production cost function) as used in Sect. 6.3, above, and the abatement cost function (marginal abatement cost function) used in this section. In terms of the cost, producing a commodity follows the same principles like producing pollution abatement.

[6] *Calculus club, mini session*: the marginal abatement cost function is the first order derivative of the total abatement cost function.

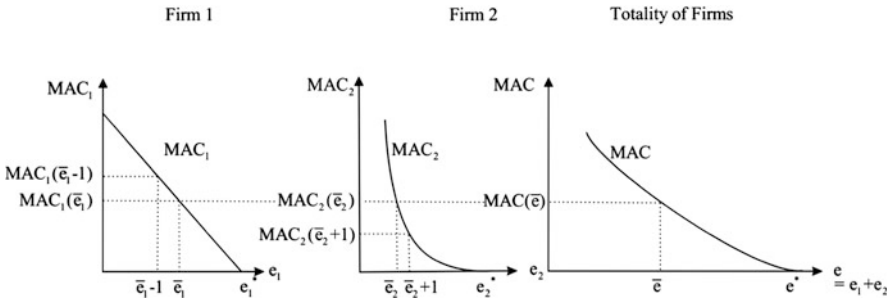

Fig. 7.2 Cost minimizing inter-firm allocation of aggregate pollution abatement

Figure 7.2 shows the marginal abatement cost curves of two typical ("representative") firms, MAC_1, MAC_2 and the aggregate marginal abatement cost function, MAC. This illustration is a complete analogy of Fig. 6.12, illustrating the cost-effective inter-firm allocation of aggregate production. The only inconvenience for the reader (as long as you did not get used to it) is that in the standard production graph the marginal cost curves are to be read "from left to right!" for increasing levels of production, whereas in the pollution abatement graph the marginal abatement cost curves are to be read "from right to left" for increasing abatement levels. This reversal of the direction in the present illustration is due to the fact that the independent variable of the marginal abatement cost function is emission abatement. However, the variable measured on the abscissa of the graph is not the level of emission abatement but the level of emissions. The more the firm abates the lower is the release of emissions. Abatement starts from the uncorrected emission level $e_1^*(e_2^*)$. Emissions move in the direction of zero emissions with increasing abatement levels. As a result, emission abatement is $e_i^* - e_i$ for any emission level e_i between 0 and e_i^*. There, "i" is a general "name" for the firm under consideration, which denotes firm 1 equally as well as it denotes firm 2.[7]

Because of the analogy to what has been said in discussing the theory of the firm we can be brief here regarding the description of the cost minimal allocation. The overall emission reduction $e^* - \bar{e}$ is brought about in the cost minimizing way if firm 1 abates $e_1^* - \bar{e}_1$ units and firm 2 abates $e_2^* - \bar{e}_2$ units. The general rule for these cost minimizing firm-specific abatement levels is that the marginal abatement costs of the two firms must be equal to each other, $MAC_1 = MAC_2$. This is illustrated in the figure for the example of society's emissions target, $\bar{e}$. Of course, the statement is perfectly general: it can be also applied to any other emissions target.

Analogously to what we have said in discussing Fig. 6.12, you can demonstrate that the social cost of reducing overall pollution to a level of $\bar{e}$ would increase in cases where the allocation of total abatement among the firms is changed, for example, to a situation where firm 1 abates one unit more (going to $\bar{e}_1 - 1$) and firm 2 abates one unit of the pollutant less (going to $\bar{e}_2 + 1$). The additional cost to

[7] In formal terms, $i \in \{1, 2\}$ holds.

firm 1, which would be a consequence of this reallocation, would be higher than the cost saving for firm 2 due to this reallocation. Therefore, the reallocation would make the cost for society increase. Accordingly, the situation in this (and any other) reallocation cannot be a cost minimum.

Calculus Club: Session 4

The objective is to minimize total abatement cost, $AC(e_1^* + e_2^* - e_1 - e_2)$, which is defined to be the sum of the firms specific abatement costs, $AC_1(e_1^* - e_1)$, $AC_2(e_2^* - e_2)$. We do this for two firms here without any loss of generality: the exercise does not change, in principle, if extended to the case of many ("n") firms. The formal expression for this cost minimization problem is

$$AC = AC_1(e_1^* - e_1) + AC_2(e_2^* - e_2) = \min!$$

Cost minimization is subject to the requirement that the aggregate emissions target, $\bar{e}$, is not to be exceeded by the sum of the two firms specific emissions, $e_1 + e_2$.[8] So the minimization is to be done under the constraint of

$e_1 + e_2 = \bar{e}$

Consequently, the Lagrange function is

$L = AC - \lambda(\bar{e} - e_1 - e_2) = \min!$

Writing MAC_i for $\partial AC_i/\partial(e_1^* - e_i)$, the first order conditions are first order conditions are

$\partial L/\partial e_1 = -MAC_1 + \lambda = 0$

$\partial L/\partial e_2 = -MAC_2 + \lambda = 0$

$\partial L/\partial \lambda = \bar{e} - e_1 - e_2 = 0$

$\rightarrow MAC_1 = MAC_2$

So the necessary condition for the cost minimum allocation for which we are looking is that marginal abatement costs are equal across firms.

Since the second cross derivates equal zero, the second order conditions are

$\partial^2 L/\partial e_1^2 = \partial MAC_1/\partial(e^* - e_1) > 0$

$\partial^2 L/\partial e_2^2 = \partial MAC_2/\partial(e^* - e_2) > 0.$

Accordingly, the extreme value characterized by the first order condition is indeed a minimum if it is located on the increasing parts of the two marginal abatement cost curves. Since, for simplicity, we assumed the marginal abatement cost curves to be monotonously increasing, above, this second order condition is, *ab initio*,[9] met.

We are confident that most (all!) of our cherished readers have noted the complete analogy between the task of deriving the cost minimizing inter-firm

[8] For simplicity, we interpret "not to be exceeded" such that the two individual emission quantities add up to exactly $\bar{e}$.

[9] "ab initio" is a mildly snobbish expression for "right from the start".

allocation of aggregate pollution abatement, as presented in this calculus club session, with the deriving of the cost effective inter-firm allocation of production, presented in Calculus Club Session 3. Indeed, the structure of these two kinds of problems is identical, and *structure* is exactly what is in the focus of microeconomic theory. In the context of cost-effective inter-firm allocation, pollution abatement is just a production activity like any other. To highlight these kinds of analogies is in the focus of our concept for "Economics for Environmental Studies".

So the first question asked above has been answered: in order to arrive at a cost-effective inter-firm allocation of a given aggregate emission reduction, the individual reduction proportions of each firm have to be determined such that the marginal abatement costs of all the firms involved are equal.

The second question is how environmental policy can be designed so as to achieve this cost minimizing situation. In the terminology of microeconomics, the question is how environmental policy can create incentives for the polluters such that their equilibrium pollution abatement quantities are identical to the cost effective abatement quantities.

7.2.3 Cost-Effective Design of Environmental Policy Instruments

Among the many environmental policy instruments considered by environmental economics analysis, we focus our attention on a tax on emissions. This is done for the sake of comparability with what we have said about the Pigouvian tax as one of several internalization strategies, as discussed above.

Consider how a firm might react to the imposition of a tax on pollutant E defined by a constant amount per unit of the pollutant (a constant *tax rate*), $\bar{t}$.

Since the firm is striving to minimize costs it would compare the cost of emitting a given unit of the pollutant under consideration, i.e. paying the per unit tax, with the cost of abating the unit under consideration, i.e. the marginal abatement cost. Following this principle, any unit for which the marginal abatement cost is lower than the tax rate will be abated in equilibrium, and vice versa, such that abatement will not be chosen when the marginal cost is higher than the tax rate.

The cost minimizing decision of a typical firm, i, can be understood using the illustration given in Fig. 7.3. If no emissions would be abated at all, the firm would produce the uncorrected equilibrium pollution quantity of e_i^*. The firm would have to pay a tax of $\bar{t}$ for each of the emitted units of a pollutant, resulting in a total tax bill of $\bar{t}e_i^*$. It would be obvious for the firm that it can do better than that in terms of cost. Consider the first unit of the pollutant that might be abated, making pollution go down from a level of e_i^* to a level of $e_1^* - 1$. As you can see from the illustration the costs to abate the first unit are quite low. Specifically, they are much lower than

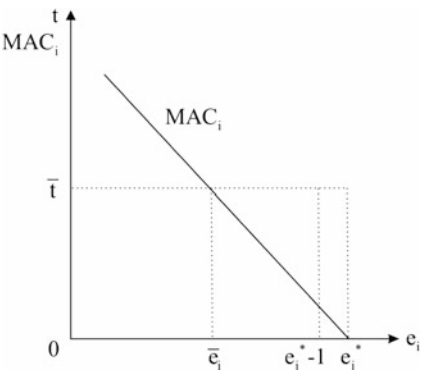

Fig. 7.3 Equilibrium emission abatement with pollution tax

the tax that has to be paid if this unit is emitted. By abating, the firm on the one hand saves the tax on this unit, while on the other it has to pay the cost for abating. Since the former cost is much higher than the latter, it is a good deal for the firm to abate this "marginal" unit. The same reasoning with the same result applies to any additional ("marginal") unit between the initial emission quantity e_i^* and emission quantity $\bar{e}_i$. $\bar{e}_i$ is defined by the fact that the marginal abatement costs of the firm under consideration are equal to the tax rate at $\bar{e}_i$. $\bar{e}_i$ is the equilibrium residual emission quantity given tax rate $\bar{t}$, and $e_i^* - \bar{e}_i$ is the corresponding equilibrium abatement quantity. The equilibrium condition "marginal abatement cost = tax rate", which is fulfilled for abatement quantity $e_i^* - \bar{e}_i$ is written as $\bar{t} = MAC_i$, in mathematical "shorthand". To abate any unit beyond this equilibrium abatement quantity would be unadvisable according to the criterion of cost minimization. For all the units between $\bar{e}_i$ and 0, marginal abatement cost is higher than the tax rate, making the firm lose money by abating.

Calculus Club: Session 5

The cost minimal adjustment of a firm in light of a pollution tax can be stylized in mathematical terms. The total cost, C_i, involved with the emission and with being subject to a pollution tax, consists of the abatement cost, AC_i, for the units not discharged, $e_i^* - e_i$, plus the tax rate, $\bar{t}$, multiplied by the emission quantity, e_i. Resultantly, the problem of the firm is $C_i = AC_i(e_i^* - e_i) + \bar{t}e_i = \min!$

Differentiating for e_i and setting to 0 leads to

$$\partial C_i/\partial e_i = -\frac{\partial AC_i}{\partial(e_i^* - e_i)} + \bar{t} = 0.$$

Writing MAC_i for $\partial AC_i/\partial(e_i^* - e_i)$,

$$\bar{t} = MAC_i$$

turns out to be the first order condition for the cost minimum. Accordingly, the firm minimizes costs by reducing emissions to an extent for which the marginal abatement cost of this firm has risen to a level that is identical to the tax rate.

The second order condition is

$$\partial^2 C_i / \partial {e_i}^2 > 0,$$

i.e., the cost minimum is located on the increasing part of the marginal abatement cost curve. Again, our assumption that the marginal abatement cost curve is monotonically increasing guarantees that the second order condition is met.

The rules of cost minimizing abatement explained above for a representative firm i apply to all other firms. So for one of these firms, j, the equilibrium abatement decision in the presence of a pollution tax with rate $\bar{t}$ is defined by the condition $\bar{t} = MAC_j$: firm j decides to reduce pollution starting from the initial level e_j^* down to a level $\bar{e}_j$ at which the marginal abatement cost is equal to the tax rate.

Above, we have explained the cost minimizing reaction of any individual firm to a pollution tax with a constant rate. That each individual firm behaves in a cost minimizing way, however, does not guarantee that the situation is cost minimal for the economy as a whole. Cost minimization of each individual firm is a necessary, but not a sufficient condition for this to occur. Additionally, the allocation of aggregate pollution abatement is to be allocated between the involved firms in a cost minimizing way. We therefore need one further step in the analysis to show that the pollution tax that we consider here is able to achieve cost minimization for the polluting industry as a whole.

We have established that each firm reduces pollution in a way that equalizes its individual marginal abatement cost with the tax rate. If this tax rate is the same for all the firms, then it follows that in the equilibrium situation the marginal abatement costs are at an identical level for all involved firms. From $\bar{t} = MAC_i$ and $\bar{t} = MAC_j$ for any firms j and i, it follows that $MAC_i = MAC_j$.

In answering the first of the two questions asked in the introduction of this section, we have established that the equality of individual marginal abatement costs is the requirement for the cost-effective inter-firm allocation of the aggregate pollution reduction at which society is aiming. In answering the second question, we have established that after the firms have adjusted to a constant and *general* pollution tax rate, the condition for a cost minimizing inter-firm allocation is met in the equilibrium.[10] So a pollution tax with the properties presumed here is a cost-effective instrument of environmental policy. We illustrate using Fig. 7.4.

[10] With the term "general", we mean that a tax rate is not differentiated across firms.

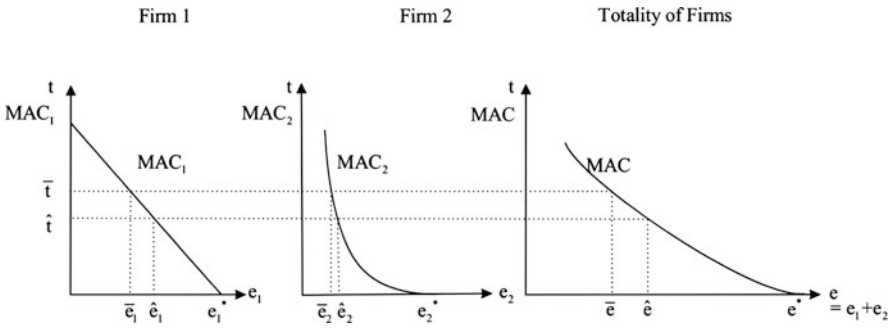

Fig. 7.4 Pollution tax as an instrument of standard oriented environmental policy

In the figure, $\bar{e}$ is the predetermined pollution target of the society. Given that the tax rate is set equal to the aggregate marginal abatement cost at the level of $\bar{e}$, i.e. at $\bar{t} = MAC(\bar{e})$, firms 1 and 2 reduce their respective emissions to $\bar{e}_1$ and $\bar{e}_2$. These two individual quantities add up to the societal target level $\bar{e}$ and, according to what has been said above, the aggregate emission reduction $e^* - \bar{e}$ is brought about in a cost minimizing way by the individual contributions of the two firms. It should be noted that any other constant and general tax rate would induce cost-effective adjustments of the two firms, but in achieving that the aggregate societal pollution target would be missed. Consider, for example, a tax rate $\hat{t}$ that is lower than $\bar{t}$. This tax rate would induce the firms to make decisions to abate pollution in a way that minimizes the social costs of pollution. This is so because the marginal abatement cost of the two firms would be equal to one another (and equal to $\hat{t}$) in equilibrium. However, the two equilibrium pollution levels of the firms, $\hat{e}_1$ and $\hat{e}_2$ would add up to an aggregate pollution level of $\hat{e}$, which is incompatible with the social target.

We have discussed the properties of taxing pollution in two different forms, above. In Sect. 7.1 we dealt with the Pigouvian tax. This is an instrument to internalize externalities. In the present section we dealt with a different kind of a pollution tax. This latter consideration is not a means by which externalities can be internalized, since it applies to a framework where there is no information on the damage function, which is a prerequisite for any internalization. Instead of aiming at achieving the socially optimal level of pollution, the tax discussed in the present context aims to achieve a more modest goal: to reduce pollution to some predetermined target level. This target level is sometimes called an aggregate *pollution standard*. This standard is not (necessarily) socially optimal. From this, an important difference between the two kinds of pollution taxes that we have discussed is that they serve different goals. On the other hand, they are quite similar. Both forms change the framework under which the individual firms make their decisions in a way that renders pollution reduction economically worthwhile for the firms to a certain extent. In both cases, the tax introduces incentives to treat environmental resources economically just as the price mechanism does for resources bought in private markets.

In order to terminologically distinguish the Pigouvian tax and the tax we have dealt with in the present section, the latter is called a tax in the *pricing and standard approach*. In this term, the word "pricing" alludes to the aspect in that the two taxes are similar: they both use a tax incentive to economize on environmental resources, and one which is a substitute for the incentive generated by the price mechanism. The terminological part with "standard" highlights the respect within which the latter tax is distinguished from the Pigouvian tax. The goal of the policy is not to achieve a socially optimal situation, but to achieve a predetermined outcome with reduced pollution. The main result of the economic analysis of the tax in the sense of the pricing and standard approach is that this is an instrument which achieves the societal goal at minimum abatement cost.

The tax we consider above is just one of several instruments that might serve to achieve a pollution target (although not necessarily a socially optimal one). Another instrument is a system of *transferable discharge permits*. Here, the environmental authority issues a certain number of "rights to pollute". The quantity of these allowances is designed to be compatible with the goal of pollution reduction followed by the environmental policy maker. In order to be able to pollute legally the firms must own the appropriate number of rights.

Emission allowances are auctioned off or given away for free. In the case of the auction, pollution permits obviously carry a market price. The permit price makes emissions costly for the polluter and thereby fulfils the same allocative task as the tax rate in the case of the pricing and standard approach explained above. Even though, at first glance, things might look completely different if permits are given away for free, the market mechanism works similarly. In the case of free initial permit distribution, a market price for each pollution allowance is generated by the firms trading permits among each other.[11]

A practical example for this kind of an environmental policy is the greenhouse gas trading programme of the European Union.[12]

Another standard-oriented approach to environmental policy is *direct governmental intervention* limiting the pollution quantities that are allowed for firms. These interventions may take various forms and are usually summarized under the expression *command and control approach* in the analysis of environmental policies. There are very many examples for this approach in practical environmental policies, such as America's *Clean Air Act*.

These and other "standard-oriented" instruments are discussed in intermediate environmental economics textbooks (like Endres 2011; Sterner and Coria 2011 and Wiesmeth 2012). Moreover, environmental economics highlights cost effectiveness as one of a number of criteria in the comparative assessment of these instruments.

[11] A prerequisite for the evolution of a market is that emission rights are scarce. If the firms are "flooded" with costless pollution allowances, no one wants to buy and the equilibrium permit price is zero.

[12] See, e.g., Ellerman et al. (2007), Endres (2011), Faure and Peeters (2008) for details and assessment.

Among these, the incentives generated by alternative policy instruments to introduce environmentally friendly technologies are important. Further, the accuracy with which the societal pollution target is attained through the use of alternative policy instruments is discussed. However, within the limits of our introductory economics textbook we cannot deal with these extensions and must refer to the literature mentioned above.

That said, there is one line of argument dealing with the economics of standard-oriented environmental policy instruments that carries a particularly favourable benefit-cost-ratio in terms of explaining policy instruments to a novice audience.

