4 Real Capital

Abstract

Preshaped by the influence of Marx, Böhm-Bawerk and modern neoclassical economics, the general opinion is that the marginal product of capital must always be positive. With the help of the "period of production" T, we define a coefficient of intertemporal substitution ψ that is always non-negative. It can also be used when the real interest rate is negative. With the help of the concept of the "waiting period" Z, we can also define an always non-negative coefficient of intertemporal substitution γ for the household side. The "loss formula" for deviations of the rate of interest from the growth rate is one application of ψ and γ. $\Omega = (\psi T^2 + \gamma Z^2)(r - g)^2/2$ provides a good approximation of the relative loss Ω. Overcomplexity of the system of production leads to negative marginal returns on capital. It can be empirically presumed that the OECD plus China region is on the cusp of overcomplexity. The hypothetical natural rate of interest in the eurozone is well into the minuses. To determine the value of the real capital of the private sector in the OECD plus China region, we use a framework of data taken from the World Inequality Database (WID.world). We have supplemented the data available there with data from other sources and adapted it to our theoretical objectives. According to our estimates, private wealth in the form of real capital in the OECD plus China region comes to approximately four times total annual consumption.

4.1 Real Capital: Theoretical Foundations

4.1.1 The Point of Differentiating Between Real Capital and Land

Real capital consists of produced goods that are used in turn for the production of other goods: this in contrast to produced goods that are consumed by households and the public sector. We call the value of the latter "total annual consumption."

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Land also enters into the production process as a factor of production. But as opposed to real capital, although land is worked, it is not produced. Hence, the value of land cannot be derived from any sort of production costs. By contrast, the value of goods comprising real capital is largely based on their production costs.

The value of the economy's total stock of real capital goods is *not identical*, however, to its production costs. Capital goods are physically altered by their use in the production process. The notion of "depreciation for wear and tear" is thus regularly employed in assessing the value of a company's assets. But capital goods can also lose value by being replaced one day by more efficient capital goods or, in other words, by being rendered obsolete. The economically useful life of goods is usually shorter than their potential physical life. Finally, changes in value can also be the result of changed market conditions or simply of changes in a company's business outlook.

Maintenance costs, like repairs, can be added to the production costs. They increase the value of the goods in question or prevent them from losing value as a result of diminishing functionality. Nonetheless, maintenance costs are largely entered under running costs. Thus, company management can simulate profit by forgoing maintenance measures and suggesting to the outside world that the goods, nonetheless, have not lost any functionality.

As shown in practice, when ownership of a company changes hands, the price paid almost never corresponds to the reported equity on the transfer date. The economic literature speaks of "Tobin's Q" almost never reaching exactly the value of 1. Tobin's Q specifies the ratio of the market value of the firm to the value of equity reported in its balance sheet (Tobin and Brainard 1977). In the case of publicly traded company shares, Tobin's Q can be determined, in effect, on a quarterly basis as a function of the stock market valuation of the company.

For the purposes of our book, the market value of firms is decisive. We want, after all, to establish how much wealth citizens have. In full-employment equilibrium, their wealth has to be equal to the desired wealth discussed in Chap. 3.

One of the reasons why the market valuation of a company deviates from its reported equity is the following. There are expenditures that are elicited by revenues in the same year. And there are expenditures that can only be justified by revenues in subsequent years. In practice, however, it is often impossible to distinguish between these two categories of expenditure in such a way that differences of opinion cannot arise about which are which. If this difficulty did not exist, then it would be possible to treat expenditures relating to revenues in later years as "investment," to which, then, there would also correspond related depreciation in later years. Because business operations are not so simple, however, it is also possible for companies to manipulate how they report expenditures and revenues. In order to eliminate this threat of manipulation, accounting rules have to be formulated in such a way as easily to allow for intersubjective verification. The consequence, however, is that expenditures that are directed toward a future beyond the current calendar year are often not entered in a way reflecting this—namely as investment—but rather as having an immediate negative impact on earnings. The capital market, however, always reserves the right to make its own judgment about the "true" value of a publicly traded company.

When it does so, a company is often assessed as being far more valuable than its reported equity suggests. But it is also not unusual to come across the opposite case. For the assets side of a company's balance sheet often includes purchases whose depreciation has been underestimated and hence whose reported value is far greater than the value that they still have on the view of the capital market.

As discussed in detail in Sect. 4.2, we use a database that has been elaborated by qualified economists, in which the value of real capital is determined according to the principle of market valuation. A Tobin's Q that is not equal to one is thus already taken into account here. This is why, in this chapter, we combine reported equity and a Tobin's Q different from 1.

In Chap. 5, we cover land as factor of production (Sect. 5.1) and as form of wealth (Sect. 5.2).

4.1.2 The Capital-Output Ratio Does Not Exhibit Any Trend

In 1961, Nicholas Kaldor already observed that the capital-output ratio does not exhibit any trend over time (Kaldor 1961). This observation was later extended by other authors to their respective presents. Figure 4.1 can serve as an example.

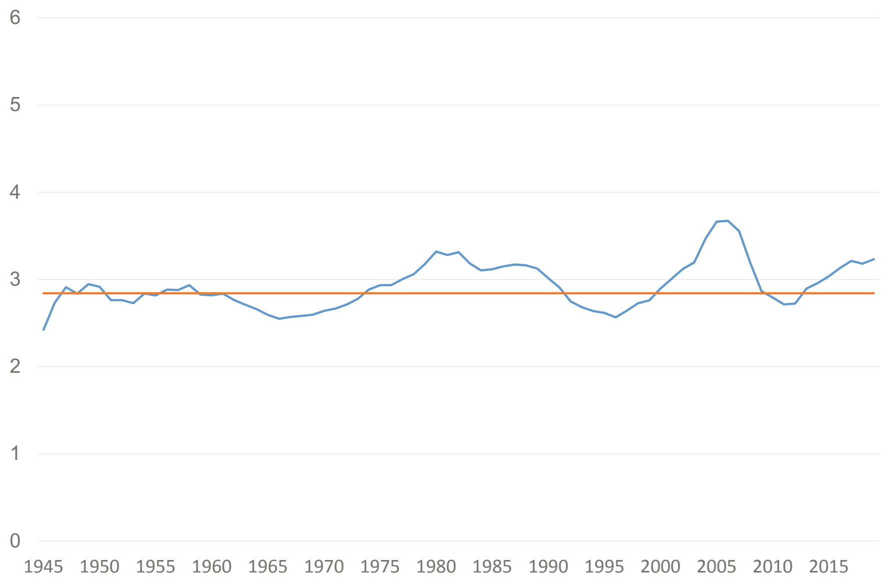

Fig. 4.1 Capital Coefficient USA, 1945–2019. *Source* Integrated Macroeconomic Accounts for the United States, https://www.federalreserve.gov/apps/fof/FOFTables.aspx, accessed: 19 January 2021; Authors' own calculations

It shows that the capital-output ratio has been nearly constant in the USA since the end of the Second World War. Similar results could be shown for most other countries. A similar picture is obtained, if real capital stock is compared to annual consumption, as in our analysis. For the ratio of GDP to consumption has hardly changed for decades. Our putting current consumption in the denominator has to do with the steady-state analysis that we have presented in Chap. 2 and in Weizsäcker (2021). Consumption is, after all, the ultimate purpose of production. Hence, it makes sense to compare the intermediate products, in the form of real capital, to this ultimate purpose of production.

The fact that the capital-output ratio, or what we will call the capital coefficient, is historically constant contrasts with the substantial increase in the ratio between private wealth and current consumption. We speak here of the *wealth coefficient*. Up to now, no comprehensive empirical presentation of private wealth has been available for the OECD countries. Our book provides a first look at the current relationship between private wealth and current consumption for the OECD plus China region (Sects. 4.2, 5.2, 6.2 and Chap. 8).

What is still missing, however, is a presentation of the historical evolution of this wealth coefficient. There have indeed been recent studies on the evolution of private wealth, but private wealth is defined differently in them than in our book: Implicit public debt vis-à-vis a country's citizens—which is highly significant in quantitative terms—is, namely, missing from these time series. On our view, this implicit public debt has to be counted as an additional element of private wealth. In particular, Piketty (2014) and Jordà et al. (2019) should be mentioned here. Both studies show considerable secular growth in the ratio between this more narrowly defined private wealth and national product or income. This secular growth would probably be even more pronounced, if our broader concept of wealth were used. For the implicit public debt that we take into account is based on the welfare state. But in all OECD countries, the welfare state has undergone massive expansion in recent decades—driven to a not inconsiderable extent by the secular increase in life expectancy—and in China too, it has started to grow.