The cost of explaining it is low because it directly relates to an argument that we have discussed above at some length. The benefit is high because it is an example for how microeconomic reasoning can support environmental policy analysis and help to derive environmental policy recommendations.

Above, we have characterized the cost-effective inter-firm allocation of a predetermined level of aggregate pollution reduction. As we saw, cost-effective allocation was such that marginal abatement costs are identical across firms. Moreover, it was shown that applying a tax on pollution in the sense of the pricing and standard approach induces the firms to abate pollution to an extent that equalizes their marginal abatement costs in equilibrium. Accordingly, this particular approach of pollution taxation is a cost-effective environmental policy instrument.

Now, compare the cost effectiveness of an alternative approach to environmental policy, a "one size fits all" command and control approach. This command and control policy is defined by requiring proportional emission reductions by the firms emitting the pollutant to be regulated as follows: if aggregate pollution is supposed to be brought down by a certain percentage as a result of the command and control regulation, then each of the involved firms is required to reduce the level of pollution by exactly this percentage.

We illustrate this in Fig. 7.5[13]

On top of this, we assume that in the example we use to illustrate the command and control policy, the approach is designed to bring the aggregate level of pollution down from an aggregate level of e^* to a target level of $e^*/2$. Then, the proportional variant of command and control that we consider here forces each of the two firms involved to cut its pollution by half. The level of firm 1 goes down from e_1^* to $e_1^*/2$ and the level of firm 2's pollution goes down from e_2^* to $e_2^*/2$. This is fine in terms of the target the policy strives to keep, since the two individual post-regulation emission levels just add up to the aggregate target, $e_1^*/2 + e_2^*/2 = e^*/2$. However, what about cost effectiveness? In general, if the two firms are forced to reduce emissions proportionally, they will end up in a situation where their marginal abatement costs differ. This is due to the fact that the marginal abatement cost functions of two firms emitting the same pollutant will have way different shapes in

[13] The curves in this figure are the same as in Fig. 7.4 illustrating the pollution tax in the standard and pricing approach. This is to facilitate the comparison between these two standard-oriented environmental policy instruments.

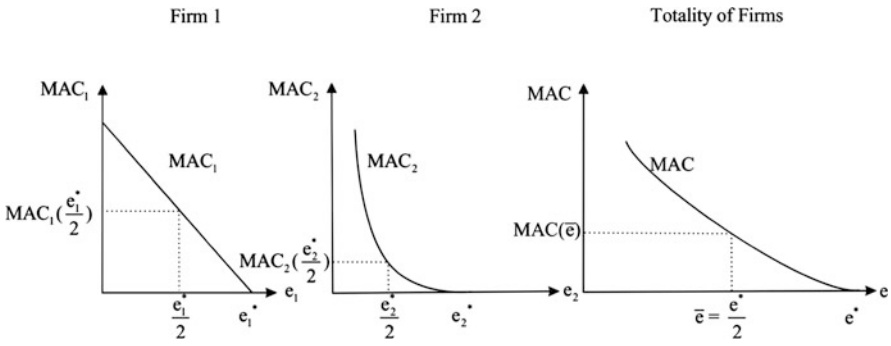

Fig. 7.5 "Command and Control" as an instrument of standard-oriented environmental policy

most cases. This general case is illustrated in the graphic. There, the marginal abatement cost of the first firm is higher than the marginal abatement cost of the second firm in the situation where both firms comply with the regulation, $MAC_1(e_1^*/2) > MAC_2(e_2^*/2)$. Applying your knowledge on the feature of the cost-effective allocation, $MAC_1 = MAC_2$, you can see at one glance that the allocation induced by the command and control regulation stylized here is cost-ineffective. So the goal of arriving at the environmental policy target, $e^*/2$, is achieved by burdening the society with unnecessary cost. Society would reduce total abatement cost and thereby save scarce resources by having the first firm abate a little less and the second firm a little more. This is exactly what a correctly specified emission tax would induce the firms to do.

7.3 International Environmental Problems

Analogously to the societal discussion in many industrialized countries, the analysis of international (specifically global) environmental problems has attracted increasing attention in the environmental economics discussion. This is a reflection of the severe societal worries that have been triggered by problems like the *greenhouse effect* and the damage to the ozone layer.

Much of what has been said above on environmental economics analysis can be applied to international environmental issues. However, there is one crucial respect within which the economic model must be changed so that it can be applied to the international arena.

In the traditional analysis used above, the state (the government) plays a superior role: the government is assumed to recognize the allocative distortion generated by externalities and to make amends it applies strategies of internalization (or in a more pragmatic context, instruments of standard-oriented environmental policy). The objective of the government is assumed to be social welfare maximization and in case the policy maker does not have sufficient information to operationalize the concept of social welfare maximization, the modest substitute of cost effectiveness

is applied. Of course, these assumptions are somewhat heroic, even in the national context.[14] The assumptions are highly inappropriate for the analysis of global environmental problems. Here, a *world government* that might be able to play the role of the policy maker akin to what is assumed in the traditional environmental economics models just does not exist. Instead, global environmental policy has to be *voluntarily* agreed upon among sovereign countries.

The question is how to design an international system of policy governance that is able to coordinate the decisions of the independent individual states and to mediate conflicts among them. Basically, this system of policy governance should be able to fulfil the same tasks as the market system coordinating sovereign firms and mediating conflicts among them, as has been discussed in the setting of Sect. 6.3, above.

Of course, in the international policy arena there is a high degree of interdependence between the states of the world. For instance, what the United States' Federal Government decides to do (or not to do) in terms of greenhouse gas abatement certainly affects the situation in China as well as in the countries of the European Union, and vice versa. This is so with respect to the effect greenhouse gas reducing activities in one country have on the level of global warming, as well as in relation to the consequences these activities have on the international competitiveness of national industries.

The problem with this interdependence is that it puts the individual decision making government into the situation of a *dilemma,* which generates extremely adverse incentives to cooperate.[15] This is so because a global environment is sort of a *public good*, the properties of which have been discussed in subsection 2.3.3. Consider global warming as an example. Given that an individual country reduces its greenhouse gas emissions, the beneficial effect of this activity is enjoyed not only by this country itself but by all other countries of the world as well. This is so because the global warming attenuating effect of a certain reduction of greenhouse gas emissions does not depend at all upon the location in which this reduction has been brought about. On the contrary, there is perfect worldwide diffusion of this effect. On the other hand, the costs incurred by the greenhouse gas producing activities do not diffuse at all. They have to be exclusively born by the country that runs these activities. Given these extremely unpleasant asymmetries in the distribution of the benefits and the costs of greenhouse gas reducing activities for a single country, it is plausible that in equilibrium national activities to reduce greenhouse gases will be underprovided. That means that the equilibrium level of these activities falls considerably short of what would be required for the benefit of the worldwide common good (the "global optimum of greenhouse gas-reduction").

[14] See, e.g., Kollmann and Schneider (2010).

[15] The problem referred to above is called a "prisoners' dilemma" in microeconomics. See, e.g., Estrin et al. (2008, pp. 343–346), Varian (2010, pp. 527–529). A critical assessment of the prisoners' dilemma's application to global environmental problems is in Endres (2011, pp. 228–235, 247–249).

In order to overcome this frustrating situation, environmental economic theory has struggled to come up with all kinds of designs for international environmental agreements. A prerequisite for these agreements to be successful is that they are *incentive compatible*. The concept of incentive compatibility has two dimensions. First, it requires that it is attractive for a government that has the welfare of its own citizens exclusively in mind to join a coalition of countries taking measures to fight global environmental problems. This property is called the *individual rationality* in environmental economics terminology. Moreover, international environmental agreements must be designed such that each country in effect keeps to what it has promised in the treaty. This property is called the *stability* of a treaty. An important problem in this respect is that cooperative behaviour would be supported by effective sanctions in the case of a breach of contract. However, it is much more difficult to punish offenders in a context where the signatories of an agreement are independent states compared to a situation where the signatories are citizens of one country.

The work on the theory of international environmental problems and policy to which we have alluded, above, is used to assess actual environmental agreements on global issues. Examples are the *Kyoto Protocol* to attenuate global warming (which is in force since 2005) or the *Montreal Protocol* to protect the old ozone layer of the earth (which went into force in 1989).

It is well-known that the international community has been struggling for decades to form a global coalition of countries to fight global warming, and has not been able to deliver. The microeconomic explanation of this highly frustrating experience is the persistence of the well-known problems to provide a pure public good by voluntary contributions of its beneficiaries.

In the environmental economics literature there is an extensive discussion of theoretical issues in international environmental cooperation as well as regarding the assessment of actual international environmental treaties and suggestions for their reform.[16] In the context of our introductory economics textbook, we must confine ourselves to the few remarks we made above.

Review Questions

1. Why is cost minimization on the part of individual firms not sufficient to avoid a waste of natural resources on a societal level?
2. Please explain the “polluter pays principle”!
3. What is the basic idea underlying a Pigouvian tax?
4. How is a Pigouvian tax to be designed in order to ensure the implementation of the idea behind it?
5. Please explain in which way a Pigouvian tax alters the polluters’ behaviour!
6. Please describe the properties of the new market equilibrium realized after a Pigouvian tax has been imposed!
7. Why is an internalization of externalities (e.g., by imposing a Pigouvian tax) not suitable for environmental policy in its pure form?

[16] See, e.g., Aldy and Stavins (2007), Endres (2011), Finus (2008), Woerdman (2004).

8. Please describe the standard oriented approach to environmental policy and distinguish it properly from the internalization approach!
9. Please deduce and explain the condition for a cost effective inter-firm allocation of aggregate pollution abatement!
10. Please describe the pricing and standard approach and distinguish it from the concept of a Pigouvian tax!

Exercises

1. Please find an example of an everyday external effect and describe the governmental response you observe!
2. Please find an example for a negative external effect where it is difficult to specify the damage function!
3. Please discuss the cost effectiveness properties of
   (a) The standard and pricing approach, and
   (b) A variant of the command and control approach, which obliges all individual polluters to reduce their emissions by the same percentage!
4. Consider the following example: a car driver and the owner of a filling station conduct a market transaction specified by the amount of petrol handed over by the owner to the car driver and by the price paid by the car driver for any single unit of petrol. The car driver undertakes a weekend trip to his/her favourite destination and, thereby, firstly uses up the petrol and secondly, through the emission of noise and pullutants, affects the people living near the road he/she uses. Please identify:
   (a) Some components of the private cost of the owner of the filling station;
   (b) Some components of the external cost imposed on the people living near the road;
   (c) Some components of the abatement cost that would be generated by an environmental policy measure that would bring about a reduction in the amount of petrol sold and used up!
5. Please explore the relevance of "free riding" in the context of international efforts to limit climate destabilization!

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Summary to Part II and Looking Ahead

8

In the two preceding chapters we offered our cherished readers a guided tour through the realm of *general microeconomics* and *environmental microeconomics* (ah, we can hear the sweet sound of applause here, at least we think so!). As it turned out, both areas may be looked at through the lenses of positive just as well as of normative analysis.

Taking the *positive view*, you perceive what is happening and you get some support understanding why. The action to be observed (and hopefully understood) in general microeconomics is producers supplying and consumers demanding goods, following the rules of the market system. The action to be observed (and hopefully understood) in environmental microeconomics is firms cutting back on pollution, under the rule of environmental law.

The most important insight from positive economic analysis, as presented in the two preceding chapters, is that the principles firms follow when operating in the (competitive) marketplace are virtually the same as the principles they follow under a regime of environmental policy. Operating in the competitive market, firms take the framework conditions as given and adjust in terms of the quantity of goods they supply in order to maximize profits. The most important elements of the aforementioned framework conditions are the market prices of end products and of productive inputs. Operating as polluters under environmental policy, the firms also take the framework conditions as given and adjust to maximize profits (minimize costs). Specifically, these framework conditions are the levels of environmental taxes.

In order to understand how firms operate under a certain environmental policy (in a more sophisticated analysis: under alternative environmental policy regimes), it is most helpful to have some proficiency in general microeconomics. The general ideas and the tools of the analysis are pretty much the same.[1] We have written this book to unveil this connotation and to make the most of it for our readers.

[1] The following chapters will make it clear that the same has to be said for macroeconomics.

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What we have just said about positive analysis in general microeconomics and environmental microeconomics carries over to *normative analysis*. The general objective of normative analysis is to develop operational concepts toward the idea of "the common good" of a society. The ideas microeconomists came up with are the concepts of Pareto optimality and of the maximization of a social welfare function. These concepts are then used to assess the results of economic activity in both market and policy contexts. Again, the principal idea is the same, whether applied to general microeconomics, or to environmental microeconomics.

In the former context, a typical question asks whether the equilibrium provision of a certain good, as realized in the market equilibrium, satisfies the requirements of Pareto optimality (of maximizing social welfare, respectively)? In the latter context, a typical question asks whether the level of pollution produced under a certain environmental policy satisfies the criterion of Pareto optimality (of maximizing social welfare, respectively)? So the criteria developed in normative analysis are the same in general microeconomics as they are in environmental economics. Moreover, they are also used for the same purpose: the evaluation of equilibria in the light of the well-being of society as a whole.

The conclusion for normative analyses in general microeconomics and environmental economics is analogous to what has been said for positive analysis: since the general ideas and tools with which to work are basically the same, the best training to attain proficiency in applying normative economic concepts in an environmental context is a good education in terms of the normative part of general economics. This is the reason why we paid more attention to *welfare economics* in our book than is done in most other introductory economic textbooks. We do not criticize these other textbooks here. They are right to give different emphasis, since they are not designed to serve a readership which is particularly concerned with environmental studies.

Considering their size, it may certainly be said that we covered a lot of microeconomic methodology and topics in the two previous chapters. Moreover, we tried to concentrate on the very aspects most relevant to the economic analysis of environmental issues and which are within the scope of an introductory exposition.

Still, it must be conceded that there is much more to microeconomics than we have discussed above. The text given above has been confined in many ways, two of which we would like to mention.

First, talking about the market system we always concentrated on a single market. This is not so bad since the market under consideration may be any market. However, we have tacitly assumed that this market is sort of an island with few interactions with the rest of the world. Particularly, we did not acknowledge that a change in the situation of one market might affect the equilibrium in another market and that this might result in feedback to the first market (e.g., if the market price for apples changes, this might affect the market price for pears and this might again affect the price of apples).

The type of analysis that we used above, concentrating on one market and ignoring repercussions between what is going on in different markets is called

partial equilibrium analysis. A clear alternative is an analysis acknowledging all the interactions among all the markets of the economy. This kind of an approach is called *general equilibrium analysis* (an alternative expression is *total equilibrium analysis*).

A second limitation of our analysis is that we did not worry very much about the idea of *equilibrium*. For example, in the case of market equilibrium we courageously drew a supply curve and a demand curve intersecting each other and, *voilà,* there it is, the precious market equilibrium! This kind of courage is the privilege of all introductory expositions. If you think about it (a lot) more, it might happen that you get a little shyer. In more advanced essays you might be prepared for supply and demand curves that intersect more often than just once or, *horrors!*, which do not intersect at all. Moreover, the question might arise how prices and quantities might develop if an economy is, from the starting point, in a situation of disequilibrium. You might wonder what the conditions are for the equilibrium to be achieved at all, and what the path from the disequilibrium situation to the equilibrium might look like.

The aforementioned questions are dealt with in advanced microeconomic studies under the headlines of *uniqueness*, *existence,* and *stability* of equilibria. In the present analysis, these issues may be disregarded, and neither authors nor readers need to spend restless nights on it.

Microeconomic analysis, whether general or environmentally oriented, whether introductory or advanced, is concerned with the decisions of individual agents. This is perfectly in line with the word *micro*, the Greek expression for "little". However, judging content from label may turn out to be somewhat misleading. This is so in the present context because microeconomics also deals with significant aggregation procedures: think of the transition from individual demand to market demand as an example. Moreover, if you consider what has just been said about total equilibrium analysis, it is clear that microeconomics may very well deal with the economy as a whole, rather than solely with "little", after all.

On the other hand, even though there is aggregation in microeconomics and that aggregation is important, the highest level of aggregation considered is markets for different products and productive factors as well as their interaction. But it is possible to take aggregation much further. For example, you may not want to take a look at individual markets for different consumer goods but at total consumption of a national economy as a whole. In doing so, we are crossing the border, migrating from the realm of microeconomics to that of macroeconomics. What has just been said for the step from the individual market for certain consumer good to total consumption analogously holds for all other types of goods like physical investment goods, or bonds and other financial assets. What has been said for aggregating to the level of one nation analogously holds for groups of nations (like the European Union), and may be even extended to the world economy.

When you take aggregation to this extent, you lose the fine structure of the economy from your focus and are instead rewarded with being able to see the big picture. This is useful when we deal with economic indicators applied to whole nations, i.e., if you want to look at inflation or unemployment in a certain nation.

Other examples are the Gross Domestic Product (GDP) of a certain country, and its balance of international payments. You might be interested to see how these indicators have developed over time and are expected to develop in the future. You might also be interested in comparing the development of these kinds of indicators between different nations, such as comparing inflation in the European Union to that in the United States of America. Obviously, there are many macroeconomic issues beyond the examples given. Some of them are more consequential in the context of environmental issues than others. Using this as a criterion to decide which macroeconomic topics to deal with in this book, we decided to focus on *economic growth* and *national accounting*. Both issues are crucial in order to understand the idea of *sustainable development* in economic terms, and to work on the operationalization of this somewhat enigmatic concept.

Part III

Macroeconomics and the Natural Environment

Fundamental Concepts of Macroeconomics 9

9.1 Objectives and Methods of Macroeconomics

As was argued in Part II above, microeconomics analyzes the behaviour of *individual* economic agents and its coordination via the market mechanism. Utility maximization on the part of individual households and profit maximization by single firms form the key focus. Individual demand and supply functions for single goods such as, say, tomatoes, are deduced. By aggregating individual demand and supply functions, market demand and supply functions are constructed. Confronting aggregate demand with aggregate supply on the market for tomatoes allows a market equilibrium to be determined which is characterized by equilibrium values of the price of tomatoes and the quantity of tomatoes bought and sold. This procedure is called microeconomic *partial analysis* because only a small part of the whole economy, namely the market for tomatoes, is analyzed, while the many other markets (for wheat, washing powder, newspapers and so on) are neglected.

Based solely on the analysis of a single market, microeconomics produces important conclusions concerning the conditions which must be fulfilled for a market to work properly, i.e., to produce outcomes which are socially desirable without governmental interventions at all. In turn, conditions that may lead to socially undesirable market outcomes are investigated as well. An important example discussed in Part II was that of "external effects".

Whenever market mechanisms produce socially undesirable results, governmental interventions in the economic process may be justified. In Part II, an example of an economic policy device dealing with the problem of external effects was presented, namely the Pigouvian tax.

In advanced microeconomics, all the complex interdependencies between all of the single markets in an economy are taken into consideration. This allows us to answer questions such as: what happens to the equilibrium values of price and quantity on the market for tomatoes after a violent thunderstorm has destroyed a significant proportion of cucumbers growing in the fields? The answer will crucially depend on the tastes of individual households. A household favouring Greek salad

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may reduce its demand for tomatoes because they generate utility only together with cucumbers. Another household, aiming at a diet rich in vitamins, may actually raise its demand for tomatoes in order to compensate for the lack of cucumbers. On the market for tomatoes, the effect of the cucumber disaster on the equilibrium values of the price of tomatoes and quantity of tomatoes produced will depend on whether the "Greek" or the "vitamin" party has the majority. These interdependencies between different markets are analyzed using the method within microeconomics that is called *total analysis*, as opposed to the partial equilibrium analysis approach referred to above. Another very common expression for this kind of approach is *general equilibrium analysis*.

Unlike microeconomists, macroeconomists are not interested in questions like these at all. From a macroeconomic point of view, it is not important whether individual households differ with respect to their tastes. It is not relevant to them whether households buy and firms produce tomatoes or cucumbers or any other certain good. The reason is that macroeconomists are dealing with problems distinct from those relevant for microeconomists.

The very problem which led to the emergence of macroeconomics was the mass unemployment that occurred during the *Great Depression*, which began in 1929 and paralyzed economies throughout the world for several years. Subsequently, macroeconomists observed that unemployment may occur when (or: is defined by the fact that) the actual production of goods falls short of the productive capacity. Even the reverse scenario is perceived as a problem by macroeconomists because if the actual production of goods exceeds the productive capacity, prices of goods will rise, i.e., inflation will occur, affecting the functioning of the price mechanism.

Here, the crucial difference in comparison to microeconomics is that the term "actual production of goods" in macroeconomics is a highly aggregate concept. It doesn't matter at all whether tomatoes, cars, uniforms or medical services are produced. All that matters is the sum of the monetary values of each kind of good produced during a given period of time.

Similarly, the macroeconomic notion of "productive capacity" is a highly aggregate concept as well. It is defined as the total value of goods (again: no matter if these are ice cream, books, or screwdrivers) which could be produced given a "normal" utilization of the available stocks of productive factors (labour, capital etc.).

To summarize, unemployment and inflation are two important problems macroeconomists are concerned with. Both of them are caused by a divergence of the productive capacity, on the one hand, and the actual production of goods, on the other. Thus, from a macroeconomic perspective, first, the "productive capacity" and second, the "actual production of goods" are two central economic concepts. This will find its expression in the structure of the remainder of Chap. 9. Specifically, the development of the productive capacity over time ("economic growth") will be discussed in Sect. 9.2 below, while the empirical investigation of the actual production of goods ("national accounting") will be reviewed in Sect. 9.3.

This structure has been chosen primarily because it corresponds to the two fields of macroeconomics that have been attracting the attention of environmental economists in the literature (see Chap. 10 below).

The first of these fields is growth theory, since the *Club of Rome* claimed that the limited availability of natural resources must eventually limit economic growth. The report titled "The Limits to Growth" (Meadows et al. 1972) predicted the collapse of the global economic system due to the foreseeable exhaustion of essential productive natural resources, and led to the emergence of natural resource economics, which has meanwhile become an established branch of economic theory.

The second field of interest for environmental economists is national accounting, in which the traditional procedure of conducting national accounts has been criticized for neglecting, firstly, severe environmental consequences of human economic activity, and secondly, important productive aspects of the natural environment. As an example of the first line of critique, consider energy production through fossil fuel combustion. Such a mode of energy production causes a degradation of air quality due to emissions of pollutants, but the associated environmental costs do not appear in the traditional measures of national income at all. The second line of critique may be exemplified by the fact that, in the traditional system of national accounts, the breeding of fish on fish farms is treated as a process of production, while the natural growth of stocks of fish in the high seas is not, even though the latter is of great economic importance.

As an unavoidable consequence of focusing on these two areas, some fields of macroeconomics must be neglected, even though they are very interesting and important in their own right and of considerable practical significance for economic policy. This holds for the vast body of literature examining the theoretical causes of unemployment, inspired by John M. Keynes' *General Theory* (Keynes 1936), and its immediate and most influential interpretation by John R. Hicks (Hicks 1937). This also applies to the literature on monetary theory and policy, which is concerned with the role of central banks in modern market economies.

However, the selection of the two areas at hand is justified by the special environmental focus of the present text. After all, in analyzing the theoretical causes of unemployment, the natural environment has never been considered seriously; and the primary duty of central banks is to avoid inflation, with environmental aspects not a feature of the concerns of central banks at all.

9.2 Economic Growth

9.2.1 Driving Forces Behind Economic Growth

Economic growth is usually defined as a rise in real Gross Domestic Product (GDP) over time.[1] Real GDP, in turn, is defined as the real value of commodities and services produced in an economy during a given period. The term "real" implies that the effects of inflation on the value of production are eliminated.[2]

[1] See, e.g., Mankiw (2010), p. 191.

[2] For more detail on the definition of real GDP see Sect. 9.3.2 below.

Table 9.1 GDP, constant prices (National Currency), annual percentage change, 2007–2010 (see IMF 2011)

Country	2007	2008	2009	2010
China	14.199	9.599	9.220	10.328
India	9.991	6.186	6.771	10.094
Brazil	6.091	5.162	−0.645	7.490
Germany	3.394	0.809	−5.078	3.562
Luxembourg	6.639	1.440	−3.639	3.516
Canada	2.200	0.689	−2.770	3.215
USA	1.913	−0.337	−3.486	3.030
South Africa	5.568	3.576	−1.682	2.841
Australia	4.570	2.585	1.374	2.683
U.K.	2.685	−0.065	−4.875	1.354

In most cases, economic growth is judged to be desirable because it implies, *inter alia*, that there are more commodities and services available for the satisfaction of needs, and that government tax revenue rises, which thus makes possible the conduction of distributional and stabilizing policies (see Sect. 3.5 above).

Table 9.1 shows the growth rates of real GDP for selected countries from 2007 to 2010. The countries are ranked according to their growth rate in 2010. In 2009, many countries experienced negative growth rates due to the global financial crisis. Two notable exceptions are the Chinese growth rate of more than 9% and India's of more than 6% even on the summit of the crisis. In all other years as well the growth in Chinese real GDP exceeded that of the other countries' GDP by far. The same holds for India as another emerging economy.

A precondition for an economy's ability to produce goods and services at all is the availability of productive assets (which are to be interpreted as components of national wealth; see Sect. 9.3.3 below). Given a certain endowment of productive assets, the notion of an economy's "productive capacity" refers to the value of real GDP which can be achieved by a "normal" utilization of these productive assets.

In the short term, economic growth (i.e., a rise in real GDP) can be caused by a rising degree of employment of the existing productive assets. However, this possibility is limited by the maximum level of physical load-bearing capacity of all productive assets. In the long term, therefore, economic growth demands a rise in the stocks of productive assets available, which is shown in Fig. 9.1.

In Fig. 9.1, the time dimension t appears on the horizontal axis, while real GDP (GDP^r) is represented on the vertical axis. The curve $GDP_{max}^r(t)$ represents real GDP achievable over time when all attainable productive assets are utilized at the *maximum* level of their physical load-bearing capacity. By definition, it is impossible for *actual* real GDP (the curve $GDP^r(t)$ in the figure) to exceed this limit. The dotted curve $GDP_n^r(t)$ shows the productive capacity, i.e., real GDP achievable over time with a *normal* utilization of all productive assets.

Figure 9.1 shows a rise in the productive capacity over time. It also shows that the utilization of productive assets fluctuates over time. Therefore, in the short run, growth in actual real GDP can be caused by increasing utilization of a given

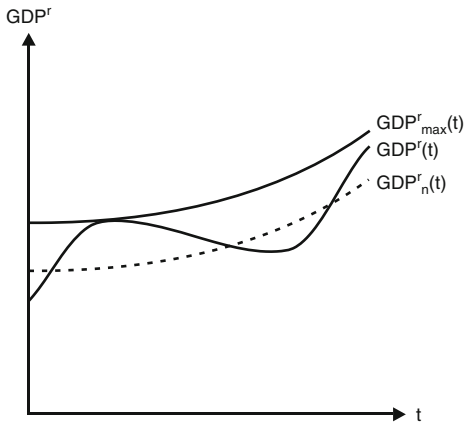

Fig. 9.1 Development and utilization of productive capacity over time

Table 9.2 Output gap in percent of potential GDP (see IMF 2011)

Country	2007	2008	2009	2010
Australia	0.994	0.839	−0.339	−0.187
Canada	1.682	0.231	−3.967	−2.425
Germany	2.700	2.325	−3.691	−1.559
U.K.	0.982	0.731	−3.696	−2.627
USA	0.017	−2.153	−7.096	−5.629

productive capacity, as is shown by the fluctuation of actual real GDP around the dotted line representing normal utilization of productive capacity. However, if, in the long run, the maintenance of a normal utilization of the productive capacity is desired (in order to avoid unemployment and inflation), continued growth in actual real GDP requires a rise in productive capacity.

Table 9.2 shows the fluctuations in the utilization of the productive capacity for selected countries. Output gaps are calculated as actual GDP less potential GDP as a percent of potential GDP. It is apparent that the global financial crisis caused a substantial underutilization of the productive capacity in all of the selected countries in 2009 and 2010. For example, in 2009 the utilization of the productive capacity of the United States was more than 7% below its potential level.

The causes and consequences of fluctuating utilization of the productive capacity in the short run are analyzed in business cycle theory. However, as was mentioned earlier, this branch of macroeconomics is not explored in detail in the present text because there has been no link established yet between business cycle theory and environmental and resource economics, which is more long-term in its focus.

A rise in productive capacity requires a rise in the stocks of one or more productive assets. In principle, a rise in the stocks of productive assets can be achieved by investment activities. Hence, investment is a precondition for a rise in the productive capacity which, in turn, is a precondition for long-term growth in real GDP.

What kind of stocks of productive assets are to be taken into consideration? In the context of the basic neoclassical model of economic growth developed by Solow (1956) and Swan (1956),[3] there are three stocks of productive assets: labour, capital, and the stock of available production methods. In this model, the term "labour" refers to the number of persons in work. The stock of "capital" consists of output from the past which has not been consumed, but instead has been accumulated for productive purposes (remember Böhm-Bawerk's roundabout character of production). Finally, the stock of available production methods determines the output achievable with given amounts of labour and capital (e.g., a plough can be drawn by an ox or by a tractor).

Hence, within this basic model of economic growth, there are three forms of investment representing the driving forces behind economic growth:

1. In the context of the Solow-Swan model, population growth is synonymous with investment in the stock of labour. Population growth raises the available workforce and, hence, the production possibilities.
2. Savings (i.e., nonconsumption) enable producers to accumulate new investment goods.[4] The stock of man-made productive capital and, therefore, the productive capacity, rise.
3. Technical progress, in the sense of a rise in the stock of available production methods, enables an economy to achieve a rising real GDP with given amounts of labour and capital (or, a given level of real GDP with lower amounts of labour and capital).

Table 9.3 shows the development of selected countries' population. Almost all of these countries (except Germany) experienced a continuous increase in population, i.e., a potential increase in the size of the labour force.

The investment in man-made capital stock is reported in Table 9.4 as a percentage of GDP. China and India, as newly emerging economies, devoted remarkably high shares of GDP to investment, although one has to bear in mind that their GDP is still rather small as compared to the developed economies appearing in the table.

9.2.2 Feasibility of Permanent Growth

In the context of their basic growth model, Solow and Swan assumed a constant rate of population growth, a constant proportion of GDP to be saved, and a constant rate of growth of the stock of available production methods (i.e., a constant rate of technical progress). Given these assumptions, the conclusions of the neoclassical growth model can be interpreted as follows: starting with a given endowment of labour, capital, and production methods, an economy will, in the long term, approximate a path of "steady state" growth. This path is characterized, for all

[3] For more detail on this model see, e.g., Mankiw (2010), pp. 191–225.

[4] This was already illustrated in Fig. 3.1 in Sect. 3.3 above.

Table 9.3 Population, million persons (see IMF 2011)

Country	2007	2008	2009	2010
Australia	21.263	21.731	21.952	22.226
Brazil	187.642	189.613	191.481	193.253
Canada	32.883	33.263	33.669	34.059
China	1,321.290	1,328.020	1,334.740	1,341.414
Germany	82.177	82.013	81.767	81.603
India	1,142.000	1,158.000	1,174.000	1,190.524
Luxembourg	0.480	0.488	0.497	0.507
South Africa	48.363	48.911	49.464	49.991
U.K.	60.975	61.373	61.798	62.222
USA	301.903	304.718	307.374	309.997

Table 9.4 Total investment, percent of GDP (see IMF 2011)

Country	2007	2008	2009	2010
Australia	29.259	29.541	27.853	27.592
Brazil	18.328	20.686	16.508	19.250
Canada	23.241	23.238	20.867	22.204
China	41.738	44.046	48.243	48.166
Germany	19.261	19.376	16.540	17.343
India	37.371	34.958	37.088	36.786
Luxembourg	20.922	20.284	16.353	16.304
South Africa	21.240	22.546	19.612	19.268
U.K.	18.175	16.648	13.478	15.015
USA	19.615	18.086	14.723	15.836

times to come, by a *constant rate of growth* of the economy's productive capacity. This constant rate of growth depends on the rate of population growth and on the rate of technical progress alone.[5] The crucial implication of this result is that, once the steady state has been achieved, the productive capacity will rise *exponentially*! Hence, in the Solow-Swan model the opportunities for economic growth to occur are principally unlimited.

9.3 National Accounting

9.3.1 Purposes of National Accounting

National accounting is conducted in order to measure the economic activity taking place in a country during a given period of time. In order to ensure international comparability of national accounts, the United Nations has provided

[5] See Mankiw (2010), p. 224f.

an "internationally agreed standard set of recommendations on how to compile measures of economic activity" (UN et al. 2009, p. 1). This standard is called the "System of National Accounts" (SNA). The SNA was last updated in 2008 (see UN et al. 2009). Since the present text addresses an international readership, the following sketch of national accounting is based on the United Nations' SNA rather than on any of the various national systems, which differ with regard to some details.

The SNA was designed for three main purposes (see UN et al. 2009, p. 4f.). First, it represents a tool for evaluating the overall performance of the economy, hence allowing judgements regarding the relative success or failure of a government's economic policies. Second, the SNA is used to investigate the causal mechanisms at work within an economy in order to provide a basis for economic policymaking and private decision making. Third, only by standardizing the procedures used in national accounting practice in different countries can it be achieved that a comparison of the resulting data will produce meaningful statements.

9.3.2 Measuring National Product

Imagine that institutional units resident[6] in country X produce 10,000 tonnes of corn, 15,000 tonnes of grapes and 5,000 barrels of wine in 2012. In the same year, institutional units resident in country Y produce 3,000 tonnes of bananas, 2,000 tonnes of sugar cane and 1,000 barrels of rum. Is it possible to compare the 2012 economic activity in both countries?

As a prerequisite for a comparison, the different goods produced in both countries need to be evaluated in monetary terms by using their market prices, including taxes on products like value added tax. After the monetary evaluation, the resulting amounts of money can be totalled. However, in order to avoid double counting, the value of "intermediate consumption" must be eliminated (the value of grapes is already included in the value of wine, and sugar cane is used to produce rum). Furthermore, the market prices used in evaluating the different products have to be adjusted for governmental taxes and subsidies which do not appear in the products' market prices.

The resulting sum of money is called "Gross Domestic Product" (GDP). GDP is defined as the periodical value of output produced by all resident institutional units less intermediate consumption, plus any taxes less subsidies on products not already included in the value of output (see UN et al. 2009, pp. 34, 630). GDP is a *flow* concept because it measures the value of all commodities and services produced from the beginning to the end of the accounting period.

[6] "An institutional unit is said to be resident within the economic territory of a country when it maintains a centre of predominant economic interest in that territory, that is, when it engages, or intends to engage, in economic activities or transactions on a significant scale either indefinitely or over a long period of time, usually interpreted as one year" (UN et al. 2009, p. 7f.).

Table 9.5 GDP, current prices, billion US$, 2010 (see IMF 2011)

Country	GDP
USA	14,526.550
China	5,878.257
Germany	3,286.451
U.K.	2,250.209
Brazil	2,090.314
India	1,631.970
Canada	1,577.040
Australia	1,237.363
South Africa	363.655
Luxembourg	55.195

It is important to note that GDP comprises only *economic* production, with economic production defined as production that crosses the "general production boundary" (see UN et al. 2009, p. 97f.). The general production boundary is crossed only if the productive activity is carried out under the control and responsibility of an institutional unit.

Readers who might have happened upon the statistical tables of the World Bank, the International Monetary Fund or national statistical offices will have noticed that sometimes "nominal" GDP is reported, whereas in other statistical tables, "real" GDP appears. The difference lies in the prices used to evaluate the products. Nominal GDP is computed using market prices from the *current* period. This bears an important disadvantage. For, if a country produces an identical physical amount of coal both in 2012 and 2013 – say, 1,000 tonnes – a mere change in the market price of coal would suggest that the economic activity has changed, which it actually has not. In order to eliminate the effect of price changes on GDP, the given amount of coal can be evaluated, in both periods, using prices from the same period: either coal prices from 2013, or prices from 2012, or from any other arbitrarily chosen year. In the general case, all goods are equalized according to a *standardized base measurement*. The resulting aggregate is called real GDP.

Table 9.5 shows the value of nominal GDP for selected countries all over the world in 2010. With regard to GDP, the United States of America is the biggest economy in the world. In 2010, the GDP of the United States was about 2.5 times higher than that of China and even about 263 times higher than that of Luxembourg.

However, the picture changes immediately if nominal GDP is divided by the number of the countries' inhabitants. As Table 9.6 reports, in 2010 the GDP per capita was substantially higher in Luxembourg than in the USA. China attained just about 4% of Luxembourg's GDP per capita.

9.3.3 Measuring National Wealth

All of the index numbers defined in the preceding subsection represent *flow* concepts. Flow concepts are measured as accumulating between the beginning and the end of the accounting period, say, between January 1 and December 31.