Nonetheless, the consequences for economic policy of this growing discrepancy between capital coefficient and wealth coefficient have not yet been thought through. Intellectual obstacles that can be traced back to venerable traditions play a role here. The next three sections are devoted to such prefabricated thinking. What is at issue is, above all, that the possibility of a long-term, massively negative real interest rate and the dangers to which it gives rise are alien to such traditional economic thinking.

4.1.3 Prefabricated Thought 1: Marx

Still today, our thinking is guided by books and articles from long ago. In the context of interest to us here, we are referring, in particular, to Karl Marx, Eugen von Böhm-Bawerk and the Solow model's CES production function. These antecedents make it hard for us to accept the possibility of a negative natural rate of interest. In what follows, we will show why.

Firstly, on Karl Marx: Thinkers who are close to Marx, both within theoretical economics and outside of the latter, adopt Marx's idea of the "internal contradictions" of the capitalist economic system. The "Law of the Tendential Fall in the Rate of Profit" is an essential component of Marx's thought in this connection. In Marx, this law is derived from the thesis of a constantly increasing "organic composition of capital," which is associated with the creation of relative surplus-value. The unfolding of capital in historical time already contains the seeds of its collapse, because it is more and more difficult for capital to find profitable investment outlets. Later, Rosa Luxemburg and other members of the Marxian school developed the theory of imperialism from Marx's finding in this regard (Luxemburg 1913). They argued that imperialism serves temporarily to delay the valorization problems of capital by providing preferential sales opportunities for domestic capital in the colonies. The theory was also used to explain the World War among the capitalist nation states.

In this context, it is worth re-reading the Marxian theory of the creation of relative surplus-value. The pertinent chapters in the first volume of *Capital* bear repeated reading, even if we do not adopt the theory that goes with them. For they describe the broad outlines of the historical development of economic modernity with a sure brushstroke—although only, of course, up to roughly the end of the nineteenth century (a third edition having been published shortly after Marx's death in 1883). (Cf., in particular, Chap. 15 of *Capital*, vol. I, titled "Machinery and Large-Scale Industry".)

Marx derives the "Law of the Tendential Fall in the Rate of Profit" in the third volume of *Capital* (Cf. also Marx's letter to Engels of 30 April 1868). The profit rate r is defined or rather explained by Marx as follows:

$$r = \frac{s}{c + v}.$$

Here, s is the surplus-value appropriated by capital, v is the variable capital employed and c is the constant capital employed. The ratio s/v is the "degree of exploitation." It specifies the ratio in which the value created by labor is divided into wages (v) and profit or surplus-value (s). The variable capital v is thus the wage due, but not yet paid to, the worker. Marx is thinking here—in a way that is realistic for his time—that workers work for the whole week, but only receive their wage at the end of it. During the week, workers thus advance capitalists, on average, half their weekly wage. Hence, v is half the weekly wage. It also follows that the rate of profit calculated in this way represents the rate of profit for half a week.

The constant capital employed, c, is embodied in the means of production: i.e., in raw materials and equipment or, in other words, precisely in what we today call real capital. "Past labor" is embodied in the constant capital.

Marx calls the ratio between the total capital employed and the variable capital the "organic composition of capital." The rate of profit can thus be understood as

$$\text{rate of profit} = \frac{s}{c+v} = \frac{\frac{s}{v}}{\frac{c+v}{v}} = \frac{\text{degree of exploitation}}{\text{organic composition}}.$$

The creation of *relative* surplus-value by capital takes place on the level of the individual business by moving from the previous methods of production to new methods, which increase the productivity of labor. This allows capitalists to increase their surplus-value by decreasing the share of wages in the value created during a working day of a given length: in other words, by raising the degree of exploitation. But inasmuch as competing capitalists do the same thing, the surplus-value falls again, such that the rate of profit returns to its previous level.

Nonetheless, at the same time, the move to new methods of production is associated with an increase in the organic composition of capital. Marx describes this relationship in Chap. 25 of *Capital*, vol. I, titled "The General Law of Capitalist Accumulation." In its second section—titled "A Relative Diminution of the Variable Part of Capital Occurs in the Course of the Further Progress of Accumulation and of the Concentration Accompanying It"—Marx writes: "Apart from natural conditions, such as the fertility of the soil, etc., and apart from the skill of independent and isolated producers (shown rather qualitatively in the high standard of their products than quantitatively in their mass), the level of the social productivity of labour is expressed in the relative extent of the means of production that one worker, during a given time, with the same degree of intensity of labour-power, turns into products. The mass of means of production with which he functions in this way increases with the productivity of his labour. But whether condition or consequence, the growing extent of the means of production, as compared with the labour-power incorporated into them, is an expression of the growing productivity of labour. The increase of the latter appears, therefore, in the diminution of the mass of labour in proportion to the mass of means of production moved by it, or in the diminution of the subjective factor of the labour process as compared with the objective factor. This change in the technical composition of capital, this growth in the mass of the means of production, as compared with the mass of the labour-power that vivifies them, is reflected in its value-composition by the increase of the constant constituent of capital at the expense of its variable constituent (Marx 1976 [1867], p. 773).

Nonetheless, Marx is aware of the fact that the mass represented by the constant capital (measured in kilos perhaps?) increases faster than the constant capital, c, as measured in labor-value. Thus, shortly further on in the same chapter, he writes: "However, this diminution in the variable part of capital as compared with the constant part, or, in other words, this change in the composition of the value of the capital, provides only an approximate indication of the change in the composition of its material constituents. The value of the capital employed today in spinning is ⅞ constant and ⅛ variable, while at the beginning of the eighteenth century it was ½ constant and ½ variable. Yet, in contrast to this, the mass of raw material, instruments of labour, etc. that a certain quantity of spinning labour consumes productively today is many hundred times greater than at the beginning of the eighteenth century. The reason is simple: with the increasing productivity of labour, the mass of the means of production consumed by labour increases, but their value in comparison with their mass diminishes. Their value therefore rises absolutely, but not in proportion to the increase in their mass" (Marx 1976 [1867], p. 774).

Marx's "Law of the Tendential Fall in the Rate of Profit" depends on the growing organic composition of capital. This law is of fundamental importance in the Marxist tradition, since it manifests the internal contradictions of the capitalist system and is thus also indispensable for the prophecy of the system's collapse. This is why it has never been called into question in Marxism.

What is of interest for us is that Marxism—translated into the categories of modern macroeconomics—thus assumes a law of a tendentially increasing capital-output ratio. For, along with the rise in the organic composition of capital, the ratio between the stock of real capital c and the resulting periodic value output $v + s$ also rises.

It is not necessary for us to discuss the well-known "transformation problem" in the present context: namely, the problem of the transformation of (labor-)values into prices of production. One of us analyzed this aspect in a paper decades ago (Weizsäcker 1977). Interestingly, the simplification undertaken by Marx in this connection, inasmuch as he expresses the rate of profit in labor values rather than competitive prices, amounts to a linearization of a curved relationship between rate of profit and real capital; this simplification is identical to the simplification undertaken by Böhm-Bawerk in his *Capital and Interest*—which we will discuss below—inasmuch as he works with simple interest rather than compound interest, as, strictly speaking, he should. As a by-product, we find that the Marxian "organic composition of capital" is *identical* to Böhm-Bawerk's average period of production. For, on closer inspection, the "organic composition of capital" is a quantity with the dimension of "time." This is only obscured by the fact that the time unit in which Marx defines the rate of profit is a highly unconventional one: namely the average time "advanced" by the worker to the capitalist. If wages are paid at the end of the week, this average time advanced is three days. When calculating the annual rate of profit, the variable capital is thus negligibly small in comparison to the constant capital. The rate of profit is then the inverse of the (constant) capital employed divided by the annual profit. But the latter expression is an amount of time that is commensurable with Böhm-Bawerk's period of production. Now, if Marx calculates using labor-values instead of prices of production and Böhm-Bawerk calculates using simple instead of compound interest, then it becomes clear that the coefficient composed of constant capital and annual value output is equal to the period of production.