Table 9.6 GDP per capita, current prices, US$, 2010 (see IMF 2011)

Country	GDP per capita
Luxembourg	108,951.721
Australia	55,671.620
USA	46,860.242
Canada	46,302.668
Germany	40,273.516
U.K.	36,164.101
Brazil	10,816.487
South Africa	7,274.416
China	4,382.136
India	1,370.800

In contrast to this, wealth is a *stock* concept. A stock is measured at a certain point in time, in particular at the beginning (on January 1) and, again, at the end of an accounting period (on December 31). In the present subsection, the procedure by which national wealth is computed within the SNA framework will be outlined.[7]

In order to report the value of national wealth, the SNA includes a *balance sheet* which gives the values of various stocks of assets held by institutional units.[8] A stock is incorporated into the SNA balance sheet only if it crosses the so-called "asset boundary", i.e., if it fulfills the following two criteria simultaneously (see UN et al. 2009, p. 7):

1. The stock in question must be owned by some institutional unit, or units;
2. Economic benefits must be derived from the stock in question by their owner(s) as a result of holding or using them over a period of time.

There are a lot of stocks which actually meet both criteria, like, e.g., a cab owned and profitably used by a taxi driver. A variety of stocks both owned and beneficially used by institutional units are listed in Fig. 9.2 below. However, there are many stocks which do not fulfill both criteria simultaneously and, therefore, are not included in national wealth accounting. In particular, this holds for numerous natural resources that meet only one of the criteria (see UN et al. 2009, p. 7). No ownership rights can be exercised over the atmosphere or the high seas, although economic benefits are derived from both of them (oxygen is an input for any kind of combustion, and fish is harvested from all over the oceans). Mineral or fuel deposits effectively owned by institutional units may be unworkable and, therefore, do not bring any benefits to their owners, given the existing technology and relative prices.

The stocks of assets included in the SNA balance sheet are listed in Fig. 9.2. In the following, the asset categories which appear in Fig. 9.2 will be explained[9] where

[7] The present subsection is based on UN et al. (2009), pp. 195–269.

[8] The institutional units taken into consideration are non-financial corporations (like producers of automobiles), financial corporations (like banks), the general government, households and non-profit institutions serving households (NPISHs, e.g., non-governmental charitable institutions like the Red Cross).

[9] For more detail on the following, see UN et al. (2009), pp. 205–15.

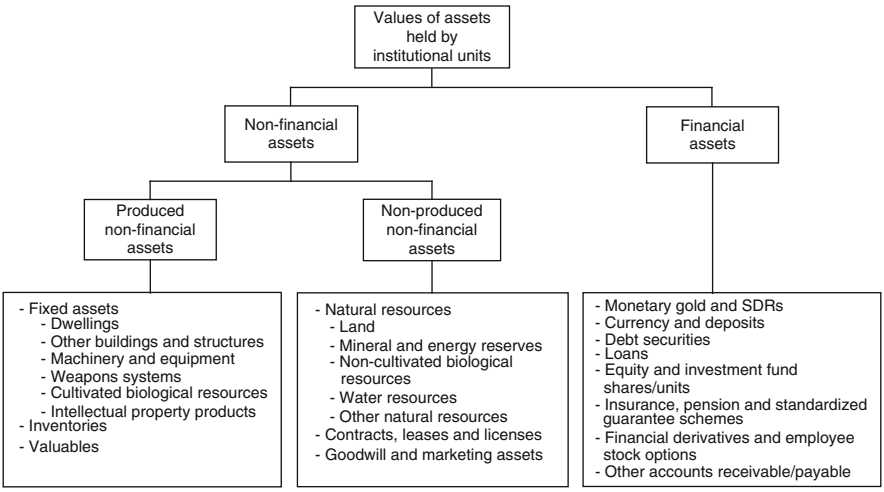

Fig. 9.2 Components of national wealth as computed in the SNA (see UN et al. 2009, p. 260)

necessary, beginning with the produced non-financial assets on the left-hand side of the diagram. Fixed assets are produced assets that are used repeatedly or continuously in production processes for more than 1 year, like machinery and equipment. But cultivated biological assets are also taken into consideration, with the term "cultivated" indicating that their natural growth and regeneration are under the direct control, responsibility and management of institutional units. These can be animals or plants that are used repeatedly or continuously to produce other products such as fruit or dairy products. The animal resources taken into account include breeding stocks, dairy cattle, draft animals, sheep or other animals used for wool production, and animals used for transportation, racing or entertainment. Aquatic resources which repeatedly yield products are included, as well as trees (including vines and shrubs) cultivated for fruits and nuts, for sap and resin and for bark and leaf products.

In addition, fixed assets may also include intellectual property products such as software or artistic originals, which are used in production. Inventories are produced assets that are held for sale, use in production or other use at a later date. Valuables are produced goods of considerable value that are not used primarily for purposes of production or consumption but are held as stores of value over time. They comprise precious metals and stones, jewellery, works of art, etc.

In the middle column of Fig. 9.2, non-produced, non-financial assets are listed. These comprise naturally occurring resources such as land, water resources, non-cultivated forests and deposits of minerals that have an economic value. The term non-cultivated indicates that their natural growth and regeneration are *not* under the direct control, responsibility and management of institutional units.

Land consists of the ground, including the soil covering and any associated surface waters, to which ownership rights apply and from which economic benefits can be derived by its owners by holding or using it. Buildings or other structures situated on the land or running through it are excluded, as well as cultivated crops, trees and animals, mineral and energy resources, non-cultivated biological

resources and water resources below the ground. Surface water includes any inland waters (reservoirs, lakes, rivers, etc.) over which ownership rights can be exercised.

Mineral and energy resources comprise reserves located on or below the earth's surface, including reserves under the sea, that are economically exploitable, given the existing technology and current relative prices. They consist of known reserves of coal, oil, gas or other fuels and metallic ores, and non-metallic minerals, etc.

Animals, birds, fish and plants that yield products either on a one-off basis or repeatedly over which ownership rights are enforced, but for which natural growth or regeneration is not under the direct control, responsibility and management of institutional units, are labelled "non-cultivated biological resources". Virgin forests and fisheries within the territory of a country may serve as examples.

Water resources include surface and groundwater resources used for extraction, given that scarcity of these resources leads to the enforcement of ownership or use rights, market valuation and some measure of economic control. The category "other natural resources" currently includes radio spectra (see UN et al. 2009, p. 215).

Another category of non-produced, non-financial assets requiring some explanation is that of "goodwill and marketing assets". These are recorded only when a unit is purchased in its entirety or an identifiable marketing asset is sold to another unit. In these cases, purchasers often pay a premium above the net value of the individually identified and valued assets and liabilities. This excess is described as "goodwill", and reflects the value of corporate structures, as well as that of an assembled workforce and management, corporate culture, distribution networks and customer base. It may also include the value of marketing assets like brand names, mastheads, trademarks, logos and domain names.

Finally, as can be seen on the right-hand side of Fig. 9.2, financial assets consist of all financial claims, shares or other equity in corporations, plus gold bullion held by monetary authorities as a reserve asset. By taking into consideration assets as well as liabilities, the net lending or borrowing vis-a-vis the rest of the world is documented here.

At the beginning of the accounting period, an opening balance sheet is set up reporting the initial values of the stocks of all the assets listed in Fig. 9.2. During the period, the changes in the values of the assets (which constitute a flow concept) are computed. Together, the stock values of the opening balance sheet and the flows of the value changes of all the assets allow a closing balance sheet to be set up at the end of the accounting period reporting the end values of the stocks of assets.

The flows of changes in the values of assets are reported in four special accounts, namely the "capital account", the "financial account", the "revaluation account", and the "other changes in the volume of assets account". The capital account reports changes in the values of non-financial assets which are the result of *transactions* between institutional units. Similarly, the financial account records changes in the values of financial assets and liabilities which are the result of *transactions*. The revaluation account reports changes in the values of both non-financial and financial assets that result from *price changes*. The other changes in the volume of assets account reports changes in the values of both non-financial and financial assets that result neither from transactions nor price changes, but from other events such as natural disasters or war.

Review Questions

1. What are the main differences between a microeconomic analysis, on the one hand, and a macroeconomic analysis, on the other?
2. Please define "economic growth"!
3. Which stocks constitute productive capacity in the basic neoclassical model of economic growth?
4. What are the three forces generating economic growth in the basic neoclassical growth model?
5. Which growth pattern will eventually emerge in the Solow-Swan-model?
6. What are the purposes of national accounting?
7. How is real Gross Domestic Product defined?
8. Please explain the "general production boundary" of the United Nations' System of National Accounts!
9. How is national wealth accounted for in the United Nations' System of National Accounts?
10. What is the "asset boundary" of the United Nations' System of National Accounts?

Exercises

1. Please explain the interrelationship between "productive capacity" and "actual production of goods"!
2. Please explain the importance of the concepts of "productive capacity" and "investment" for the process of economic growth!
3. Please explain the difference between a "flow concept" and a "stock concept" and give some examples!
4. What is the difference between "nominal GDP" and "real GDP"?
5. Please explain the main categories of national wealth as reported in the balance sheet of the United Nations' System of National Accounts!

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A Sketch of Environmental Macroeconomics

10

10.1 Economic Growth and the Natural Environment

10.1.1 Natural Limits to Growth

In Sect. 4.3 above it was argued that natural resources make a substantial contribution to production. Many stocks of natural resources are components of an economy's productive potential. For a country like Norway, exhaustible natural resources, namely the deposits of fossil fuels below the Norwegian sea, belong to its productive capacity, as well as renewable natural resources like the famous Norwegian wood and water resources used in energy production. For agriculturally structured regions like the United States Mid-west, the quality of the soil and the availability of water resources are of great productive importance. In a country like Austria, engaging heavily in the tourist sector, climate stability may be considered an important component of the productive capacity because, on the one hand, global warming may reduce the snowfall in skiing areas in winter and, on the other, it may endanger mountaineers by causing rockfall and mudflows in summer. From a Caribbean point of view, the cleanliness of the sea water is a precondition for generating income by attracting spa visitors, and for China, rare earths become an increasingly important component of the productive capacity.

However, in the basic model of neoclassical growth theory, the productive contribution of natural resources is neglected completely. The question arises as to whether the conclusion of neoclassical growth theory – that infinite economic growth is feasible – is invalidated by the presence of productive natural resources, in particular non-renewable natural resources. In 1972, the optimistic perspective of the Solow-Swan model (see Sect. 9.2) was challenged by the Club of Rome's report "The Limits to Growth" (Meadows et al. 1972). In this report it was predicted that, in just a few decades, some essential non-renewable natural factors of production would be exhausted. As a consequence, the global economy would collapse, and the

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standard of living would fall significantly all over the world.[1] As early as 1973, the first oil crisis, though not caused by natural scarcity but by the market power of the Organization of the Petroleum Exporting Countries (OPEC), gave people a realistic impression of the scenario delineated by the Club of Rome just 1 year before.

10.1.2 Sustainable Development

In economic theory and growth theory in particular, the challenge posed by the Club of Rome led to the emergence of natural resource economics, on the basis of some prior work by Hotelling (1931). The starting signal was given by some recognized neoclassical growth theorists in a special edition of the Review of Economic Studies in 1974. The aim of this joint effort was to disprove the pessimistic theses of the Club of Rome within the context of a neoclassical growth model supplemented by a non-renewable natural factor of production. The authors tried to demonstrate that unlimited economic growth would be possible, even if production relied on non-renewables.

In these early stages of neoclassical resource economics, the predominant goal became the achieving of the highest possible constant per capita level of consumption of produced commodities and services for all times to come, irrespective of the dependence of production on an exhaustible natural factor of production. Solow (1974) deduced this goal from Rawls' (1971) theory of justice. Since then, the goal of sustainable development has rested on the postulate of intergenerational justice. Even the terminology of these early analyses makes clear the close link to the contemporary sustainability debate:

> This study is an attempt to determine more precisely under what conditions a *sustainable* level of [...] consumption is feasible [...] in the presence of an exhaustible natural resource. (Stiglitz 1974, p. 123, italics added)

The central message of this work was stated more precisely a few years later by Hartwick (1977) and generalized by Dixit et al. (1980): the economic collapse predicted by the Club of Rome could be prevented if, at any point in time, the inevitable decline in the stock of the non-renewable factor of production (e.g., fossil fuels) were offset by "sufficient" investment in other productive assets. Those other productive assets could be man-made capital goods (like wind energy plants), as well as human capital (increased knowledge concerning energy saving technologies) or renewable natural resources (firewood from forests).

There are many ways to invest in various productive assets. Investment can be both quantitative and qualitative in nature. The labour potential depends both on the number of workers available and on their level of education, health, and motivation.

[1] The "doomsday" vision of the Club of Rome's report has frequently been linked to Thomas R. Malthus' thesis that the chance of human progress is limited because "the power of population is indefinitely greater than the power in the earth to produce subsistence for man" (Malthus 1999, p. 13), which he published anonymously in 1798.

The quantity of an economy's labour force can be enhanced by a rising number of births or by immigration. It can also be increased by a rise in labour market participation, e.g., on the part of parents with young children or by extending the working lifespan by attaining an earlier entry into work (perhaps via shortening the education period) or delaying entry into retirement. The quality of labour can be improved by education and training, improved health care and measures to enhance employee motivation.

With regard to man-made capital, its quantity can be enhanced by installation of additional machines, tools and buildings, by building infrastructure like highways, railroads, harbours, and airports. The quality of the man-made capital stock rises if new capital goods are more productive than the older ones, owing to, for example, the embedding of a more advanced level of technical knowledge.

Investments in the stock of knowledge can be made by research and development activities. In this context the special feature arises that new knowledge stored in books, on DVDs, or on web servers is not productive on its own. However, it must be incorporated into the labour force by education, training, and/or into a new generation of machines by construction activities.

But, of course, the idea and nature of investment activities carries over to natural resources as well. In analogy to man-made and human capital, the stocks of productive natural resources can be enlarged by investment activities. In the case of renewable natural resources like forests, stocks may be enlarged actively by afforestation (which, incidentally, has positive effects on climate stability as well). A "passive" form of investment would be a (temporary) renunciation of harvesting renewable natural resources in order to allow for a regeneration of the stocks of endangered plants (tropical wood) or animals (sea fish). Finally, the stocks of endangered species can be protected by the establishment of protected areas where human activities are regulated.

With regard to non-renewable natural resources like fossil fuels, investments are possible as well, although the stock of the resource existing on earth, by definition, cannot be enlarged. Investments can take the form of exploration activities which add former unknown resource deposits to the reserves. At present, there are significant exploration activities being carried out in the North Pole region which bear a significant potential for conflict, namely between Russia and Canada. In the special case of fossil fuels, however, one should bear in mind that investment in reserves through exploration activities implies a negative investment as regards another stock of natural resources, namely the cleanliness of the atmosphere and climate stability: the productive use of the newly explored fossil fuels will inevitably raise the atmospheric concentration of greenhouse gases.

Another "roundabout" method of investing in non-renewable natural resources may take the form of developing new techniques of depletion or utilization. On the one hand, new depletion techniques can make already known but formerly unattainable deposits workable. On the other hand, more efficient techniques of using non-renewable natural resources may extend the time span over which the resource remains available.

To summarize, the basic idea developed in neoclassical resource economics in order to avoid the Club of Rome's "doomsday" scenario was to substitute for the decline in some of the productive natural resources by investing in both other natural resources and in man-made capital, human capital, and knowledge. Apparently, this strategy depends crucially on the assumptions, firstly, that substitution for natural resources is possible at all and, secondly, that substitution possibilities are sufficiently "good".

Let us more closely explore the nature of the argument that sustainable development requires investment on the part of the present generation within the context of a little example. Imagine a country (like Norway or Venezuela) possessing large offshore deposits of fossil fuels. The quantity of fossil fuels available measured in barrels is R, which cannot be increased over time. For the sake of simplicity, assume that there are only two time periods, namely "today" (period 1) and "tomorrow" (period 2). The country has to decide which share of R to extract today and which share, in turn, tomorrow. In each period, the amount extracted can be sold on perfectly competitive world markets (see the explanation of a perfectly competitive market in Sect. 6.4, above). At the beginning of the first period, the government has to sign contracts with regard to resource sales and prices today and tomorrow.

An intertemporally efficient utilization of the resource deposit (i.e., a utilization satisfying the economic principle, see Sect. 3.1 above) requires maximizing intertemporal profits from extracting and selling the resource. Intertemporal profits can be enhanced by investing today's profit on competitive world capital markets at the prevailing interest rate, r.

The very nature of the decision the country faces has been analyzed by Harold Hotelling, whose article "The Economics of Exhaustible Resources" (Hotelling 1931) provided the foundation for modern natural resource economics and its applications today. Hotelling interpreted this decision in the following way: on the one hand, any barrel extracted today, if invested on world capital markets, yields an interest rate r. On the other, any barrel left in the ground and extracted tomorrow benefits from the increasing scarcity of the resource, resulting in a rise in the resource price. In negotiating both the amounts extracted and the prices today and tomorrow at the beginning of period 1, the government should balance both effects. As long as the interest rate exceeds (falls short of) the growth rate of the resource price, the government should offer a higher (lower) extraction today. If rational suppliers all over the world behave in this way, a rising (declining) scarcity in the second period will be the consequence and the price change from today to tomorrow will increase (decrease). Eventually, the government should agree upon an extraction path characterized by the famous *Hotelling Rule*[2]:

$$r = \frac{p_2 - p_1}{p_1}. \tag{10.1}$$

[2] See, for example, Tisdell (2010), Endres (2011), Hackett (2011).

Note that p_i represents the resource's *net* price in period i, i.e., the price received for an additional resource unit extracted after paying the marginal cost of extraction (see Hotelling 1931, p. 141). As soon as the percentage change of the resource's net price (appearing on the right hand side of Eq. 10.1) equates the interest rate, the interest return of any barrel extracted today is the same as that of any barrel left in the ground for future extraction.

Some of our readers may suspect that efficiency in the sense of intertemporal profit maximization is the wrong approach in dealing with our natural environment. Of course, it is exactly this attitude that might stand behind the goal of sustainable development, the latter being deduced from the criterion of intergenerational justice. After all, it might be objected, what has profit maximization to do with justice?

Surprisingly, there is no conflict between the goals of intertemporal profit maximization and intergenerational justice. On the contrary, intertemporal profit maximization makes it possible to attain intergenerational justice *at the highest possible level*. Sure, if it is postulated that both the present and future generation get an equal share of the benefits of resource extraction, this condition can be met by leaving the entire resource stock in the ground. There will be no benefit attained from the resource neither today nor tomorrow, but at least intergenerational justice is implemented. A more comfortable alternative would be to extract exactly one half of the resource stock in each period. Since identical supply in each period implies constant resource prices, both generations would get the same amount of money.

However, if intergenerational justice is to be realized at a *maximum* (and, of course, equal) benefit from the resource use for both generations, it turns out that the extraction path should satisfy Hotelling's Rule as well: the amounts of resource extraction should be exactly the same, in both periods, as under the goal of intertemporal profit maximization. This might be surprising at first glance, but it is absolutely convincing that, in the first instance, the cake should be baked as big as possible, before justice is implemented by saving and investing on the part of the present generation.

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Let us first analyse an efficient utilization of a non-renewable natural resource. The amount extracted today, R_1, can be sold at the present market price P_1. Extraction imposes cost $C(R_1)$ which has to be subtracted from today's revenue P_1R_1 in order to obtain today's profit $\Pi_1 = P_1R_1 - C(R_1)$. The latter can be invested at the interest rate r. Tomorrow's profit is $\Pi_2 = P_2(R-R_1) - C(R-R_1)$. Viewed from the end of period 2, total profit is

$$\Pi = (1+r)\Pi_1 + \Pi_2 = (1+r)[P_1R_1 - C(R_1)] + P_2(R-R_1) - C(R-R_1).$$

(continued)

Intertemporal profit maximization requires zero marginal profits:

$$\frac{d\Pi}{dR_1} = (1+r)[P_1 - MC(R_1)] - P_2 + MC(R - R_1) = 0.$$

Defining $p_i = P_i - MC(R_i)$ as the resource's net price in period i, we can rearrange to obtain Hotelling's Rule:

$$r = \frac{p_2 - p_1}{p_1}.$$

Now we turn to an intergenerationally just utilization of the non-renewable natural resource. According to Solow (1974), the latter requires identical consumption in both periods. Consumption in the first period is profit minus savings (S), while consumption in the second period is profit plus savings of the first period plus interest payments. Hence, intergenerational equity requires:

$$P_1 \cdot R_1 - C(R_1) - S = P_2 \cdot (R - R_1) - C(R - R_1) + (1+r) \cdot S. \quad (10.2)$$

Does the extraction path change, as compared to intertemporal profit maximization, if intergenerational justice is postulated? In order to answer this question we maximize, by the choice of R_1 and S, today's consumption subject to the restriction that consumption in both periods is equal:

$$P_1 \cdot R_1 - C(R_1) - S = \max!$$

subject to Eq. 10.2.

We solve this problem using the Lagrangian approach. The Lagrangian function is

$$\begin{aligned} L = {} & P_1 R_1 - C(R_1) - S \\ & + \lambda[P_2(R - R_1) - C(R - R_1) + (1+r)S - P_1 R_1 + C(R_1) + S]. \end{aligned}$$

The first order conditions for a maximum of L are:

$$0 = \frac{\partial L}{\partial R_1} = P_1 - MC(R_1) + \lambda[-P_2 + MC(R - R_1) - P_1 + MC(R_1)]. \quad (10.3)$$

$$0 = \frac{\partial L}{\partial S} = -1 + \lambda[(1+r) + 1]. \quad (10.4)$$

$$0 = \frac{\partial L}{\partial \lambda} = P_2(R - R_1) - C(R - R_1) + (1 + r)S - P_1 R_1 + C(R_1) + S. \quad (10.5)$$

Again, using the already defined symbol p_i for the resource's net price in period i, we solve Eq. 10.4 for λ, substituting for λ in Eq. 10.3 and rearrange to obtain:

$$r = \frac{p_2 - p_1}{p_1}.$$

This is exactly Hotelling's Rule, which was already obtained in maximizing the intertemporal profits above! This means that the intertemporal extraction path of the non-renewable natural resource is exactly the same as that which is obtained without any idea of intergenerational justice.

Sustainable development is not attained by changing the path of resource extraction but solely by appropriate savings of the present generation. Apply the definition of the periodical profit $\Pi_i: = P_i \cdot R_i - C(R_i)$ given above, and rearrange Eq. 10.2 to obtain:

$$S = \frac{\Pi_1 - \Pi_2}{2 + r}.$$

This is the saving rule which ensures, in our simple model, sustainable development. It only holds if, in addition, Hotelling's Rule is obeyed, such that sustainable development is realized at a *maximum* level of consumption for both generations.

The saving rule states that there is no need to save for the present generation at all if the resource is extracted so as to obtain equal profits in both periods. However, if a path of resource extraction that generates a higher profit in the first period than in the second is realized (which may be motivated by the goal of realizing intergenerational justice at a maximum level of consumption for both generations), the present generation has to save a positive amount of money in order to share the difference $\Pi_1 - \Pi_2$ among both generations. Since savings yield an interest payment, the amount to be saved is less than one half of the difference $\Pi_1 - \Pi_2$ (note that $1/(2 + r) < 1/2$, if $r > 0$).

Theoretical considerations like these have been brought into the political focus as well since the United Nation's "Brundtland Commission" published its report titled "Our Common Future" (WCED 1987). The so-called Brundtland Report made popular the notion of sustainable development, as was already mentioned in Sect. 4.5 above.

In 1983, the United Nations founded a "World Commission on Environment and Development", WCED. The commission's task was to develop a strategy for sustainable development. It consisted of non-governmental representatives of many countries and was led by the then Norwegian Prime Minister Gro Harlem Brundtland. The "Brundtland Commission" concluded that a continuation of the usual patterns of societal and economic development had to be avoided because their consequences were the hunger and poverty of a growing number of people in the developing world, on the one hand, and environmental degradation, on the other. The commission linked the problems of poverty and environmental degradation. One of the commission's main theses was that poverty is, at the same time, cause and consequence of environmental damage.

The WCED recommended a bundle of measures in order to achieve sustainable development. As a central element, this bundle contained the goal of stimulating economic growth in order to fight poverty in many developing countries. The commission has been criticized for favouring economic growth because it was questioned whether the latter could simultaneously solve the global environmental problems as well.

In 1992, the United Nations made sustainable development one of their predominant goals of the United Nations Conference for Environment and Development (UNCED) in Rio de Janeiro. At the 1992 Earth Summit, the international community adopted Agenda 21,[3] a global plan of action for sustainable development. Ten years later, delegations from all over the world met again at the World Summit on Sustainable Development in Johannesburg, South Africa, feeling that progress in implementing sustainable development had been disappointing since Rio 1992, since poverty had been deepening and environmental degradation worsening. Another decade later, the 2012 United Nations Conference on Sustainable Development will be held (written March 2012) from 4 to 6 June 2012, again, in Rio de Janeiro, Brazil.[4] "Rio + 20" is the attempt "to secure renewed political commitment for sustainable development, assess the progress to date and the remaining gaps in the implementation of the outcomes of the major summits on sustainable development, and address new and emerging challenges".[5] A few months before Rio + 20, the international negotiations on sustainable development held so far seem to illustrate the problem described in Sect. 7.3, above: since a world government does not exist, policies toward sustainable development have to be voluntarily agreed upon among sovereign countries. In situations like this, there is a strong incentive for free riding. Hence, sustainable development as a global public good has not yet been provided.

Meanwhile, a quarter of a century after the Brundtland Report, many countries have adopted the goal of sustainable development. However, despite all the confessions, it seems that the idea of substituting for declining stocks of non-renewable natural resources with investments in other productive assets up to

[3] See http://www.un.org/esa/dsd/agenda21/res_agenda21_00.shtml?utm_source=OldRedirect &utm_medium=redirect&utm_content=dsd&utm_campaign=OldRedirect. Accessed 29 March 2012.

[4] See http://www.un.org/News/Press/docs/2011/envdev1201.doc.htm. Accessed 29 March 2012.

[5] http://www.uncsd2012.org/rio20/objectiveandthemes.html. Accessed 29 March 2012.

now has been implemented by the Norwegian government only. As already mentioned in Sect. 4.6 above, the Norway's Government Pension Fund invests the revenues from the exploitation of Norwegian stocks of fossil fuels in the buying of shares in firms all over the world. However, while the Norwegian government implements the idea for the sake of its own people, the fund cannot be seen as an instrument of *global* sustainability, because the fossil fuels extracted from Norwegian seas will inevitably contribute to the acceleration of global warming. There seems to be no compensation on the part of the Norwegian government for this.

The Brundtland Report provided a platform for the emergence of a new branch of economic theory called "Ecological Economics", which has been labelled the "science and management of sustainability" (Costanza 1991). Ecological economists criticize neoclassical natural resource economics on three counts.[6] First, it is argued that the ethical foundations of neoclassical theory are inappropriate for tackling environmental problems. With regard to this line of critique, we may again refer to Sect. 4.5 above, where the anthropocentric point of view of neoclassical economics was contrasted with the ecocentric point of view held by many ecological economists. Secondly, ecological economists deny the possibility of substituting man-made assets for natural resources which is of great importance in the growth models of neoclassical resource economics. Thirdly, ecological economists have lamented that neoclassical economists neglect the insights of natural sciences like physics, biology and ecology in their models. For example, ecological economists frequently emphasize the importance of thermodynamics for economic processes and conclude from that, again, that economic growth is limited by the natural framework of human economic activity. Moreover, ecological economists not only deny the possibility of unlimited growth but interpret economic growth as socially undesirable.

10.2 National Accounting and the Natural Environment

10.2.1 Integrated Environmental and Economic Accounting

If the focus is shifted to the natural environment, various shortcomings of both the concept of a country's product (discussed in subsection 9.3.2 above) and that of a country's wealth (explained in subsection 9.3.3) come to light. In particular, the integration of the natural environment in the process of computing national product and wealth proves to be *incomplete* (see UN et al. 2009, pp. 6–9). In the present subsection, continuing the systematology set up in subsections 9.3.2 and 9.3.3, two broad lines of critique of the traditional SNA framework are delineated. The first line claims that the natural environment is not appropriately taken into account in the process of measuring national product, while the second suggests that important parts of the natural environment are also neglected computing national wealth.

[6] See, e.g., Daly and Farley (2011).

In order to illustrate that natural resources are not considered comprehensively in measuring national product, let us consider an example which has become a sad reality in recent decades more than once: an oil tanker sinks and coasts are made filthy; many plants and animals die. Huge amounts of money must be spent on cleaning up birds, beaches, the water surface, and so on. The latter expenditures find expression in GDP, because private corporations are hired and gain income which appears in GDP. However, the cost of damage to the environment does not appear in GDP. But, it is argued, it should appear in GDP, and if it did, the resulting index number would be lower than GDP itself.

Moreover, it is argued that the measurement of the productive services of natural resources in GDP is incomplete in the traditional SNA framework. In particular, certain natural processes may or may not be counted as production depending upon whether or not they are carried out under the control and responsibility of some institutional unit that exercises ownership rights over whatever is produced. While the natural growth of stocks of fish in the high seas is not counted as production because the process is not managed by any institutional unit and the fish do not belong to any institutional unit, the growth of fish in fish farms is, however, treated as a process of production.

The traditional SNA is also incomplete with regard to the measurement of national wealth, because many natural resources do not cross the asset boundary (see UN et al. 2009, p. 212 f.). First, only those natural resources over which ownership rights have been established and are effectively enforced qualify as assets. Certain naturally occurring resources may be such that it is not feasible to establish ownership over them, for example, air, or the oceans. Others cannot be treated as economic assets because they do not actually belong to any particular units. These include those whose existence is unknown, as well as those, including uncultivated forests, that may be known to exist but remain so remote or inaccessible that, in practice, they are not under the effective control of any units.

Secondly, natural assets must also be capable of bringing economic benefits to their owners, given the available technology, scientific knowledge, economic infrastructure, resources and set of relative prices.

In light of these arguments, a vast number of approaches have been developed in the literature intending to modify or to supplement the SNA in order to document the interdependencies between the environment and human economic activity properly. However, it seems impossible to discuss this diverse range of approaches in an introductory text like this. Therefore, the present section refers mainly to the 2003 revision of the United Nations' System of Integrated Environmental and Economic Accounting (see UN et al. 2003), which is commonly referred to as "SEEA".[7] The 2003 revision was undertaken as a joint project between the United Nations, the European Commission, the International Monetary Fund, the Organization for Economic Co-operation and Development and the World Bank. The handbook has been selected here because it can be seen as a major step towards internationally

[7] A first part of the latest revision of the SEEA was published in May 2012, after the work on the present textbook had been already published. See https: unstats.un.org/unsd/envaccounting/seearev/. Accessed 26 July 2012.

standardized concepts and definitions, and will also provide the basis for the further discussion of the development of standards. In particular, "[t]he handbook provides a common framework for economic and environmental information, permitting a consistent analysis of the contribution of the environment to the economy and of the impact of the economy on the environment" (UN et al. 2003, p. iii).

The SEEA is a satellite system of the SNA (see UN et al. 2003, p. 8). The notion of a "satellite system" implies that the SEEA is alongside the conventional SNA without modifying the actual aggregate measures of the SNA, i.e., the aggregate index numbers measuring national product (like GDP) and the balance sheet measuring national wealth.

There are strong links, in the SEEA, to subsection 9.3.3, dealing with national wealth. However, there are no such links to subsection 9.3.2 above, which discussed the measurement of national product.

The wealth measurement of the traditional SNA excludes stocks of natural resources over which ownership rights have not been established and are not effectively enforced. Such stocks are not under the control and responsibility of some institutional unit and are therefore not taken into account in the SNA. In contrast to this, the SEEA seeks to investigate the contribution of a nation's natural capital to its well-being in a comprehensive manner. The SEEA consists of four data categories:

1. Accounts of environmental assets in physical and monetary terms;
2. Accounts of depletion of natural resources, of defensive expenditure as a reaction to environmental damages, and of environmental degradation;
3. Accounts of *physical flows* of materials and energy and of *hybrid flows* connecting physical information about the use of environmental resources to information in both physical and monetary terms about the associated processes of economic production;
4. Accounts of environment-related transactions like environmental protection expenditure made by governments, firms and households, as well as governments' economic policy instruments intended to encourage environmentally friendly behaviour.

While the data of type 1 directly assist in the measurement of natural components of national wealth, data of types 2–4 may be interpreted by analogy with the "capital account" and the "other changes in the volume of assets account" of the traditional SNA. As was mentioned at the end of subsection 9.3.3, the latter accounts are designed to measure changes in the stocks of assets.

In order to exemplify the SEEA procedure, the physical stocks of natural assets taken into account in the SEEA (i.e., type 1 data) are listed in Table 10.1. The difference in comparison to the traditional SNA becomes most clear in point 3, where ecosystems are taken into consideration. Ecosystems are defined "as groups of organisms and the physical environment they inhabit . . . They are recognized as assets in the SEEA for their provision of indirect use benefits for humans in the form of a variety of services, including the cleansing of fouled air, water and soil, protection against solar radiation, regulation of geochemical flows and others" (UN et al. 2003, p. 257).

Obviously, atmospheric ecosystems protecting against solar radiation (including the ozone layer) are not owned by or under the control of any institutional unit.

Table 10.1 SEEA classification of natural assets (see UN et al. 2003, p. 252)

1. Natural resources	2. Land and surface water (hectares)	3. Ecosystems
1.1 Mineral and energy resources (cubic metres, tonnes, tonnes of oil equivalents, joules)	2.1 Land underlying buildings and structures	3.1 Terrestrial ecosystems
1.2 Soil resources (cubic metres, tonnes)	2.2 Agricultural land and associated surface water	3.2 Aquatic ecosystems
1.3 Water resources (cubic metres)	2.3 Wooded land and associated surface water	3.3 Atmospheric systems
1.4 Biological resources (timber, crops and plants, aquatic resources, animals other than aquatic)	2.4 Major water bodies	–
–	2.5 Other land	–

Therefore, they are not taken into account in the traditional SNA. The SEEA is an attempt to overcome this incompleteness. Unfortunately, the measurement of the associated stocks proves to be extremely difficult, as the reader may have already assumed. The problems are multiplied if a monetary valuation is to be carried out.

10.2.2 Accounting for Sustainability

10.2.2.1 The Neoclassical Theory of Measuring Sustainable Development

Given the neoclassical goal of achieving the highest possible constant per capita level of consumption of produced commodities and services for all times to come (see subsection 10.1.2 above), with regard to national accounting, the question arises whether it is possible to find a *single* index number providing a valid and reliable statement on whether or not a society is managing its affairs in a sustainable manner. Does the current path of economic development ensure that future consumption per capita will, at least,[8] never be lower than today?

Mäler (2007) reviews and interprets the neoclassical discussion of indicators of sustainable development. He distinguishes between "income like concepts", on the one hand, and "wealth like concepts", on the other. The question is whether measures of a nation's income or product, which represent *flow* concepts accumulating during a period, or measures of a nation's wealth, which are conceptualized as *stock* concepts measured at a certain point in time, are better suited to measure sustainability.

[8] "At least" means that it is not intended, in what follows, to account for the *maximum* sustainable level of consumption per capita.

According to Mäler, income like concepts were the focus of the early neoclassical reflections of the concept of sustainable development and its measurement. However, more and more, the insight emerged that wealth like concepts are better suited to measure sustainable development. While income like concepts reflect the *goal* to be achieved (e.g., to sustain consumption per capita following Solow and Stiglitz), wealth like concepts generate information with regard to the *prerequisites* of maintaining a certain level of the chosen income like concept over time. Following Mäler's classification, in the remainder of this subsection we will first discuss some income like concepts and then some wealth like concepts.

With regard to income like concepts, we can refer to one of the concepts already introduced in subsection 9.3.2 above, namely Gross Domestic Product. Once again we consider this concept and explore its meaning with respect to the goal of sustainable development.

As was explained in subsection 9.3.2 above, GDP represents the market value of all commodities and services intended for final consumption and produced by resident institutional units of a country during a certain time period, usually a year. If all goods are equalized according to a standardized base measurement in order to eliminate the effects of inflation, real GDP is obtained. In the public, an increase in real GDP from one period to the following is called "economic growth".

At a first glance, it seems to be very natural to interpret real GDP as a country's periodical income. But a different picture emerges if this interpretation is confronted with the famous definition of "income" given by Sir John R. Hicks,[9] who wrote:

> The purpose of income calculations in practical affairs is to give people an indication of the amount which they can consume without impoverishing themselves. Following out this idea, it would seem that we ought to define a man's income as the maximum value which he can consume during a week, and still expect to be as well off at the end of the week as he was at the beginning. (Hicks 1939, p. 172)

On a national level, real GDP does not fit Hicks' definition. The reason is that, in the course of producing the goods that constitute GDP, other goods are used up, namely investment goods like machines, vehicles, buildings and tools. Interpreting the GDP in 2012 as national income and, consequently, consuming it would imply that a country would be worse off at the end of 2012 than on January 1, because the stock of investment goods will have diminished. Hence, it would be impossible

[9] John Richard Hicks (1904–1989) studied at Oxford and was Professor first at Manchester University and later on at Oxford. His seminal contributions to the development of economic theory cover both microeconomic and macroeconomic issues. Two of his best-known works are "Mr. Keynes and the classics", already cited in Chap. 9 above (one of the most influential interpretations of Keynes' *General Theory*, published in Econometrica in 1937), and "Value and capital", from which the citation given in the text above is taken. He was knighted in 1964 and awarded the Nobel Prize in Economics in 1972 (see Bliss C, 2008, Hicks, John Richard (1904–1989), in: Durlauf SN, Blume LE, eds., The New Palgrave Dictionary of Economics, Vol. 2, Palgrave Macmillan).

during the subsequent period to achieve the same real GDP again. Taking this into account, Hicks' definition forms the basis for the definition of "[n]et domestic product (NDP)[, which] is obtained by deducting the consumption of fixed capital from GDP" (UN et al. 2009, p. 34).