It is thus virtually dogma in the politically highly influential Marxian school that the ratio between the stock variable "real capital" and the flow variable "value output" tends constantly to increase. Returning to Marx, however, we find that while he recognizes the difference between the physical composition of "past labor" and its "value" c, he does not draw the consequence of going on to verify whether —despite the noted constant decrease in the coefficient composed of the value of the means of production divided by their quantity—this value has a tendency to increase in relation to variable capital. Such verification is omitted. As we now know, had it been undertaken, it would have shown that the "organic composition of capital" has not increased.

4.1.4 Prefabricated Thought 2: Böhm-Bawerk

Efforts to explain the phenomenon of interest in neoclassical theory began with Eugen von Böhm-Bawerk. Even if he was criticized often and ingenuously, the influence of his work on the theory of interest was ultimately greater than that of any other neoclassical economist. It was only the modern neoclassical economics of the period since the Second World War that broke away from Böhm-Bawerk, in order, in general equilibrium theory and modern macroeconomics, to work with models that distanced themselves from his ideas. In the 1930s, there was still intensive discussion of the period of production, in which authors like Boulding, Marschak, Hayek, Oskar Morgenstern, Machlup, Gaitskell, Keynes, Knight, Kaldor, Oskar Lange, Ludwig von Mises, Harrod, Eucken and Hicks took part. (Cf. Lutz 1967, p. 56 and p. 96.)

After the Second World War, the Solow production function replaced the heavily debated period of production as a practical tool for empirical analysis within the framework of macroeconomic models. Only Böhm-Bawerk's "second reason" was retained: namely, in the form of the "time preference" that goes back to Irving Fisher.

Böhm-Bawerk adduced three reasons why the natural rate of interest is positive. The first reason is "the different circumstances of want and provision in present and future": namely, the need intertemporally to shift the means of providing for want (purchasing power). According to Böhm-Bawerk, thanks to the possibility of maintaining stocks, which costs little in the case of money, shifting to a future point in time is unproblematic, whereas shifting from the future to the present or from a distant future to a nearer future is either impossible or indeed costly. This asymmetry in the possibilities of intertemporal shifting of the means of providing for want leads, on his account, to a "lesser value being attached to future goods as compared to presently available goods." This "first reason" was already the target of harsh criticism during Böhm-Bawerk's lifetime—and, in our opinion, justifiably so. For maintaining a stock of physical goods is associated with considerable costs and risks. And even under conditions of price stability in the economy as a whole, maintaining a stock in the form of money presupposes that either a borrower is available who, for reasons other than the "first reason," is willing to assume this position of borrower or that enough money is available in the form of central bank money to satisfy this need for maintaining a stock. The latter, however, by no means goes without saying. If, for reasons that we have presented in Chap. 3 on desired wealth, the desire to shift resources into the future is very great, money with stable purchasing power can at most ensure that the real rate of interest does not fall below zero. The "first reason" cannot serve to explain a positive natural rate.

The "second reason" for the lesser value attached to future goods is the "undervaluation of future needs as compared to current ones." Irving Fisher introduced the expression "time preference" for this phenomenon, which plays a significant role in his theory of interest. In modern presentations, it is mostly depicted as follows. We presuppose that the individual in question maximizes a utility integral that looks like this:

$$\int_{0}^{t_0} e^{-ht} u_t(c(t))dt; \quad h > 0; \quad t_0 > 0$$

Here, $c(t)$ is the consumption flow, h stands for the rate of "time preference" and u_t represents the period utility function at time t.

Other things being equal, the equilibrium rate of interest will undoubtedly be higher in a macroeconomic model, if the rate of time preference h is higher. But on its own, a positive h will not be sufficient to raise the equilibrium rate of interest to a positive level. It is easy to construct counterexamples here.

The "third reason" given by Böhm-Bawerk to explain a positive rate of interest is the "greater productivity of more roundabout production." This greater productivity is the real core of the "temporal" theory of capital, which is often also referred to as "Austrian" capital theory. In Chap. 2 on the natural rate of interest, we carried out an "Austrian" analysis: The natural rate of interest ρ is lower than the rate of growth g precisely when, at $r = g$, the private waiting period Z is greater than the period of production T.

For Böhm-Bawerk, the measure of the roundaboutness of production in the economy is the average period of production. On his account, labor productivity rises with a longer period of production. Furthermore, the capital requirements of the economy are, for him, the product of total annual wages and the period of production. In Böhm-Bawerk, the rate of interest is the price signal for the extent of the raised productivity as measured by a marginal increase in the period of production. In other words, for him, the rate of interest r equals the marginal yield in labor productivity of the period of production divided by labor productivity. If the (real) rate of interest is 5% per year, then a one-year increase in the period of production leads to a 5% increase in labor productivity.

The idea that the amount of real capital corresponds to the extent of the roundaboutness of production has become deeply embedded in the intuition of economists. And with it, so too has the notion that more roundaboutness of production leads to a rise in labor productivity. This intuition has also been taken over by modern macroeconomics: namely in the idea that equipping jobs with more real capital leads to increased labor productivity. It is treated as self-evident that labor productivity is a monotonically increasing function of capital intensity.

Böhm-Bawerk predicted that the average period of production would become longer and longer in the twentieth century, due to the greater productivity of more roundabout production and due to increasing prosperity. He thus essentially adopted the same position as the Marxian school. Both schools, the "bourgeois" or "neoclassical" and the Marxian, were long in agreement that the capital-output ratio would continue to rise. But they were wrong. One of the most well-known "Kaldor facts" is that the capital-output ratio does not exhibit any secular upwards trend.

4.1.5 Prefabricated Thought 3: The CES Production Function

After the Second World War, Böhm-Bawerk's concept of the period of production was set aside and replaced by the Solow production function. The latter involves a symmetrical treatment of the factors of production "labor" and "capital" in the macroeconomic production function. This approach even survived the Cambridge versus Cambridge capital controversy—despite harsh criticism on the part of the theorists from Cambridge in the UK. The fact that empirical work in macroeconomics is greatly facilitated by working with the Solow production function is certainly one reason why. For information on labor inputs and real capital inputs is abundantly available. Solow's pioneering 1957 study, which gave rise to the flourishing field of growth accounting, already made use of the long time series for labor and real capital inputs that were available for the USA. (And Solow himself, who both knew the capital-theoretical literature well and made important contributions to it, always stressed that the Solow production function is to be understood as an approximation, which, depending on the context, either successfully adds to our knowledge or is misleading.)

The symmetrical treatment of labor and capital in the macroeconomic production function also allows for an empirically relevant approach to the topic of substitution. The notion of elasticity of substitution between two factors of production has been known since the 1930s. The notion was already developed by Hicks in 1932 in his *Theory of Wages*, where it was applied to the factors "labor and capital." Building on Hicks's work, Arrow, Chenery, Minhas and Solow introduced the CES production function into the literature in 1961. The latter is defined by the property that the elasticity of substitution between the two factors is the same for every combination of factors. By virtue of the assumption that it is a constant, the value of the elasticity of substitution, which is a local property of the production function, becomes a global property of the production function.

This, however, makes empirical work on macroeconomic models considerably easier. Since the latter are usually supposed to describe economic growth, researchers have to cope with drastic changes in the ratio in which capital and labor are employed. In order, for instance, to make predictions, researchers have to deal with the consequences of future capital intensities that are far removed from those observed in the past. It is helpful here to assume the elasticity of substitution that has been econometrically estimated using historical values as a constant, in order thus to be able also to model the behavior of the production function at future capital intensities.

But it is a property of the CES production function that the marginal products of both factors remain positive, regardless of the factor ratio at which the marginal products are being evaluated. It is thus ruled out in advance that the factor "capital" could also have a negative marginal product. The CES production function thus rules out the main thesis of this book by assumption.

We can, of course, work with forms of the Solow production function in which a negative marginal product of capital is possible. But then we lose the property of a constant elasticity of substitution between labor and capital.

Let us sum up the three Sects. 4.1.3–4.1.5. Hitherto, models have predominated in macroeconomics whose simplifying strategies imply that there can never be a negative natural rate of interest. Both Marx and Böhm-Bawerk believed that there would be an increasing capital-output ratio in the future. In Marx, this is the tendentially rising organic composition of capital, from which he derives the tendential fall of the profit rate. Böhm-Bawerk predicted that there would be increasing roundaboutness of production in the twentieth century. Both of them assumed, however, that this rising capital-output ratio would be associated with a rate of profit or, respectively, a rate of interest that remains positive. And modern, neoclassical macroeconomics and growth theory does not hesitate to work with the CES production function, which excludes a negative marginal product of capital from the outset. Our thesis of a negative natural rate of interest has thus to struggle against a prevailing intuition, according to which, at full employment, the equilibrium rate of interest cannot be negative.