Weitzman (1976) analysed real Net Domestic Product (NDP^r) as a welfare indicator.[10] In the traditional SNA, NDP^r is computed by subtracting from real Gross Domestic Product (GDP^r) the real value of the depreciation of the stock of productive man-made capital, K_m, where depreciation is indicated by the letter "d":

$$NDP^r = GDP^r - dK_m. \tag{10.6}$$

In Eq. 10.6, depreciation of man-made capital stock, dK_m, comprises the reduction in value of tools, machines, and vehicles due to wear occurring in the process of production. Hence, as opposed to GDP^r, NDP^r takes into account the reduction in value of a society's man-made wealth and, therefore, meets the requirement of Hicks' definition of income. If only NDP^r was consumed and the remaining part of GDP^r was invested in man-made capital goods, the man-made capital stock would remain unchanged and the same NDP^r could be reproduced in the subsequent period. In *this* sense, NDP^r can be interpreted as "sustainable income".

However, taking the natural environment into account, NDP^r (i.e., in Eq. 10.6) undoubtedly exaggerates a society's income. The reason is that not only are man-made capital goods productive, but also natural resources like fossil fuels, wood, seeds, or cattle. If the stock of natural productive assets, K_n, is affected by production, future production possibilities will be equally diminished. Hence, extending the interpretation of a society's wealth to natural resource stocks makes it necessary to subtract from GDP^r, in computing sustainable income, not only the depreciation of man-made capital, but also the depreciation of natural resource stock (dK_n) during the accounting period. Therefore, real "green" Net Domestic Product ($GNDP^r$) can be defined as[11]

$$GNDP^r = GDP^r - dK_m - dK_n. \tag{10.7}$$

The depreciation dK_n reflects the real value of the reduction in value of the natural components of a society's wealth due to productive or consumptive activities during the accounting period. For example, forests are uprooted, rivers are polluted, and biodiversity (both in forests and rivers) declines. Note that, in computing $GNDP^r$, depreciation of man-made and natural assets is measured in the same monetary unit. This implies perfect substitutability between man-made and natural capital because, in principle, rising depreciation of natural assets can

[10] The traces of Hicks' income conception in the sustainability context can also be found in Mäler (2007).

[11] See, e.g., Welfens et al. (2011), p. 22.

be offset by declining depreciation (or even appreciation) of man-made capital, leaving $GNDP^r$ constant.

From an environmentalist's point of view, it may be a substantial progress to correct GDP^r for environmental damages caused by economic activities. However, under the headline "Accounting for Sustainability" this is not enough. On the contrary, the question must be answered as to whether $GNDP^r$ is a valid measure for judging the degree of sustainability of a society's performance. Given the neoclassical definition of sustainable development cited in Subsection 10.1.2 above, such a measure must answer the question whether future consumption per capita will maintain the present level. In general, income like concepts cannot answer this question because they represent the goal to be achieved and not the prerequisites of such achievement. Specifically, $GNDP^r$ measures sustainable consumption, but it contains no information at all about the question as to whether exactly this level of consumption can be *actually* achieved in the future as well. The reason is that $GNDP^r$ does not tell us whether consumption has actually been restricted to $GNDP^r$ itself. The latter question can only be answered by concepts that indicate the change in a society's *wealth*.

One of the most prominent concepts designed to fulfill this task is genuine savings (G), defined as the totalled changes in the values of all components of national wealth, including, *inter alia*, both man-made and natural assets[12]:

$$G = \sum_{i=1}^{N} p_i \cdot dK_i \tag{10.8}$$

In Eq. 10.8, K_i represents the stock of the ith component of national wealth available at the beginning of the accounting period. There are a lot of different components i of national wealth, with their total number equalling N. For example, component K_1 could represent the number of available excavators, component K_{17} could represent the reserves of fossil fuels measured in barrels, and component K_{138} might be the area covered by virgin forests, measured in hectares. In principle, even human capital could be incorporated: for example, component K_{2043} might represent the intangible stock of productive knowledge of all bakers in a country, maybe measured by the total time used to teach them the baker's trade.

Given that all N stocks were exactly known in litres, tonnes, hectares et cetera, how could a society's total wealth be computed? The problem is adding the number of excavators to the available barrels of fossil fuels, hectares of virgin forests, and the bakers' knowledge, given the length of their periods of training. The aggregation of various stocks measured in different dimensions, in order to obtain "total wealth", requires a quantification of all the different stocks according to a common unit of measurement. This task is conducted (as seen in Eq. 10.8) by evaluating each single stock according to its price p_i. For all stocks, the valuation is carried out using

[12] See Atkinson/Hamilton (2007), p. 45.

prices having the same dimension, namely monetary units. When all stocks have been valued in monetary units, their values can be totalled so as to obtain a society's wealth as a whole.

The symbol dK_i denotes (in Eq. 10.8) the change in the available amount of a certain asset i during the accounting period, i.e., between January 1 and December 31. It should be noted that, in principle, dK_i can be negative ("depreciation") as well as positive ("appreciation"). For example, imagine that the number of available excavators (our component K_1) rose by 250 during a year. If the price of an excavator, p_1, equalled 1,000 monetary units according to the standardized base measurement, this would imply that the value of the stock of excavators rose by 250,000 monetary units. If, during the same period, the stock K_{138} of fossil fuels diminished by 1,000 barrels due to extraction, and the price p_{138} was 300 monetary units according to the same base measurement, total wealth would have fallen by 50,000 monetary units, given that all other stocks remained unchanged.

To sum up, a positive value of genuine savings implies that a society's wealth has been increasing during the accounting period. However, a negative value of genuine savings indicates a decline in wealth. Wealth has been constant, if genuine savings have been zero. The adjective "genuine" emphasizes that *all* components of national wealth are taken into account. It is important to notice that the idea of genuine savings allows for perfect substitution of man-made assets with natural assets, and vice versa.

Genuine savings makes it possible to assess whether current consumption can be sustained in the future. If current genuine savings is zero (negative), the depreciation of all productive wealth components has been (has not been) compensated for by replacement investments. This means that current consumption has been (has not been) *actually* restricted to Green Net Domestic Product and, therefore, can be (cannot be) sustained. Hence, non-negative genuine savings is a prerequisite for current GNDP to be sustainable.

The World Bank uses the term "Adjusted Net Saving" (ANS) as a synonym for genuine savings (see World Bank 2011, p. 18). ANS is defined as gross savings plus education expenditure, minus consumption of fixed capital, energy depletion, mineral depletion, net forest depletion, carbon dioxide damage, as well as particulate matter damages (see World Bank 2011, p. 185). Table 10.2 shows ANS as a percentage of Gross National Income[13] in 2008 for selected countries.

10.2.2.2 The Index of Sustainable Economic Welfare in Ecological Economics

As mentioned earlier, criticism of GDP has frequently motivated the search for alternatives. In particular, GDP has been criticized for (see Mäler 2007, p. 64)

[13] Gross National Income (GNI) "is equal to GDP less taxes (less subsidies) on production and imports, compensation of employees and property income payable to the rest of the world plus the corresponding items receivable from the rest of the world" (UN et al. 2009, p. 34).

Table 10.2 Adjusted net saving as a percentage of gross national income, 2008 (see World Bank 2011, pp. 185–195)

Country	ANS
China	35.1
India	24.2
Japan	15.3
USA	0.9
Netherlands	−1.2
Equatorial Guinea	−38.4
Angola	−42.6

- Neglecting the depreciation of productive assets;
- Neglecting household production (cooking, cleaning up, washing et cetera, which is not paid for on markets and, therefore, not reflected in official statistics);
- Neglecting numerous determinants of human well-being like health, environmental quality et cetera.

The first critique has been already dealt with in the preceding subsection. It postulates that GDP exaggerates an economy's productive performance and motivates alternative measures like NDP and GNDP. The second critique postulates that GDP underestimates economic performance.

The third critique questions the desirability of economic growth. One of the reasons for the positive judgement of a rise in GDP is that it implies an improved provision of goods and services. The latter, in turn, is very often assumed to enhance people's "well-being" or "welfare". This is an important reason why a growth in GDP is a declared goal of many politicians. However, it should be noted that it has been questioned whether GDP represents a valid indicator of welfare because the latter depends not only on the consumption of commodities and services but on many other things like health, social interactions, participation in societal decision making and many other aspects.

Based on these lines of critique, it has been concluded that GDP cannot serve as an indicator of sustainability and, therefore, has to be modified. One of these modifications is the "Index of Sustainable Economic Welfare" (ISEW), which was developed by Daly and Cobb (1989, pp. 401–455). The ISEW is computed by correcting GDP in several ways (see Daly and Cobb 1989, p. 418 f.), inter alia:

1. Private consumption expenditure is divided by an index number reflecting a societal preference for an egalitarian income distribution;
2. The estimated value of household production is added;
3. The value of benefits generated by durable consumer goods bought in the past is added; current expenditure for durable consumer goods is subtracted because the latter generates benefits in future periods;
4. Government expenditure for streets and highways is added; a portion of government expenditure for health care and higher education is added as well (the rest is not because it is assumed to be "defensive", i.e., intended to repair damages which could have been avoided);

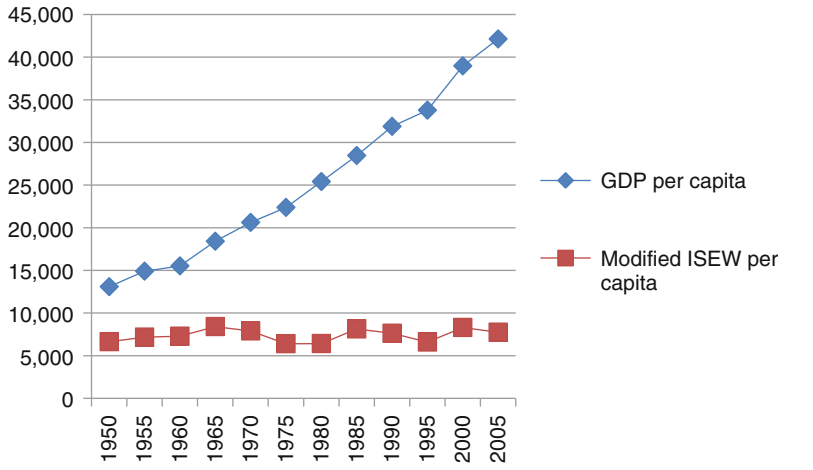

Fig. 10.1 US per capita values for modified ISEW and GDP, $US, constant 2005 prices (see Beca and Santos 2010, p. 815)

5. Defensive private expenditure is subtracted (for example expenditure serving to remove damages caused by car accidents and private defensive health expenditure);
6. The value of environmental damages occurring during the accounting period is subtracted (e.g., water and air pollution, loss of wetlands);
7. The value of the decline in non-renewable natural resource stocks is subtracted;
8. Future costs of current environmental damages are subtracted;
9. The value of the changes in man-made capital stocks is added (which can be positive or negative);
10. The balance of foreign investment inflows and outflows is added (which can be positive or negative).

Figure 10.1 compares US values of real Gross Domestic Product per capita to a modified version of the ISEW as proposed by Beca and Santos (2010). As compared to the initial approach of Daly and Cobb, the "Modified ISEW"includes new components and methodological changes for the estimation of the index. Nevertheless, the message is still obvious: by using real GDP per capita as a welfare indicator, a substantial improvement in people's well-being during the past decades can be deduced. By contrast, the Modified ISEW per capita indicates a stagnation in well-being between 1950 and 2005.

In subsection 10.2.2.5 below, the Index of Sustainable Economic Welfare will be assessed and compared to the approaches described in subsections 10.2.2.1, 10.2.2.3, and 10.2.2.4.

10.2.2.3 The *World Wide Fund for Nature*'s Living Planet Index

The "Living Planet Index" (LPI) of the World Wide Fund For Nature (see WWF 1998, 2004, 2006, 2010) may serve as an example of an indicator that does not

Table 10.3 Trends in living planet indices, 1970–2007 (see WWF 2010, p. 103)

Realm	Percent change, 1970–2007
Total	−28
Terrestrial	−25
Freshwater	−35
Marine	−24

Table 10.4 Change in the LPI by country income group, 1970–2007 (see WWF 2010, p. 103)

Income category	LPI percent change, 1970–2007
High	5
Middle	−25
Low	−58

incorporate any measure of human well-being at all but accounts for physical stocks of natural resources exclusively. The LPI is an aggregate measure of biodiversity on earth. It measures the changes in the stocks of about 1,300 vertebrates in terrestrial, freshwater, and marine ecosystems. These 1,300 stock measures are aggregated by the use of a rather complex procedure[14] to obtain, in a first step, three index numbers (terrestrial, freshwater, and marine). In a second step, these three index numbers are totalled to obtain a single index number, the LPI. Note that this means that the LPI allows for substitution *within* natural wealth, because the index value can rise in spite of the fact that the stocks of some species decline, given that the stocks of other species grow sufficiently.

Table 10.3 illustrates the decline in biodiversity from 1970 to 2007. It reports the percentage changes in total global biodiversity as well as the decline in terrestrial, freshwater, and marine biodiversity.

It seems noteworthy that the loss in biodiversity was higher in countries with low income per person than it was in middle and high-income countries. As Table 10.4 reports, the LPI shows a rise in biodiversity by 5% in high-income countries, while the LPI saw a decline by 25% in middle-income countries and by even 58% in low income countries.

10.2.2.4 The *European Union*'s Set of Sustainability Indicators

Based on a set of sustainable development indicators adopted by the European Union, the European statistical office Eurostat issues related monitoring reports. The 2009 issue includes a complete list of EU sustainable development indicators (see Eurostat 2009, pp. 292–300). These are more than 140 index numbers, classified into ten fields, namely "Socioeconomic development", "Climate change and energy", "Sustainable transport", "Sustainable consumption and production", "Conservation and management of natural resources", "Public health", "Social

[14] See WWF (2006), p. 37 for details.

Table 10.5 Selected EU sustainability indicators (see Eurostat 2009, pp. 292–300)

Socioeconomic development	Sustainable consumption and production	Social inclusion	Climate change and energy
Growth rate of GDP per inhabitant	Resource productivity	Inequality of income distribution	Greenhouse gas emissions
Net national income	Municipal waste generated	Individuals' level of computer skills	Gross inland energy consumption, by fuel
Employment rate	Emissions of acidifying substances by source sector	Public expenditure on education (for subtheme Education)	Electricity generated from renewable sources
Total investment	Electricity consumption of households	Life expectancy at age 65, by gender	Implicit tax rate on energy
Genuine savings (to be developed)	Livestock density index	General government debt	External costs of energy use (to be developed)

inclusion", "Demographic changes", "Global partnership" and "Good governance". Table 10.5 gives just a few examples.

The 140 indicators are not aggregated to a single index number. Thus, the question about substitutability between man-made and natural aspects is not dealt with.

10.2.2.5 Assessment of the Approaches

In the dispute around the concept of sustainable development, the question as to how the welfare of a society can be properly measured rightly plays an important role. But the development of valid welfare measures alone is not sufficient to judge whether a society has been and, more importantly, *will be* performing sustainably or not. The reason for this is that welfare measures are static concepts that serve the purpose of measuring the flow of people's well-being in a given period of time. However, sustainability is a dynamic concept that poses the question as to whether welfare can be *maintained* in the long run, and at which level.

In order to explore the last question it is necessary to look at the *prerequisites* of generating welfare at all. These prerequisites are located at the level of a society's stock of *wealth*. The periodical *flow* of welfare is fed from the *stock* of wealth. Hence, in general a society's stock of wealth can be seen as an appropriate indicator of sustainability because it contains the information whether welfare can be maintained in the future or not. In the following, therefore, indicators of sustainable development are interpreted as index numbers which measure the prerequisites for maintaining a certain level of welfare, irrespective of the way welfare is measured itself.

In light of this interpretation, the indicators discussed so far can be explored with regard to their ability to measure sustainable development. For this purpose, these indicators are classified in Table 10.6, where income like concepts (i.e., flows which measure welfare) are separated from wealth like concepts (i.e., stocks which feed flows). Moreover, the wealth like concepts are differentiated with

Table 10.6 Classification of indicators

Source	Welfare	Hybrid	Wealth Man-made	Wealth Natural	Wealth Total
UN SNA	GDP	–	–	–	Balance sheet
UN SNA	NDP	–	–	–	Balance sheet
Atkinson/Hamilton	GNDP	–	–	–	Genuine savings
WWF	–	–	–	LPI	–
UN	–	–	–	SEEA	–
Daly/Cobb	ISEW	–	–	–	–
Eurostat	–	EU set	–	–	–

regard to the question whether man-made or natural stocks are measured and whether both are aggregated or not. The ability to measure sustainable development increases from the left hand side to the right hand side in Table 10.6. In the second column, welfare measures are reported. In the fourth to sixth columns, the corresponding measures of wealth appear which represent the prerequisites for maintaining the respective welfare measure and, therefore, can be interpreted as sustainability indicators. Moreover, in the third column of Table 10.6, hybrids are reported incorporating both welfare and wealth measures.

With regard to the relationship between the welfare measures on the left hand side and the wealth measures appearing on the right hand side, when both are in the same row, it can be noted that, in some cases, the welfare measure directly depends on the measure of wealth. This is because the respective wealth measure explores the prerequisites for maintaining the corresponding welfare measure. In the following, this relationship is explained, row by row, in some detail.

Gross Domestic Product and the balance sheet of the United Nations' System of National Accounts. Real GDP, as reported in the SNA, measures the real value of an economy's actual periodical production. However, the prerequisite for production to take place at all is an economy's productive capacity, which partly is reported in the balance sheet of the SNA. The productive capacity comprises all productive stocks available to an economy. These are man-made capital, natural resources, human capital, and technical knowledge. The balance sheet as a part of the United Nations SNA reports only two of them, namely man-made capital and natural resources. Therefore, it is incomplete.

Bearing in mind this restriction, the balance sheet can be used to judge whether GDP can be sustained over time. If, on January 1, the existing productive capacity is known, the GDP attainable between January 1 and December 31 can be forecasted. If the *development* of the productive capacity over time is monitored, it can be judged whether the GDP attained in the past can be attained in the future as well. This means that the determination of the productive capacity on January 1 alone is not an appropriate indicator of sustainability because it contains no information at all about the GDP which can be maintained in the long run. If, in a period, the productive capacity is fully employed and the maximum GDP is attained, the productive stocks depreciate during the accounting period. If this depreciation is

not compensated for by replacement investments, the same GDP will not be attainable in the subsequent period again. Therefore, the productive capacity computed at a certain point in time makes possible the computation of the GDP attainable during the current period, but not the computation of the GDP attainable in subsequent periods. The productive capacity measured at a point in time can only reveal the sustainable level of GDP given that in every period the depreciation of the productive stocks is compensated for by replacement investments. The SNA balance sheet is placed in the column "total wealth" in Table 10.6, because "[a]ssets and liabilities can be aggregated across all types so as to show the total value of assets less liabilities, or net worth, of an institutional unit" (UN et al. 2009, p. 257).

Net Domestic Product and the balance sheet in the United Nations System of National Accounts. As in the case of GDP discussed before, with regard to NDP the development of productive capacity over time is, in principle, the appropriate indicator of sustainable development. As compared to GDP, NDP contains the additional information indicating to which level consumption must be restricted in order to maintain the productive capacity. However, the computation of NDP cannot guarantee that the required replacement investments are actually carried out. The productive capacity makes possible the determination of the NDP attainable during the current period. However, the appropriate sustainability indicator is the level of net investment. If net investment is non-negative, an identical NDP is attainable in the subsequent period as well. Surprisingly, replacement investment as a *flow* concept qualifies for a sustainability indicator! The reason for this is that the flow of net investment reveals whether the stock of productive resources rises, declines, or remains constant. The balance sheet of the United Nations' SNA makes possible the computation of the development of the *man-made* productive capacity over time by reporting man-made assets. In this sense, the "conventional saving" can be computed.

Green NDP and genuine savings. As compared to conventional NDP, the adjective "green" signals that an extended interpretation of the productive capacity is employed. Beside man-made capital, the productive character of natural resources is acknowledged as well. Both natural factors of production exchanged on markets (fossil fuels, wood) and natural factors of production for which no markets exist (atmosphere) are considered. As a consequence, genuine savings takes into account not only net investment in man-made assets, but in natural assets as well. Of course, in the case of natural resources not exchanged on markets the problem of a correct monetary evaluation arises due to the lack of market prices. The balance sheet of the United Nations' SNA makes possible the computation of the development of productive capacity over time by reporting man-made and natural assets (but not human capital and knowledge).

Index of Sustainable Economic Welfare. The ISEW uses GDP as a point of departure and conducts several corrections and modifications to it. Therefore, ISEW qualifies as an "income like concept". In particular, it picks up the idea of Hicks to correct current production for the depreciation of productive assets: environmental damages and extraction of natural resource deposits are substracted from GDP as well as changes in the stocks of man-made capital. However, there are

several modifications of GDP which cannot be explained by Hicks' idea of income (for example, weighing private consumption by a distributional factor). However, ISEW does not represent an indicator of sustainability, because there is no presentation of a corresponding "wealth like concept" that might serve as a related sustainability measure.

WWF's Living Planet Index. The LPI is a pure wealth like concept because it reports exclusively on stock levels. A corresponding flow concept measuring income or welfare is not considered at all. That means that no definition of sustainable development is given. Moreover, the LPI highlights only a small part of all the natural resource stocks, namely the number of 1,300 vertebrate species.

European Union set of sustainability indicators. On the one hand, the EU set of sustainability indicators includes few indices which reflect stocks of wealth. For example, the "livestock density index" reports on a component of natural wealth, while the indicator "individuals' level of computer skills" refers to human capital. On the other, the EU set comprises a lot of income like indicators, such as for example, growth in GDP per capita and Net National Income. Moreover, many indicators represent depreciation in several components of wealth, like "municipal waste generated" and "emissions of acidifying substances". Hence, the EU set is classified, in Table 11.6, as a hybrid approach.

United Nations System of Integrated Environmental and Economic Accounting. The SEEA which was discussed in subsection 10.2.1, above, is intended to represent a framework for measuring sustainable development, which was linked to the notion of justice in Sect. 4.5 above. It is based on the so-called "capital approach" to sustainable development. Referring explicitly to Hicks, "[t]he income of a nation [is] defined as the amount that it can collectively spend during a period without depleting the capital base (or wealth) upon which it relies to generate this income" (UN et al. 2003, p. 4). Consequently, "[s]ustainable development is development that ensures non-declining per capita national wealth by replacing or conserving the sources of that wealth; that is, stocks of produced, human, social and natural capital" (ibid.).

The SEEA does not incorporate any flow concept measuring periodical income or welfare. Therefore, it does not qualify as an "income like concept". Instead, it comprises wealth like indices in its accounts of environmental assets. In addition, the accounts of natural resource depletion, defensive expenditures to correct for environmental damage and environmental degradation can be used to compute changes in natural resource stocks, which may be interpreted as another hint to the wealth like character of the SEEA. The same holds for the accounts of environmental protection expenditure and economic policy instruments. Therefore, the SEEA is classified as a "wealth like concept", which is restricted to natural wealth (without intra-substitution possibilities) in Table 10.6, although it comprises accounts of "hybrid flows" connecting information about the use of environmental resources to information in both physical and monetary terms about the associated processes of economic production. The latter information can neither be classified as purely "income like" nor as "wealth like".

To summarize, it seems to be the most appropriate approach in order to construct indicators of sustainable development, firstly to specify which income like measure should be sustained, and secondly to explore which wealth like measure can be seen as a prerequisite for achieving this goal. Hence, a *system* of sustainability indicators should comprise both income like and wealth like concepts. Thirdly, it should work out the links between these two.

While the ISEW is lacking the second step, the LPI and the SEEA do not conduct the first. The European Union's set of sustainability indicators, in turn, does not implement the third step. Eventually, in our (surely incomplete) selection of indicators, the most promising approach seems to be the system of indicators represented by GNDP as an income like concept and genuine savings as the *related* concept indicating changes in national wealth.

Review Questions

1. Are there unlimited chances for economic growth?
2. What can be done, according to neoclassical growth theory, in order to avoid the collapse of the global economic system, as was predicted by the Club of Rome?
3. What is "sustainable development"?
4. Are there any examples for the productive character of natural resources and for investments in their stocks?
5. What does Hotelling's Rule say?
6. Is there a contradiction between an efficient use of a natural resource, on the one hand, and an intergenerationally just use of it, on the other?
7. What are the objections of ecological economists against the analysis of neoclassical resource economics?
8. What is the basic idea behind the concept of "Net Domestic Product"?
9. In what respects is the traditional System of National Accounts incomplete with regard to the incorporation of natural resources?
10. What are the differences in accounting for national wealth in the SNA, on the one hand, and the SEEA, on the other?

Exercises

1. Please find an example of a natural resource that can (or cannot) be substituted for by accumulation of man-made or human capital!
2. What kind of investments might be appropriate to sustaining a "sufficient" global energy supply per capita, on the one hand, and the atmospheric temperature, on the other?
3. Please consider the following decision problem: a country owns a deposit of 1,000 barrels of mineral oil and intends to extract and sell the resource on competitive world markets within two time periods. The government of this country negotiates with a potential buyer, who offers to buy 800 barrels in the first period at the present net price, which is $100 per barrel. The remaining 200 barrels he offers to buy in the second period at a net price of $110 per barrel.

Should the government agree or should it renegotiate, given an interest rate of 3% prevailing on international capital markets?

4. Please find an example of a natural process that does not cross the "general production boundary" of the System of National Accounts!
5. Please explain whether the following stocks pass the "asset boundary" of the United Nations' System of National Accounts!
   (a) A population of chamois in the Swiss Alps;
   (b) A herd of cows feeding on a Swiss alp;
   (c) Weeds in a garden.

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Summary to Part III

11

Large parts of the natural environment are excluded from the mainstream of economic thinking. Basic models of economic growth neglect the productive character of natural resources completely. The procedure of accounting for the flows of national product applied in the traditional system of national accounting does not account for productive services of natural resources which are not controlled by institutional units. In computing national wealth, the SNA neglects natural assets which are either not owned by institutional units or not of economic value to their owners.

It is an important aim of environmental and resource economics to fill in this gap. In Part III, two approaches designed to serve this purpose were outlined. First, the effort made to supplement the theory of economic growth by including natural factors of production was delineated in Sect. 10.1. Secondly, the attempts to augment national accounting procedures to take the natural environment into account more completely were explained in Sect. 10.2.

It became clear that both approaches face severe problems. Growth models incorporating natural factors of production eventually face the question of whether certain natural resources can be replaced by other assets or not. Within the framework of an integrated system of environmental and economic accounting, it is often extremely difficult to measure environmental assets and their productive services in tonnes, litres, or even monetary units.

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Solutions to Exercises

Chapter 2

1. Basic needs: doctor's help. Safety needs: policeman's care. Belongingness and love needs: digital social networks. Esteem needs: advice of the supervisor while taking one's academic degree. Self-actualization needs: concert of a famous pianist.

2. (a) In a developed country today, the needs on lower levels of the needs' hierarchy may be fairly satisfied. Therefore, it seems likely that people feel local non-satiation on higher levels. On the contrary, in the same country five centuries ago many people were not able to satisfy even their basic needs as regards nutrition, sanitation, and health care. It should be noted, however, that basic needs around 1500 AD were not the same than today. Nowadays, some goods that satisfy our basic needs were unimaginable at that time (electric lighting, telephone, protection by vaccination). In 2050, this pattern of development might have continued, such that people are, to an even greater extent, provided with goods satisfying lower level needs than today. Perhaps the availability of some goods, which are today perceived as luxury goods, will be widely used in the future. However, the opposite is equally possible. In the worst case scenario, many people might be starving (no fish left in the oceans) and scared (rising frequency and dimension of natural catastrophes).

(b) In many countries, income and wealth are distributed more or less unevenly. Therefore, even in today's "rich" countries, some people cannot satisfy their basic needs (for example, the homeless), while others lead a luxurious life (for example, movie stars and famous sports(wo)men – not to mention College Professors).

(c) In many less developed countries, people are starving, suffering from diseases like AIDS and malaria, and fearful of civil wars. Obviously, they are not able to satisfy their basic needs and, therefore, there is not much room for the needs on higher levels. On the contrary, in developed countries many people perceive the satisfaction of their basic needs as a matter of cause and, consequently, are focused on goods that satisfy needs on higher levels (for example holidays, the arts, further development, and entertainment).

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3. (a) A zoo exhibits the characteristics of excludability (it is surrounded by a fence) and non-rivalry (many people can enjoy it simultaneously, overcrowding excepted). It is, therefore, a club good.
(b) A street light is a collective good because it is shining for all passers-by (non-excludability), while the simultaneous use by many people does not affect the brightness available to each of them (non-rivalry).
(c) In some families, a family size pizza may be an open access good if each member of the family is free to make a grab as long as there is pizza left (non-excludability), while the pieces already devoured are no longer available for anyone (rivalry).
(d) If you own a smartphone, you can prevent others from using it (excludability). While you are using it, no other person can use it (rivalry). Hence, a smartphone is a private good.

4. In general, a good cannot be classified as a consumer good or an investment good by its characteristics, but by the mode of its use. However, there are some exceptions.
(a) A limousine is an investment good if it is owned and used by a firm for the ensuring of the mobility of one of its managers. If, however, the same manager owns the same limousine and uses it to reach his/her holiday destination, it is a consumer good.
(b) For a laptop, the explanations given for (a) apply analogously.
(c) Bookkeeping software is an exception. It is rather unlikely (though not completely impossible) that it will be used by a consumer during his/her leisure time because it is designed to facilitate certain procedures in firms.
(d) A video game will be bought and used, in most cases, by consumers and, therefore, represents a consumer good. However, in many supermarkets you can find video games provided for children in order to ease shopping for their parents. In those cases, the video game represents an investment good.

5. (a) In Israel, like in other semi-arid areas, the limited availability of water severely restricts agricultural production; (b) In Germany, there is a growing lack of qualified employees, which affects industrial production; (c) There might be little time left for sports, parties, and other leisure activities.

Chapter 3

1. Some countries carried out an "ecological tax reform" in recent decades. For example, a tax was levied on the use of fossil fuels while the tax revenue was used to limit the rise in the cost of labour by subsidizing pension schemes. It was intended, firstly, to reduce the waste of natural resources (lower resource extraction and less greenhouse gas emissions), while secondly, a decline in unemployment (which represents a waste of human resources) was aimed at.

2. In general, the economic principle can either be applied in the form of the maximum principle or in the form of the minimum principle.

(a) A first semester student has to decide how to split his/her time between learning, earning his/her livelihood, and leisure activities. If the maximum principle is applied, the student may intend to attain the best mark, given his total time. This may require the minimizing of the time spent for work and leisure. If the minimum principle is at work, the student may intend merely to earn his/her Bachelor degree regardless of the mark. This would allow the minimizing of the time spent for learning to the time needed in order not to fail in the examinations.
(b) For a taxi driver, the minimum principle might demand, for example, that a given transportation performance is conducted with minimal inputs of, inter alia, time and fuel. The maximum principle requires that, given the inputs of time and fuel, a maximum transportation performance is attained.
(c) A doctor may try to provide his/her patient with the best health, given the patient's budget available for health care services (maximum principle). Alternatively, the doctor may attempt to stabilize a patient's given health status with a minimum amount of money spent on medicine (minimum principle).

3. Through the labour market, the real flow of labour services flows from the consumers' sector to the firms' sector. On the same market, the monetary flow of labour income flows in the opposite direction. On the goods market, commodities and services as a real flow are transferred from the firms' sector to the consumers' sector, and to the firms' sector as well. The consumption expenditure and the investment expenditure constitute the corresponding monetary flows from the consumers' sector and the firms' sector to the firms' sector. The capital market is passed by monetary flows only: saving flows from the consumers' sector to the firms' sector, and capital income flows in the opposite direction.

4. It is the primary goal to satisfy the needs of an economy's people. This goal rests on anthropocentrism, since it is exclusively human needs that are considered. Moreover, the concept of consumer sovereignty implies that only human individuals themselves can judge the nature and intensity of their own needs. From the primary goal of human needs satisfaction, the secondary goals of efficiency, justice, and stability are deduced. The reasons for this are that, firstly, inefficiency would frustrate the chance to enhance the needs satisfaction of at least one member of society without affecting the level of needs satisfaction of all other members. Secondly, injustice might imply, in its extreme, that the needs of some members of society are satisfied to a high degree while the needs of the vast majority are completely neglected. Thirdly, instability might cause, for example, unemployment, which severely limits the chance of the unemployed and their families of satisfying their needs.

5. If the new product meets people's needs better than prior ones, people will exhibit a high willingness to pay for it. The firm that invented the product observes this high willingness to pay and, expecting high profits, extends production. This firm will try to attract additional labour and capital by offering higher wages and dividends. Other firms will imitate the product and try to attract additional factors of production as well. Because of the higher factor prices paid in the new sector of production, labour and capital will move from sectors producing commodities and services for which there is no longer such a high willingness to pay on the part of

consumers. Eventually, signals generated by the system of product and factor prices will pull the factors of production to those sectors where goods are produced that best meet the desires of the population.

Chapter 4

1. "Climate stability" is a natural collective good because, once it has been provided, it is impossible to exclude any agent from using it. For example, neither South East Asia nor the Caribbean could be excluded from enjoying a non-rising or even declining probability of catastrophic weather events. In addition, there is non-rivalry in enjoying climate stability, because the Asian benefits are not affected by Caribbean consumption. In order to provide climate stability, individual contributions of all agents/countries would be necessary, where "contribution" means a reduction in greenhouse gas emissions. However, each agent feels the incentive not to contribute by him- or herself because, once climate stability is provided at the expense of the contributions of others, an agent not contributing cannot be excluded from enjoying it and his/her consumption cannot affect the chances of the others to consume climate stability. The poor outcomes of all the bigger and smaller climate conferences held in recent decades may serve to illustrate the relevance of this problem.

2. There are some important natural resources that are overexploited and severely threatened because they exhibit the properties of non-excludability and non-rivalry. This might even endanger the sustenance of mankind. For example, no one can be excluded from using the atmosphere as a waste outlet. The most critical consequence is global warming. Climate stabilization would require substantial reductions in greenhouse gas emissions, but because climate stabilization is a collective good (non- excludability, non-rivalry), the incentives for free riding prevent sufficient contributions. A second example is sea fish. Because there is non-excludability with regard to the stocks in the oceans, the rivalrous situation with regard to the catch means sea fish are an open access resource. This implies an incentive to catch the next ton of fish before another fisherman can do so. Consequently, many species are threatened by extinction.

3. Firstly, the use of tropical wood as a productive factor (for example, in furniture production) affects the stock of tropical forests. The flows of timber harvested imply a decline in tropical forests if they exceed their rate of regeneration. The latter may be rather vulnerable due to special characteristics of the ecosystem: a tropical forest, once cleared, is unlikely to recover to its initial state. Secondly, clearing tropical forests affects other stocks of natural resources as well. In particular, a decline in the size of the habitat may lead to a severe loss in biodiversity. Thirdly, because tropical forests store a lot of carbon dioxide, their clearing may accelerate climate destabilization.

4. A natural resource stock exhibits an existence value if individuals don't need the stock either to satisfy their basic needs or their safety needs but, instead, to satisfy their self-actualization needs. For example, the value of a clean atmosphere

(which is actually a natural resource stock) is not an existence value because people need clean air for breathing (which is a flow concept). In this case, individuals receive flows which satisfy basic needs from a stock of a natural resource. However, if people assign a value to a resource stock, although they don't receive any flows from that stock, this is called an existence value. For example, it reflects people's desire to know that certain habitats remain intact, despite the fact that they might never visit those habitats.

5. The notion of justice shifted to the center of environmental and resource economics after the Brundtland Report (WCED 1987) was published. The report emphasized a strong link between environmental degradation, on the one hand, and the current unjust distribution of the chances to satisfy human needs between less developed and developed countries, on the other. Moreover, the Brundtland Report hinted at the problem of realizing intergenerational justice in the presence of rising environmental degradation and, thereby, promoted the idea of sustainable development.

Chapter 6

1. Have you already made your plans for the coming Saturday night? Wouldn't it be nice to go to the cinema? Or would you like dancing instead? Dinner in your favourite restaurant surely would be great! Of course, there might be various other alternatives. The necessity to choose arises, firstly, from the scarcity of your time (did you already try to eat and to dance at the same time?), and secondly, from your (probably) limited budget.

2. They all face scarcity, although it appears in different forms to each. While the electric power-supply company has to manage the limited availability of energy resources like fossil fuels or sunlight, some cooks may suffer from a lack of creative inspiration, and the rugby player may experience his physical limits and vulnerability. Scarcity implies that they cannot realize all available alternatives simultaneously. On the contrary, they all have to choose between alternatives and, therefore, face opportunity costs. The power company has to decide on its energy mix, the cook must select his clientele, and the rugby player has to choose the intensity of his training as well as the frequency of the contests in which he engages. In choosing between alternatives, they all behave rationally (in case you find power companies, cooks, or rugby players who don't, the behaviour of these people is not dealt with in mainstream microeconomics). This means that they obey the economic principle. The result is efficiency, meaning the absence of any waste of resources.