4.1.6 The Coefficient of Intertemporal Substitution

It is worthwhile to look for another instrument for measuring the phenomenon of substitution at the macroeconomic level. To this end, it is useful to reconsider the temporal theory of capital, which was founded by Böhm-Bawerk with his notion of the "roundaboutness of production" and which we already touched upon in Chap. 2 on the natural rate of interest. We found there that Böhm-Bawerk's idea of an equality between capital requirements per worker, on the one hand, and the product of the period of production and annual wages, on the other, comes true precisely in that steady state in which the risk-free interest rate equals the growth rate. But this means that this equation holds precisely when the prosperity-maximizing rate of interest has been realized. Moreover, the period of production T for the economy as a whole is then equal to the waiting period $Z - D$ for the economy as a whole. The assumptions that we have to make to obtain this result are, in principle, largely independent of the specific growth model. *This means, however, that it is a fundamental finding*. In particular, it does not depend on the restrictive assumptions of the Solow model. The Solow model is here merely a special case of a far more general result. Hence, we call the equation

$$T = Z - D$$

the *Fundamental Equation of Steady-State Capital Theory*.

We thus propose replacing the traditional elasticity of substitution between labor and capital by a *coefficient of intertemporal substitution*. The latter indicates the influence of the interest rate level on the steady-state period of production.

In the chapter on the natural rate of interest, we discussed the period of production T. If we compare different steady states, then T varies with the rate of interest. In general, we can write: $T = T(r;\ \theta)$. For T was defined as

$$T = -\frac{\partial w(r;\theta)/\partial r}{w(r;\theta)} = -\frac{\partial \ln w(r;\theta)}{\partial r}.$$

As already mentioned, it was Hicks who, in 1939 in *Value and Capital*, recognized that (as against Böhm-Bawerk's procedure) the period of production should be calculated using present values, in order to arrive at useful results. But this means that the period of production is not only dependent on the physical structure of the production apparatus, but also on the rate of interest used to calculate the present values of wages for labor inputs and the present values of consumer good outputs.

We can now form the partial derivative of T with respect to θ, remembering that, thanks to our naming convention, $\theta(r) = r$ holds. This partial derivative looks, then, as follows, whereby we calculate the derivative at $\theta = \theta(r) = r$:

$$\frac{\partial T(r;\theta)}{\partial \theta} = -\frac{\partial^2 \ln w(r;\theta)}{\partial r \partial \theta}.$$

The partial derivative of the period of production with respect to the production technique $\theta(r)$ induced by the rate of interest is thus the negative value of the mixed second partial derivative of the natural logarithm of the wage with respect to the rate of interest and with respect to the production technique. Now, in "Capital Theory of the Steady State" (Weizsäcker 2021) we show that

$$\frac{\partial T(r;\theta)}{\partial \theta}$$

is negative (Theorem 7A). The economic intuition corresponding to this mathematical result is not difficult to grasp. Let us imagine a completely vertically integrated *virtual firm*, whose only input is "labor" and whose only output is a basket of consumer goods. The period of production specifies the average time lag between the consumer goods that become available later and the wages that are due earlier. A higher rate of interest means that the relative prices of future goods become lower and of past goods become higher. Hence, the average wage must fall. This is expressed by the equation

$$T = -\frac{\partial w(r;\theta)/\partial r}{w(r;\theta)} = -\frac{\partial \ln w(r;\theta)}{\partial r}$$

The virtual firm responds to the change in relative prices by economizing on the inputs whose prices have increased the most: namely the labor inputs that are furthest in the past. It modifies its output by reducing the consumer good output that is furthest in the future, since this is the output whose prices have fallen the most, in favor of additional production of output in the near future. Both changes—on the input side and on the output side—bring about a shortening of the period of production. We can now conceive of the economy growing in the steady state as a collection of overlapping, completely vertically integrated, virtual firms. It can thus be shown that the inequality

$$\frac{\partial T(r;\theta)}{\partial \theta} = -\frac{\partial^2 \ln w(r;\theta)}{\partial r \partial \theta} \leq 0$$

also holds for the economy as a whole.

Analogously to the traditional elasticity of substitution, we want to define a measure of substitution that is dimensionless and hence is not dependent on the chosen unit of measurement. In this case, it is

$$\psi = \frac{\partial(1/T)}{\partial \theta}.$$

Since the rate of interest r and hence also $\theta\ (r) = r$ have the dimension "1/the unit of time," they have the same dimension as the expression $1/T$. Hence, the derivative of the latter expression with respect to the former is dimensionless. Moreover, this derivative is naturally positive, since T becomes smaller with an increasing θ. At the limit, when there is no substitution at all, ψ is equal to zero.

This procedure would only run into difficulties, if the period of production were not continuously, i.e., at every relevant rate of interest, positive. However, we can rule out this possibility as "pathological," since it would mean that the economy is producing without capital. But we must not rule out the possibility of the rate of interest r becoming negative. And this is significant for our approach.

We call the theorem showing that ψ is always non-negative the *Law of Intertemporal Substitution*: The change of production technique induced by a rise in the rate of interest replaces earlier than average inputs by later than average inputs; and it replaces later than average outputs by earlier than average outputs. It thus corresponds to a pattern of intertemporal substitution: a pattern that exhibits a definite direction of substitution. It can be regarded as analogous to well-known substitution effects where the good that has become more expensive is replaced as input by the good that has become cheaper—and where the good that has become cheaper is replaced as output by the good that has become more expensive.

We can also consider the waiting period Z on the household side in an analogous fashion to the production side. Here too, there is an analogous Law of Intertemporal Substitution. As already discussed in Chap. 2 on the natural rate of interest, we can assign a work-consumption pattern $\eta(r)$ of the representative consumer to each steady state. Using an appropriate naming convention, we can write $\eta(r) = r$.

We define $\bar{w}$ (η; r) as the "wage" that is required to finance a given work-consumption pattern at a given rate of interest r. As shown in Weizsäcker (2021), the equation

$$\frac{\partial \overline{w}}{\partial r} = -Z(r;\eta)\overline{w}(\eta;r);$$

holds; such that

$$\frac{\partial \ln(\overline{w}(\eta;r))}{\partial r} = -Z(r;\eta).$$

From this, at $\eta = \eta(r)$, we derive

$$\frac{\partial Z}{\partial \eta} = -\frac{\partial^2 \ln(\overline{w}(\eta;r))}{\partial r \partial \eta}.$$

We show that this expression for the partial derivative of Z with respect to the work-consumption pattern is always positive (Theorem 7B). The work-consumption pattern responds to a rise in the interest rate by the household moving its labor supply forward in time and, conversely, postponing its consumption. This too is a variant of the well-known neoclassical substitution theorem: Supply falls and demand rises for what becomes cheaper; and supply rises and demand falls for what becomes more expensive. Accordingly, we can define a coefficient of intertemporal substitution γ on the household side. Let it be

$$\gamma = -\frac{\partial(1/Z)}{\partial \eta}.$$

This coefficient is non-negative, since $\partial Z/\partial \eta$ is non-negative.

4.1.7 An Application of the Coefficient of Intertemporal Substitution

In Weizsäcker (2021), we show an application of both coefficients of intertemporal substitution. In many respects, our *meta-model* is far more general than the models that are typically developed in macroeconomics, capital theory and growth theory. It owes its usefulness to the restriction to a steady-state perspective. For the purpose of addressing the main question of our book—namely that of the natural rate of interest—this restriction to steady states is entirely appropriate. The assumptions made amount to the claim that the steady-state rate of interest is a correct price signal for intertemporal allocation. If the steady-state rate is a correct price signal, then the Golden Rule of Accumulation holds. Its validity is thus not dependent on more specific assumptions that are made in each model.

But the more specific assumptions made in each model do, of course, have an influence on the extent to which the standard of living declines with respect to the optimum, when the rate of interest is not equal to the rate of growth.