3. The first task of an allocation mechanism is to solve conflicts between agents that compete for scarce resources. For example, if two individuals compete for the last ticket for a concert, a decision must be made as to whom may enjoy the event and who may not. In situations like this, an allocative mechanism must bring about a socially acceptable decision (therefore, brute force does not qualify, nevertheless it can still be frequently observed). The second task of an allocative mechanism is to

coordinate actions of agents whose goals are compatible. For example, a baker's plan to sell bread, on the one hand, and his/her customers' plans to buy it, on the other, in principle fit together. However, the question at which quantity of bread these plans coincide needs to be answered by virtue of an appropriate allocative mechanism. (See also subsection 3.5.1, above, for a more detailed discussion of the advantages and disadvantages of various allocative mechanisms, namely "appeal to the common sense", "bureaucratic assignment", and the "price mechanism".)

4. On the individual level, it follows from the concept of consumer sovereignty that there is not much microeconomists can do: they have to respect the judgement of the individual consumers. On a societal level, however, there are many individuals that might judge the same market outcome in a complete different way. If there are diverging individual judgements, a societal judgement inevitably requires a weighted aggregation of the latter in order to obtain some societal welfare measure. This aggregation imposes difficult questions with regard to measuring and weighing individual well-being.

5. According to the microeconomic theory of consumer behaviour (see Sect. 6.2), you should, as a typical (or "representative") consumer, reduce your demand for pizza and increase your demand for burgers. The law of demand would then be realized with regard to your demand for pizza (increasing pizza prices should imply a decline in your demand for pizza).

Chapter 7

1. A person exchanges money for a package of cigarettes in a store. The agreed-upon price reflects the private costs of the store's owner (including the price of the cigarettes he paid to the producer, the rent for the store building, heating, labour, et cetera) and the satisfaction of the smoker's desires. When the buyer smokes in a restaurant, people who were not involved in the market transaction between the store's owner and the smoker are affected. Because they were not involved, their disadvantage (stench, health) was not reflected in the market price bargained between the store's owner and the smoker. In some countries, therefore, governments have forbidden smoking in restaurants.

2. Consider a case where, in several industrial areas, sulfur dioxide is emitted by, inter alia, power plants. In several other regions, acid rain occurs and forests are affected. The first problem arises in the field of natural sciences: which unit of sulfur dioxide emitted by which power plant has caused which tree to fall ill? The answer might depend, for example, on a complex profile of weather characteristics (wind direction and velocity, humidity, temperature, et cetera) as well as on the initial state of the forest. The second problem is an economic one: what's the monetary value of the damage occurring in forests? This question might easily be answered with regard to the marketable resource "wood". However, for the ecosystems affected or even destroyed, there is no market price that could be used to evaluate the damages.

3. (a) The standard and pricing approach leaves room for all polluters to adjust their individual emissions in an individually cost minimizing manner. Hence, every single polluter will choose exactly the amount of emissions equating his individual marginal abatement cost to the tax rate, which is the same for all polluters. Consequently, the marginal abatement cost of all polluters will be the same, which means that the condition for minimum societal abatement cost is fulfilled. (b) As opposed to the standard and pricing approach, the obligation to reduce the initial emissions by a given percentage does not leave any room for the individual polluter to adjust his/her emission level. On the contrary, the latter is fixed by the government. Because the polluters are characterized by different individual abatement cost functions, a measure requiring all polluters to reduce their emissions by an identical percentage cannot bring about identical marginal abatement costs for all individual polluters. Therefore, the goal of minimum abatement cost on a societal level will be missed.

4. (a) Labour of the owner; petrol bought by the owner from an oil company; electricity used for illumination and petrol pumps; rent paid for the building; mineral oil tax imposed by the government in order to gain tax revenue. (b) Damages to facades due to acid pollutants; stress due to noise; damages to health caused by pollutants (for example, diseases of respiratory ducts). (c) Income loss and, consequently, declining consumption possibilities of the owner of the filling station; loss in utility derived from mobility on the part of the car driver. In somewhat more technical terms: loss in producer surplus and in consumer surplus.

5. Climate stabilization is a global collective good. If it were attained, no country could be excluded from its benefits. Moreover, the fact that country A would enjoy climate stabilization would not affect the chances of country B to also enjoy it (non-rivalry). Consequently, every country feels an incentive to behave as a free rider. Once other countries had provided the collective good "climate stabilization" (by national efforts to reduce greenhouse gas emissions), a country that had not contributed could enjoy the benefits for free. If all countries follow this incentive, there will be no national contributions at all. On a national level, the provision of collective goods can be ensured by the government by imposing sanctions on free riding or by financing it from tax revenue. Unfortunately, on a global level, there is no government that could analogously carry this out.

Chapter 9

1. Cyclical divergences of "actual production" from "productive capacity" are called "business cycles". Those divergences are measured by the concept of "output gap". If actual GDP falls short of potential GDP (output gap is negative), the productive stocks are underemployed. However, if actual GDP exceeds potential GDP (output gap is positive), inflation may result. In the short run, a rise in real GDP (i.e., economic growth) can be the result of an increasing output gap.

2. Economic growth is defined as an increase in real GDP over time. Real GDP represents the value of all commodities and services produced during a given time

period. In order to produce commodities and services at all, an economy needs stocks of productive resources. In neoclassical growth theory, the labour force, the stock of capital goods, and the stock of productive knowledge are considered as productive resources. While, in the short term, real GDP can grow by means of an improved utilization of the existing productive stocks, in the long term a rise in the productive stocks available is a prerequisite for a growing real GDP. A rise in productive stocks, in turn, presupposes investment activities that enhance the labour force ("population growth"), the capital stock ("savings"), and productive knowledge ("technical progress").

3. While a flow is measured as accumulating between the beginning and end of a given time period, a stock is measured at a given point in time. In many cases, flows can change stocks. For example, a person can increase her stock of wealth by generating a flow of savings. Similarly, labour force as a stock concept can be increased by the flow of net births.

4. In order to compute nominal GDP, all goods produced during a time period are valued by current prices, i.e., by the prices in the period in which the goods are produced. A growth in nominal GDP from one period to the next can result from two causes: either an increase in the volume of production or an increase in the goods' prices. Therefore, if it is intended to compare the volume of production of two periods, the effect of price changes has to be eliminated. This is done by evaluating the goods produced in different periods in terms of prices of the same period. This procedure is called standardized base measurement.

5. Firstly, "financial assets" are distinguished from "non-financial assets". While the former include, inter alia, claims like currency and equity, the latter mainly entail physical objects. Secondly, within the set of non-financial assets, produced assets like buildings are separated from non-produced assets, such as natural resources like land.

Chapter 10

1. In energy production, wind turbines can be substitutes for fossil fuels. However, there is no substitute for clean air in breathing.

2. The amount of energy per capita perceived as "sufficient" might be reduced, for example, by a reduction in building heating requirements. This could require investment in knowledge (research and development) with regard to insulation, as well as investment in man-made capital embodying the improved knowledge (new buildings or renovation of existing ones). An alternative way could be to develop renewable energy sources like, inter alia, wind, solar power, and tidal power in order to reduce greenhouse gas emissions, given the level of energy production and consumption. This might also require investment in the creation of new knowledge and, in a second step, investment in man-made capital (for example tidal power stations), which embodies the newly created knowledge.

3. The government should renegotiate, because, given the quantities and net prices offered, a unit of the resource left in the ground would earn an interest rate of

10 % (which is represented by the rate of growth of the resource's net price). A unit extracted and sold immediately, however, would earn an interest rate of 3 % only, if the revenue would be invested on international capital markets. Hence, it would be favourable to the government to sell less than 800 tonnes in the first period and more than 200 in the second. This would reduce the future scarcity of the resource and, consequently, reduce the rate of growth in the resource's net price. The shift in extraction from the first to the second period should be continued until the rate of growth in the resource's net price is equal to the interest rate (Hotellings's rule).

4. Rain generates goods like drinking water, waterways, and increased cereal yields. However, it is not under the control and responsibility of any institutional unit. Hence, its important contribution to production is not included in a country's Gross Domestic Product.

5. (a) No, because a population of chamois in the Swiss Alps is not owned by any institutional unit (the animals are free to pass the Austrian border without becoming "Austrians", and vice versa). (b) Yes, because the cows are owned by a cattle-breeder who derives economic benefits from the stock. (c) No, because the owner of the garden (who owns the weeds, as well) derives no economic benefit from the weeds.

Glossary

Note: Terms which are defined elsewhere in the glossary are marked in italics.

Abatement cost *Opportunity cost* to reduce a negative *externality* (to reduce pollution)

Agent Synonym for *economic agent*

Allocation Certain amounts of productive resources assigned to competing productive activities and of *consumer goods* assigned to competing individual *consumers*

Allocation mechanism Mechanism that guides both productive resources to various productive sectors and the outcomes of productive activity to various *consumers*

Allocative policy Use of policy measures in order to achieve an *efficient* use of resources

Anthropocentrism Philosophical position which acknowledges human interests and rights only

Bergson-Samuelson welfare function Function which defines the *welfare* of a society as the weighted sum of the *utilities* of the individual *consumers* belonging to the society

Boom Phase of a *business cycle* characterized by actual production exceeding the *productive capacity* of the economy

Bureaucratic system Economic system characterized by public ownership of resources and by an *allocation mechanism* in the form of governmental planning

Business cycle Cyclical divergence of *productive capacity* and actual production

Capital market, macroeconomic Institution which coordinates the aggregate amounts of savings supplied and funds demanded for the purpose of investment

Cardinal measure Unit of measurement which generates meaningful statements based on the difference between two measurement values (e.g., metre, litre, degrees Fahrenheit)

Central bank State-run institution exclusively issuing domestic currency and seeking to avoid *inflation*

Circular flow System of real and monetary transactions between the various sectors of an economy

Club good Good which exhibits the properties of *excludability* of use and *non-rivalry* in use

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Coase theorem Policy strategy aiming at the *internalization of a negative external effect* by attributing property rights to a natural resource, thereby creating an incentive for both the *agents* responsible for the *external effect* and the victims of the effect to engage in negotiations about the level of the *external effect*

Collective good Good which exhibits the properties of *non-excludability* of use and *non-rivalry* in use

Commodity Tangible *good* (like shoes, milk, cars etc.)

Competition Situation in which various *economic agents* supplying/demanding the same *good* try to attract the same set of buyers/sellers

Consumer *Economic agent* that demands *consumer goods* and supplies factors of production

Consumer good Good which satisfies human *needs* directly (like an apple or a newspaper)

Consumer sovereignty Postulate that only human individuals themselves can judge the character and the intensity of their own *needs*

Distributive policy Use of policy measures in order to achieve a just distribution of income and wealth between individual *consumers* or factors of production

Division of labour Division of employment or a process into parts, each of which is carried out by a separate *economic agent*

Ecocentrism Philosophical position which acknowledges, besides human interests and rights, the interests and rights of other species as well

Economic agent Acting unit whose behaviour is guided by the *economic principle*

Economic principle Postulate of achieving, given the resources available, the maximum possible level of goal attainment (maximum principle) or a given level of goal attainment using the minimum amount of resources (minimum principle)

Efficiency Absence of wasting of resources

Environmental liability law Policy instrument aiming at the *internalization of a negative external effect* by specifying legal conditions obliging the *agent* responsible for the *external effect* to pay compensation for the damage

Equilibrium Situation in which an economic agent does not want to change his/her plans; see also *market equilibrium*

Equilibrium price Price of a *good* which equates the total quantity demanded of this *good* to the total quantity supplied

Excludability Property of a *good* which implies that it is possible, by acceptable costs, to prevent *economic agents* from using that good

Existence value Individual *consumers*' *willingness to pay* for the mere existence of a natural resource stock irrespective of its use value

Exploration The search for and investigation of deposits of non-renewable natural resources

External benefit Positive *external effect* evaluated in monetary terms

External effect Positive or negative effect of an economic activity which is not attributed to the *economic agent* carrying it out because the effect does not enter the *market price*

Externality Synonym for *external effect*

External cost Negative *external effect* evaluated in monetary terms

Firm *Economic agent* that supplies *goods* and demands both factors of production and *investment goods*

Flow Quantity measured as accumulating during a period (e.g., the sum of 12 monthly income payments received by a *private household* between January 1 and December 31)

Free riding Incentive scheme which prevents the private provision of *collective goods*; due to *non-excludability* and *non-rivalry*, each *economic agent* refuses to make a personal contribution, expecting that the *good* will be provided by the contributions of other *agents* who do not suffer from *agents* who do not contribute using the *good*

Good Any aspect of reality able to satisfy a human *need*

Goods market, macroeconomic Institution coordinating the aggregate amounts of *goods* supplied and demanded

Inefficiency Wasting of resources

Inflation General increase in the prices of *goods*

Instability Deviation of the actual utilization of the *productive capacity* from its normal utilization

Internalization of external effects Attribution of *external costs* or *external benefits* to the *agent* responsible

Investment good *Good* which contributes indirectly to the satisfaction of human *needs* via the production process

Justice Concept of how to weight individual *utilities* in a *social welfare function*

Kaldor-Hicks criterion Principle according to which an *allocation* A is better than an *allocation* B for society as a whole if in A, at least one of the *economic agents* belonging to society is made better off, while at least one of the other *agents* is made worse off compared to B, but what is won by the benefiting *agent*(s) is enough to compensate the loser(s) and still leave a positive net improvement for the benefiting *agents*; it is not a prerequisite that compensation actually takes place, with all that is required being that compensation is possible

Labour market, macroeconomic Institution which coordinates the aggregate amounts of labour supplied and demanded by virtue of the wage rate

Macroeconomics Branch of economic science which deals with the problems of unemployment, *inflation*, stagnation and foreign trade imbalance within highly aggregated models

Market Institution which coordinates the amounts of a *good* supplied and demanded by virtue of the *good's* price

Market equilibrium *Allocation* characterized by (1) the total quantity demanded of a certain *good* being equal to the total quantity supplied, (2) *utility* maximization on the part of all *consumers* participating in the *market* and (3) profit maximization on the part of all *firms* participating in the *market*

Market price Equilibrium price paid for a single unit of a certain *good*

Market system Economic system characterized by private ownership of resources and by an *allocation mechanism* in the form of the *price mechanism*

Maximum sustainable yield *Sustainable yield* associated with the particular stock level of a renewable natural resource that produces the highest possible amount of growth of the resource

Microeconomics Branch of economics dealing with the problem of *scarcity* within disaggregated models of *consumers*, *firms*, and *markets*, as well as other agents and institutions

Need Feeling of suffering or dissatisfaction (e.g., hunger, fear, loneliness)

Non-excludability Property of a *good* which implies that it is not possible to prevent *agents* from using it by acceptable costs

Non-renewable natural resource Natural resource characterized by an earthly stock which remains constant over the time span relevant to human planning

Non-rivalry Property of a *good* which implies that the use of it by one *agent* does not prevent other *agents*' using it

Normative analysis Analysis which assesses whether a certain situation is "good" or "bad"

Normative individualism Postulate that the *welfare* of society is to be deduced from the *utilities* of the individual members of society

Open access good *Good* which exhibits the properties of *non-excludability* of use and *rivalry* in use

Opportunity cost The cost of the chosen alternative, interpreted as the benefit that the best alternative forgone would have generated if chosen

Ordinal measure Unit of measurement which does not generate meaningful statements based on the difference between two measurement values (e.g., measurements of beauty, dignity, humanity)

Pareto criterion According to the *Pareto criterion*, an *allocation* A is better than an *allocation* B for society as a whole if in A at least one *agent* belonging to society is better off than it is in B and no other *agent* is worse off in A than it is in B

Pareto efficiency Synonym for *Pareto optimality*

Pareto optimality An allocation is *Pareto optimal* if it is not possible to introduce any change by which at least one *economic agent* belonging to society is made better off without making any other of society's *agents* worse off

Pigouvian tax Policy instrument aiming at the *internalization of a negative external effect* by charging the *agent* responsible for the *external effect* a tax equal to the marginal *external cost* prevailing in the *socially optimal allocation*

Positive analysis Analysis which describes, explains and forecasts events

Preferences The tastes of an individual *consumer* which enable him/her to rank alternatives

Price mechanism Adjustment of the price of a *good* in reaction to a discrepancy between the total quantity demanded and the total quantity supplied of this *good*

Private good Good which exhibits the properties of *excludability* of use and *rivalry* in use

Private household Synonym for *consumer*

Productive capacity Total value of *goods* which can be produced given a "normal" utilization of the available *stocks* of productive factors (labour, capital, etc.)

Public good Synonym for *collective good*

Rational behaviour Behaviour of *economic agents* guided by the *economic principle*

Rawlsian welfare function Function which defines the *welfare* of a society as equal to the utilities of those individual *consumers* belonging to society who are worst off

Recession Phase of a *business cycle* characterized by actual production falling short of the *productive capacity*

Renewable natural resource Natural resource characterized by an earthly stock which grows over the time span relevant to human planning

Rivalry Property of a *good* which implies that the use of it by one *agent* prevents other *agents*' using it

Social optimality An *allocation* is said to be *socially optimal* if the *welfare* of society based on the *social welfare criterion* applied cannot be increased

Social welfare Level of a society's well-being derived from the *utilities* of individual *consumers* belonging to society

Social welfare criteria Definitions of *efficiency* (*Pareto efficiency*, *Kaldor-Hicks efficiency*) and *social welfare functions* (*utilitarian social welfare function*, *Bergson-Samuelson welfare function*, *Rawlsian welfare function*)

Social welfare function Mathematical rule which links the level of society's well-being to the level of society's individual *consumers*' *utilities*; the rule incorporates a certain view of *justice*

Stability Sustained normal utilization of the *productive capacity*

Stabilizing policy Use of policy measures in order to maintain a normal utilization of the *productive capacity*

Standard oriented environmental policy Policy designed to achieve an exogenously given amount of emissions rather than an *internalization of external effects*

Stock Quantity measured at a fixed date (e.g., the *stock* of machinery existing on January 1)

Sustainable development "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, p. 43)

Sustainable yield Amount that can be harvested eternally from a given stock of a renewable natural resource if the resource's periodical growth matches the amount harvested, thereby leaving the stock and its periodical growth unchanged

System of solidarity Economic system characterized by private ownership of resources and by an *allocation mechanism* in the form of an appeal to the common sense of individual members

Utilitarian social welfare function Function that defines *welfare* of society as the sum of the *utilities* of the individual *consumers* belonging to society, where all of the individual *utilities* contribute to *social welfare* with the same weight

Utility Satisfaction an economic agent derives from being in a certain situation, e.g., consuming a *commodity* or enjoying an environmental amenity

Welfare Synonym for *social welfare*

Willingness to pay Amount of money an individual *consumer* is prepared to give in exchange for a *good*

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