Nonetheless, on the basis of the meta-model, we can already derive a second-degree Taylor approximation for the relative loss of wealth. With the help of the notion of a steady-state standard of living, we will here provide an abridged presentation of the result that is mathematically derived in Weizsäcker (2021). We speak here of the "standard of living" of a representative household and not of its real consumption, since, by the Samuelson Theorem (Samuelson 1958), what is important is not only the amount of consumption per labor year, but also the intertemporal distribution of the latter. By the generalized Phelps-Weizsäcker Theorem, real steady-state consumption is lower at $r \neq g$ than at $r = g$. By the generalized Samuelson Theorem, at the same steady-state consumption per labor year, lifetime utility U is lower at $r \neq g$ than at $r = g$. We can now derive an approximation formula for the relative loss in the standard of living as a second-degree Taylor approximation. We call this percentage loss in standard of living Ω. The following, then, holds:

$$\Omega \approx \left(\psi T^2 + \gamma Z^2\right)(r - g)^2/2$$

whereby the symbol "≈" indicates that we are dealing here with a second-degree Taylor approximation.

The "error" that we commit using this Taylor approximation is, of course, dependent on the properties of the specific model we use to calculate the exact loss in standard of living. At realistic values for T and Z, it turns out, in the case of the Solow Model and a lifetime utility model with realistic values for intertemporal substitution, that the deviations of the Taylor approximation of the meta-model from the real values for Ω are small as long as we are working with deviations of the annual rate of interest from the rate of growth of up to five percentage points. It is evident that the meta-model is very well-suited for calculating the loss in standard of living as long as we work with small, but still perceptible, deviations of the rate of interest from its optimal value.

In Weizsäcker (2021), we assessed the approximation formula

$$\Omega \approx \left(\psi T^2 + \gamma Z^2\right)(r - g)^2/2$$

using a numerical example. At the values $\psi = 1$, $\gamma = 3$, $T = 4$ years, $Z = 10$ years, $g = 3\%$ per year, and $r = -2\%$ per year, there is a resulting decline in prosperity of more than 40% as compared to prosperity under the Golden Rule $r = g$. If we assume a natural rate of interest of –2% per year, then, by comparison, a public-debt-free steady state exhibits this decline in prosperity. A public debt period of $D = Z - T - L = 4$ years corresponds to $r = g$. L is here the capitalized value of land rents, as expressed in annual consumption units. Cf. the following Chap. 5.

In Chap. 6 on public debt, we show that the estimates of $T = 4$ years and $Z = 10$ years roughly reflect the current reality in the OECD plus China region.

4.1.8 A Model with Constant Intertemporal Substitution

In this context, it makes sense to ask what consequences it would have, if we assumed that the coefficient of intertemporal substitution ψ is constant. In Weizsäcker (2021), we calculate the formula in the case of the Solow production function. For a constant ψ and on the assumption of constant returns to scale, we get the following result. Let $f(k)$ be value output per labor year as a function of capital intensity. We make the following standard assumptions:

$$f = f(k) \geq 0; f'(k) \geq 0 \text{ for } 0 \leq k \leq \bar{k}; f''(k) < 0; \; k \geq 0$$

The value $\bar{k}$ maximizes the value output per labor year. $\bar{k}$ can be either finite or infinite. For every production function of this sort, we can calculate the "local" coefficient of intertemporal substitution ψ for every positive k. If we assume now that ψ is a positive constant, we can explicitly calculate the associated production function by way of double integration of an ordinary second order differential equation. For $\psi > 1$, the following holds:

$$f(k) = \lambda k^{\frac{1}{\psi}} - \mu k, \lambda > 0, \mu \geq 0.$$

For $\psi < 1$, we obtain

$$f(k) = \bar{\bar{\mu}} k - \bar{\lambda} k^{\frac{1}{\psi}}, \bar{\bar{\mu}} > 0, \bar{\lambda} > 0.$$

For $\psi = 1$, we get

$$f(k) = \frac{k}{T}\left\{\ln \bar{k} - \ln k + 1\right\} = \frac{k}{T}\left(1 + \ln \frac{\bar{k}}{k}\right).$$

To the extent that when $\psi > 1$, the value μ is strictly positive, then in all three cases, we get the result that labor productivity f reaches its maximum at a finite value $\bar{k}$ for capital intensity and falls again beyond this value, with k continuing to increase. The case in which $\psi > 1$ with $\mu = 0$ is that of the well-known Cobb-Douglas production function. If at $\psi > 1$, the constant of integration μ is strictly positive, then we can interpret $f(k)$ as a Cobb-Douglas function for gross output from which a value for depreciation proportionate to the capital stock is subtracted annually.

Empirically, there are good reasons to assume that ψ is not far from unity, to the extent that we are satisfied with the approximation that the Solow production function represents. These reasons are laid out in Weizsäcker (2021). Hence, the case where $\psi = 1$ merits our particular attention. If we differentiate this production function with respect to k and interpret this derivative as an interest rate, we get the equation

$$r = f'(k) = \frac{1}{T} \ln \frac{\bar{k}}{k}.$$

The marginal productivity of capital is inversely proportional to the logarithm of the capital intensity. If the latter is greater than $\bar{k}$, then the marginal productivity is negative. The "wage" per labor year, w, is

$$w = f(k) - kr(k) = \frac{k}{T}.$$

It is proportional to the capital intensity. The factor of proportionality is the inverse of the period of production T, which is constant in this case, since at $\psi = 1$, the substitution effect of the change in the interest rate and the weighting effect of the change in interest rate cancel one another out when calculating present values. This wage function can be expressed as follows: The "wage" that is generated within the period of production is equal to the capital employed along with the worker.

4.1.9 And What, then, of the "Greater Productivity of More Roundabout Production"?

We now return to the subject of the "greater productivity of more roundabout production". The kernel of truth in Böhm-Bawerk's theory was that the capital requirements of a production technique are explained by the fact that the original means, i.e., the labor input, has to be available earlier than the ultimate purpose of all production: namely consumption. The analogy of a lake makes this especially clear for a stationary economy without interest. In a stationary state, the volume of water in the lake is equal to the product of the inflowing quantity of water per hour (= the outflowing quantity of water in the hour) times the average amount of time the water molecules remain in the lake. In a system of production, this average amount of time corresponds to the period of production T. The hourly inflow of water corresponds, for example, to the annual flow of value in the form of labor years times annual wage. The water outflow corresponds to the value of annual consumption.

The same result can be achieved for a growing system. If we assume that the parts of the total mass increase annually on their own (i.e., without inflow) at the percentage rate r and if we assume, furthermore, that the inflow quantity (like the outflow quantity) also increases each year at the percentage rate g, then the ratio between volume and inflow remains constant precisely when $r = g$. And then it again holds that the volume equals the inflow quantity times the amount of time the water molecules remain in the lake. The same holds for a system of production that is growing in a steady state with a rate of interest that equals the growth rate.

Böhm-Bawerk takes the period of production T to be the measure of the average roundaboutness of production in the economy as a whole, which, precisely on the condition that $r = g$, is also equal to the capital coefficient (capital divided by annual consumption = capital divided by "total annual wages"). The claim that a higher capital coefficient also leads to greater consumption per labor year follows from the stipulated "greater productivity of more roundabout production."

Since thinking within Böhm-Bawerk's model is a form of thinking in stationary systems, Böhm-Bawerk was still not able to grasp the theory of a steadily growing system of production. Already in Böhm-Bawerk's lifetime, Josef Schumpeter attempted, in his *Theory of Economic Development* (Schumpeter 1934 [1911]), to break free from thinking in stationary systems. At the start, however, his theory of entrepreneurial activity—to which he later gave then name "creative destruction" and which, over the years, has become, in effect, the standard theory—suffered from a misinterpretation of what Böhm-Bawerk had achieved using his model of a stationary equilibrium. Schumpeter's claim that a stationary equilibrium is always distinguished by an interest rate of zero could not stand up to the incisive criticism of a Böhm-Bawerk (Böhm-Bawerk 1913).

It was only modern, neoclassical growth theory—and, in particular, the Golden Rule of Accumulation—that demonstrated that the maximization of prosperity is not tied to the greatest possible capital stock. But it thereby became clear to all economists that it does not make sense to increase the roundaboutness of production as much as possible. The optimal degree of roundaboutness of production was at most that corresponding to a situation in which the rate of interest is equal to the rate of growth. And, thanks in large measure to the influence of the Solow production function, there was no one anymore who did not recognize that there could be a problem of excessive accumulation of capital. An early proponent of the thesis of overinvestment was Horvat (1958).

Surprisingly, however, apart from a few exceptions (like precisely Horvath, for example), the universal validity of Böhm-Bawerk's idea of the greater productivity of more roundabout production was not called into question. It was recognized that the marginal productivity of capital can be less than a positive growth rate, but not that it could become negative.

4.1.10 Roundaboutness of Production, Division of Labor and Complexity

If we recall the thoroughly familiar concept of *complexity*, however, the idea that there could be a limit to the increased productivity of more roundabout production seems almost obvious. Living from hand to mouth is a simple life. We imagine the life of hunters and gatherers in the Stone Age as having been such a simple life (cf. Sahlins 1968). The transition to a sedentary agrarian society, which we already discussed in Chap. 3, was connected to considerably more roundaboutness of production and hence also to greater capital intensity. But it thus also involved greater complexity. As the Property Rights School has taught us, in order to be able to cope with this increased complexity, private property in land, and in the structures built on it, was introduced. Private property means precisely a significant *reduction of complexity*, since it eliminated a considerable part of the interference between the different members of society. Too many cooks spoil the pot. Private property functions as a wide-reaching principle of non-interference. In this way, the results of production spanning long periods of time could be internalized. The incentive to engage in production processes spanning long periods of time on account of their roundaboutness was thus greatly increased. For productive complexity to become feasible, a system of institutions has to prevail in society that allows us to take advantage of opportunities for reducing complexity.

It is conceivable, however, that too much complexity comes into being in the end. In the social sciences and social philosophy, liberal thinkers (in the sense of classical liberalism) often employ the notion of "overregulation." It was Adam Smith who established economics as an academic discipline. From an administrative point of view, his plea for free trade—also and especially, free international trade—was a condemnation of the authorities' creation of artificial complexity by way of governmental prohibitions and requirements. We mention this merely as an example of the possibility of unproductive overcomplexity.

The idea of the division of labor is highly instructive in this connection. As is well known, Adam Smith's *The Wealth of Nations* begins with the sentence: "The greatest improvement in the productive powers of labour, and the greater part of the skill, dexterity, and judgement with which it is anywhere directed, or applied, seem to have been the effects of the division of labour" (Smith 1776, I.i.1). This sentence captures the decisive role of the division of labor in modernity. The division of labor makes it possible to exploit a large store of useful knowledge. This knowledge grows over time, since, in a constant process of trial and error, a further refinement of the division of labor, and hence a further accumulation of knowledge, always proves on average to represent progress. But it is important that this is a process of trial and error (in the Popperian sense), which also includes precisely numerous wrong turns. Thus, the scourge of overspecialization arises again and again.

An increase in the division of labor or specialization is an increase in complexity. There is no doubt about the usefulness of this complexity. But when there is a problem of excessive specialization, of excessive division of labor, then there can also be a problem of excessive complexity.

We can distinguish between horizontal and vertical division of labor. The horizontal division of labor is manifest, for example, in the wide variety of goods that people consume nearly simultaneously parallel to one other. Or in the variety of professions. The vertical division of labor concerns the fact that labor is, on average, employed before its ultimate use, in the form of consumer goods, falls due. The vertical division of labor is thus closely tied to the capital requirements of the system of production.

The mere fact that there can be excessive specialization or an excessive division of labor already makes it plausible that there can be an excessive vertical division of labor and hence an excessive capital stock—and this even when we are dealing with a stationary system of production or at least one that is not growing.

We can present this idea in somewhat greater detail. Division of labor or specialization provides us with well-known advantages: in particular, because it makes it possible massively to increase the stock of knowledge that is useful for the system of production. This knowledge includes the “tacit knowledge” to which Michael Polanyi has referred. The division of labor or specialization distributes the overall process of production among many different people. This gives rise to transaction costs in Coase’s (1937, 1960) sense. The optimal degree of division of labor is reached at the point at which the additional knowledge obtained thanks to a further refinement of the division of labor is exactly offset by the additional transaction costs it creates, such that, as a result, this additional division of labor is not worthwhile.

We now apply this general idea to the vertical division of labor. Let us first consider a strictly stationary economy. Its rate of growth g is zero. The generalized Golden Rule of Accumulation tells us that the standard of living of the population reaches its maximum when the marginal productivity of an additional extension of the period of production (which, according to Böhm-Bawerk, can be read off from the real rate of interest) is zero. A longer period of production means a greater vertical division of labor: People involved in the production of today’s consumer goods are more widely distributed across the axis of time; hence, at a given length of the active working life of the individual, there must also be more of them. If we keep this in mind, then the transaction costs of the vertical division of labor must rise. It is thus to be expected that the net yield of an extension of the period of production falls to zero at some finite value and beyond this point becomes negative.

To express this idea in terms of the history of economic doctrines: We bring together Adam Smith (“division of labor”) with Ronald Coase (“transaction costs”) and combine this team with the Austrian team of Carl Menger (“lower and higher order goods”) and Eugen von Böhm-Bawerk (“roundaboutness of production” and/or “period of production”), in order thus to derive the conclusion that the prosperity-maximizing period of production, and hence the prosperity-maximizing capital coefficient, is finite in a stationary economy. There is a limit to the law of the “greater productivity of more roundabout production.”

The same idea can also be expressed more in terms of “business economics.” Every firm and all business operations are persistently confronted by the question of outsourcing. The business obtains some intermediate products from external suppliers and thus reduces the complexity of its own production process. But apart from this advantage, there is also the disadvantage that additional transaction costs are incurred. This was the main idea of Coase’s study on “The Nature of the Firm.” Typically, the business purchases external goods or services at a price that is above the marginal cost of the supplier. This is worth it, if the difference between price and marginal cost is small enough so that the supplier’s price is still less than the marginal cost of the purchasing firm’s producing the good itself.

If, however, there is a very high degree of vertical division of labor among many firms that are involved in the production process almost one after another, then it will be possible to reduce the total cost of the end product by vertically integrating. Thus, it can also be empirically established that there is no tendency toward ever greater vertical division of labor. This is indicative of the fact that the optimal period of production is not infinitely large.

4.1.11 Real Interest Rates of Zero as Price Signal for the Negative Marginal Productivity of More Roundabout Production

If we take the risk-free capital market interest rate as our standard, then for a long time now, there have been real interest rates of zero or even negative real interest rates in the eurozone. And it would appear that this very low interest rate level is not the consequence, but rather the cause of the monetary policy of the European Central Bank (ECB). As Wicksell already showed, the monetary policy of a central bank has to be guided by the "neutral" equilibrium rate of interest. For if the lower rates were merely the consequence of a particular policy orientation of the ECB, then in light of how long they have persisted, there would have to be the onset of massive inflation in the eurozone. But this has not come to pass.

Hence, the evolution of the rate of interest in the eurozone shows that in a hypothetical closed economy consisting of the euro countries, the natural rate of interest is negative. The hypothetical closed eurozone economy has a hypothetical "neutral" rate of interest that is lower than the empirically observed rate. This is so for two reasons: Firstly, the real eurozone enjoys a current account surplus; secondly, there is not full employment in the eurozone. In order to achieve full employment, with given fiscal policy and given economic policy in other respects, the interest rate level would have to be lower than what it actually is. In order to offset the hypothetical disappearance of the current account surplus, the real full-employment rate of interest would have to be even lower. This hypothetical neutral, real full-employment rate of interest is thus already negative. But the natural rate of interest of this economic area is even lower than the neutral full-employment rate. For the level of public debt in the eurozone is equivalent to several years of consumption. Hence, the hypothetical "neutral" rate of interest of this hypothetical closed economy is considerably higher than the natural rate corresponding to a hypothetical steady state without public debt.

We do not want to engage here in speculations about where exactly this natural rate of interest of the eurozone is situated. In our thought experiment on the losses in prosperity of a steady state with a natural rate of interest, we assumed a real natural rate of interest of −2% per year. In keeping with our empirical analysis, we had the OECD plus China region in mind here. Already for demographic reasons alone, the eurozone is among the less dynamic parts of the larger OECD plus China region. Hence, we can presume that the natural rate of interest is algebraically even less than −2% per year. It is, then, even further from zero than −2%.

If, in the tradition of Böhm-Bawerk, we insist, at least for the purpose of a steady-state analysis, on the idea that the real rate of interest is a price signal for the marginal productivity of roundabout production, then we come to the conclusion that an economy without public debt, like the hypothetical closed eurozone, would be characterized by considerably *decreased productivity* of additional roundaboutness of production. It would represent a massive squandering of wealth for the purpose of maintaining full employment. In Chaps. 10 to 13, we will provide better answers, from the point of view of economic policy, to the problem of the structural private savings glut. These answers are related to public debt.

Estimating a real natural rate of interest that is conceived as negative is difficult, because peoples' behavior massively changes, if the returns that they are able to achieve on financial investments signal a risk-free real rate of interest that is no longer positive, but rather massively negative. A "flight to tangible assets" then occurs, which can take very different forms depending upon the investor's opportunities. But this flight is very harmful to the economy.

Buying gold may be a sensible strategy during a transition from higher to lower real interest rates. But in the steady state of a negative real rate of interest that is not, however, falling any further, gold appears to be a very risky investment. Buying real estate can also be a strategy for getting around negative real interest rates, but it too involves considerable risks. We will discuss them in greater detail in Chap. 5. If only due to the "counterparty risk," all these risks are difficult to eliminate by way of hedging with financial instruments. This is especially the case for people who have little wealth. On the whole, historical experience—for example, the experience of the "great inflations" of the 1920s in Europe or of inflation in Latin America—indicates that the losses in efficiency, and hence losses in prosperity, that occur when there are extremely negative real interest rates are even greater than our steady-state thought experiment suggests. If, for example, large parts of the German and Austrian middles classes lost practically all their wealth in the "great inflation," the upheavals to which this would later give rise point to the dangers for prosperity that lie in wait, if real interest rates slide too far into the minuses.

4.2 Determining the Value of Private Real Capital in the OECD Plus China Region

4.2.1 Definitions and Concepts

In this chapter and the following ones, we aim to determine the wealth of private persons. More specifically, the objective of Sects. 4.2, 5.2, 6.2 is to estimate the respective magnitudes of the particular types of private sector wealth that are discussed in greater detail in Sects. 4.1, 5.1 and 6.1. In our analytical framework, private sector wealth is composed of financial assets and non-financial assets in the form of real capital (a produced asset) and land (a non-produced asset) (cf. Table 4.1). The financial assets of the private sector consist exclusively of its financial claims on the state. For the state, there are corresponding liabilities of the same magnitude. The reason why the financial assets of the private sector only exist in this form becomes clear when we elucidate two matters. Firstly, within the private sector, the balance of reciprocal claims and liabilities is zero. Domestically,

Table 4.1 Basic structure of a balance sheet

Assets	Liabilities
Non-financial assets	Liabilities
Produced assets	
Non-produced assets	
Financial assets	Net wealth

Source Authors' own presentation

therefore, the private sector only has net claims vis-à-vis the state. Secondly, we are treating the OECD plus China region as a closed economic area (cf. Sect. 3.11). The balance of reciprocal foreign claims and foreign liabilities within this area is likewise zero.

Hence, the net wealth of the private sector consists of its net financial claims on the state and the two non-financial assets: real capital, the subject of the present chapter, and land, which we will examine in Chap. 5. The private sector's net claims on the state represent public debt, which is composed of explicit and implicit debt. We will deal with public debt in detail in Chap. 6. Excess value plays a special role. The excess value is the difference between the market and the book values of the real capital of the corporate sector in the sense of Tobin's Q. We will go into excess value separately below.

Thus, in our approach, private wealth (W_P) is, by definition, composed of the following four types of assets:

$$W_P = K_P + L_P + V + \tilde{D}$$

The meanings of the symbols are as follows:

K_P: private real capital (including buildings, etc.); L_P: private land (including subsoil reserves, water resources, etc.); V: excess value of the corporate sector; $\tilde{D}$: (explicit net and implicit) public debt.

All of the calculations we have carried out in this chapter and the following ones for estimating the magnitudes of these wealth components are ultimately based on data drawn from the official statistics. In this connection, the conversion of national accounting to the United Nations' 2008 System of National Accounts (2008 SNA) (European Commission et al. 2009) and the European System of Accounts 2010 (ESA 2010) (Eurostat 2013), which is used in all EU Member States, has brought about some significant improvements for our purposes. These improvements involve, in particular, conceptual changes and the expansion of the databases for compiling balance sheets. On the one hand, we should mention information on the present value of retirement benefit claims that have accrued in the context of social security; this data will serve as the basis for the estimation of implicit public debt that we undertake in Chap. 6.2. On the other hand, for some years now, the statistical offices of the OECD countries have been compiling national and sectoral balance sheets (Lequiller and Blades 2014, pp. 231–254).[1] A national balance sheet is a presentation of the assets and outstanding liabilities in an economy at a given point in time. The resulting balance is the net worth (Eurostat 2013, p. 193) or, in our (and Piketty's) terms, net wealth. "Only economic assets…to which institutional units have property rights and from whose use or possession the owner can obtain economic benefits count as assets in the balance sheet" (Schmalwasser and Müller 2009, p. 138). "Institutional units" here refers to the institutional sectors of an economy.

However, not all assets are included in the national and sectoral balance sheets. For instance, human capital, non-mineral natural capital (water, air, etc.), and national monuments are not covered (van de Ven and Fano 2017, pp. 281–283). It is particularly relevant for our investigation that the following three assets are likewise either not included at all or not fully included among the fixed assets:

1. The present value of future public retirement benefits (and medical services) in "pay-as-you-go" social security systems. Recently, however, a number of countries have provided data on entitlements to public retirement benefits separately from their balance sheets in so-called supplementary tables. At least for Eurostat, these tables are a standard part of the data delivery program. This only applies, however, for the public retirement plan. Up to now, it is not the case for other claims on social security systems (e.g., health insurance).
2. The consumer durables owned by households: such as motor vehicles, household appliances and furniture. The reason for this is that national accounting follows a predominantly production-oriented approach. Most statistical offices do not include consumer durables among assets in the balance sheets. Many countries, however, append the value of consumer durables to the balance sheets as a memorandum. For example, in Germany consumer durables owned by households were worth more than 1 trillion euros in 2019, which is equivalent to 12% of households' non-financial assets (Deutsche Bundesbank and Statistisches Bundesamt 2020). Since on our view, such assets form part of the wealth of households, we will add their value in later.
3. Certain intangible assets, like goodwill and marketing assets (brand names, mastheads, trademarks, logos, domain names, etc.) are only added, when they are included in a company balance sheet in the context of its sale (Eurostat 2013, p. 177). If the market values of companies that are not being sold differ from their book values, then excess value comes into being, which is not recorded in the official statistics, since fixed assets are included in the balance sheets at their book values.

[1] In Germany, complete sectoral and national balance sheets have been prepared since 2010. These are composed of data on fixed assets from the Federal Statistical Office [*Statistisches Bundesamt*] and the results of the calculation of monetary assets by the Bundesbank (Schmalwasser and Weber 2012, p. 944). Balance sheets are a key source of empirical data for Piketty and Zucman (2014) and Piketty (2014). Their analyses connect up with the pioneering work of Goldsmith (1985).

In this chapter and the following ones, we attempt to include the value of the three abovementioned types of assets, which are not included in private wealth as represented in the national and sectoral balance sheets. In doing so, we are able to draw on data that is available elsewhere, which is either directly or indirectly taken from official statistics. Various national statistical offices have published related data on certain of these assets (some of them having only begun to do so recently). We will use this data to the extent that it is helpful in making our estimates.

In order to make clear which of the national accounting figures correspond to the abovementioned types of assets that are relevant for us, we will now juxtapose the concepts we use and the terms from the national accounts.

- By real capital, we understand all produced assets. These include, in particular, buildings, machinery and equipment, infrastructure (roads, railway networks, etc.), inventories and intellectual property.
- Land is our generic term for all non-produced assets. The latter include, in particular, land in the strict sense of the term, but also exploitation rights and other natural resources (mineral and energy reserves and other natural assets). They are regarded as non-produced assets, because they are "discovered" and not produced by human beings (van de Ven and Fano 2017, pp. 283).[2]
- Excess value is what we call the intangible assets (goodwill and marketing assets) that do not appear in the balance sheet. Although they also figure among the non-produced assets, we want to separate them from the latter. These intangible assets become apparent when a company is sold and the price paid for it exceeds the reported value of its equity.[3] Excess value is the result of a difference between market value and book value.
- In the case of public debt, the focus of our interest is the balance of the state's liabilities and claims vis-à-vis the private sector. We are thus considering *net* public debt. Public debt includes both explicit public debt and the implicit public debt represented by the social security benefits to which households are entitled.

We assign these four types of wealth (real capital, land, excess value and public debt) to the various institutional sectors of the economy in a way that is guided by our research objectives. To this end, we subdivide the economy as a whole into the following institutional sectors, as is also done in the 2008 SNA and the ESA 2010:

- Private households (including the self-employed).
- Non-profit institutions.
- Financial corporations.

[2]In statistical practice, for certain assets, it is difficult or even impossible to determine what part of their value is produced and what part is not produced. Land improvements—thanks to cultivation—are an example. The value that they create represents a produced asset. But it is practically impossible to separate this value from the value of land as non-produced asset.

[3]In correctly determining the excess value, it should be taken into account that the value of the equity has to be reduced "for any subsequent reductions as the initial value is written down as an economic disappearance of non-produced assets" (Eurostat 2013, p. 177).

- Non-financial corporations.
- General government.
- Rest of the world.

Moreover, we combine financial and non-financial corporations under the generic category of firms, and we also subsume non-profit institutions under households. Since we are treating the OECD plus China region as a closed economy, the "rest of the world" can be dropped.

We are left, then, with the following three institutional sectors:

- Private households, H
- Firms, F
- Government, G

Table 4.2 shows how the abovementioned wealth components are apportioned among these sectors.

The three institutional sectors—households, firms and the government—each possess real capital (K) and land (L). In the case of firms, real capital is mostly composed of plant and equipment. In the household sector, residential buildings are particularly important. But since the self-employed are assigned to the household sector, equipment, commercial real estate, software, etc., are also included in the sector's real capital. In the case of the government, real capital consists almost entirely of non-residential structures, including public infrastructure (roads and waterways) and public buildings (schools, administrative buildings, etc.) (cf. Schmalwasser and Weber 2012, p. 945).

The household sector, firms and the government all possess land in the strict sense, which in most countries constitutes the greater part of land in the enlarged sense (L) adumbrated above. For instance, in Germany, the household sector, with a share of almost 80%, holds by far the most land (in the strict sense).[4]

In the corporate sector, there can also be negative excess value (V).[5] Excess value comes into being when the market and book value of firms diverge. The quotient of market and book value is known as Tobin's Q (Tobin 1969; Tobin and Brainard 1977). We are interested in a value quantity and hence define excess value as the difference between the market value and the book value of firms (Alvaredo

[4]Up to now, mineral and energy reserves and other types of natural assets are not included in the determination of the economic value of land in Germany. They are, however, in France: the country that, apart from Australia, provides the most complete account of its fixed assets. Non-produced assets like non-cultivated biological and water resources, mineral and energy reserves, and other natural resources are also covered in the French statistics. For more details, see Chap. 5.2.

[5]In our present context, it is irrelevant that discrepancies can also arise between the book and market values of the real capital of self-employed persons, who are included in the household sector.

Table 4.2 Wealth components and institutional sectors

Households (H)	Firms (F)	Government (G)
K_H	K_F	K_G
L_H	L_F	L_G
$\tilde{D}$		$-\tilde{D}$
	V	

Source Authors' own presentation

et al. 2017, pp. 45–47).[6] Different causes for a diverging of market values from book values are discussed in the relevant literature. We examine some of them in what follows. If book values are greater than market values, there is negative excess value in the aggregate corporate sector (Tobin's Q is then less than one). In this case, firms possess assets that are undervalued on the stock exchange in comparison to their book value. This can be a result of errors in assessing the book values of the assets, as well as of errors in assessing their market values. If, on the contrary, the market values are greater than the book values, there is positive excess value (Tobin's Q is then greater than one). The value of firms on the stock exchange is then higher than the value of the assets in their books. Different types of errors in assessment can likewise be responsible here. The overvaluation of the firms can also be due to the fact that in the market's view, they possess intangible assets, like rights, market power or reputation, that will increase their future profitability, but that are not included in their balance sheets.

Excess value is thus to be understood in the following sense. Since, in the final analysis, firms are owned by the other two domestic sectors (the household sector or the public sector) or by the rest of the world, positive excess value has to be added to the real capital of the corporate sector as measured in book values or, respectively, negative excess value has to be subtracted from the latter, in order for us to be able to determine the wealth of the other sectors as measured in market values. It is only when excess value is equal to zero (in which case, Tobin's Q equals one) that the market value of firms is already included in the wealth of the private or the public sector.[7]

In the developed economies, Tobin's Q was on average less than one on the macrolevel in the non-financial corporate sector from 1970 to 2010 (Piketty and Zucman 2013, p. 29). For many years now, however, there have been differences between individual countries that are difficult to explain. In Germany, France and Japan, Tobin's Q has been consistently less than one since the beginning of the 1970s (Piketty and Zucman 2013, p. 29). It is the common opinion that firms in these countries are undervalued. Expressed in the terms of our analysis, this means that the corporate sector exhibits negative excess value. By contrast, in some (above

[6]Piketty and Zucman (2014) and Alvaredo et al. (2017) call the difference between the book value and the market value of national income "corporate residual wealth." The concept of excess value that we employ here is equivalent to "corporate residual wealth," but with the plus or minus sign reversed. (For more on this, see below.)

[7]Since we are considering a closed economy, the rest of the world plays no role here.

all, Anglo-Saxon) countries, Tobin's Q has been greater than one on the macrolevel in the non-financial corporate sector for quite some time. This is so, above all, for the USA, where, apart from the years after the two stock market crashes in 2001 and 2008, Tobin's Q has been greater than one since around the middle of the 1990s (Hautle 2016, pp. 495–496).[8]

A whole series of factors could be responsible for the long-term divergence of market values from book values. A variety of hypotheses on the reasons for these differences are to be found in the relevant literature. Statistical offices' reporting too high a book value of company equity is presumed to be one key cause for a negative difference between market and book value. Gordon (1990) has shown that there is a tendency to underestimate quality improvements in capital goods, thereby overstating the evolution of their prices. Wright's (2004, p. 570) explanation has a similar tenor. He assumes that the reported depreciation of plant and machinery is too low, since the speed at which capital goods become technically obsolete is systematically underestimated. As consequence, the replacement costs of real capital are set too high. (Cf. also Hautle 2016, pp. 496).

Piketty and Zucman (2013, p. 31) explain the difference in Tobin's Q between the Anglo-Saxon countries, on the one hand, and the continental European countries and Japan, on the other, by the different degrees of shareholder control in the two groups of countries. They argue that in countries like Germany, France or Japan, shareholders have to cede some control to other stakeholders (such as trade unions and the government). Hence, they would have more limited opportunities for increasing the value of their capital and likewise could not simply liquidate all the company's assets, if they so wish. "According to this 'stakeholder' view of the firm, the market value of corporations can be interpreted as the value for the owner, while the book value can be interpreted as the value for all stakeholders" (ibid.).

On the other hand, there are a whole series of factors that cause the market value of firms to be greater than their book value. These include inadequate recording of intellectual property (patents, licenses, copyrights) or of the value of a corporate brand. The fact that a company as a whole is normally worth more than the sum of its parts would also lead to Tobin's Q being greater than one and hence to the corporate sector having positive excess value.

Whatever the reasons are for a long-term divergence of the market value of firms from their book value, the existence of positive as well as negative excess value has to be taken into account when calculating the wealth of households. If the corporate sector has positive excess value, the wealth of households is greater than what is shown in the official balance sheets; if the excess value is negative, the wealth of households is less.[9] Further on, we will discuss how we deal with this in the empirical analysis.

[8]It is interesting to note that some studies find that Tobin's Q is greater than one on the microlevel for both American companies and non-American companies (Fernandes et al. 2013, pp. 331–332). But American companies are shown to have a considerably higher Tobin's Q.

[9]This holds on the assumption that the fixed assets of the corporate sector are recorded in the official statistics at their book values.

We already pointed out above that the government's public debt corresponds to private household wealth of exactly the same magnitude.[10] The net claims of private households on the government ($\tilde{D}$) is the balance of the financial claims of households on the government minus the financial claims of the government on households. $\tilde{D}$ thus represents net public debt. Apart from the latter, the value of publicly owned real capital and of public land are decisive for the net wealth of the public sector.[11]

We have now examined all the assets that play a role in our analysis. Just one further step is required, in order to arrive at the concept of total private wealth. We need, namely, to take into account that households and the government are what could be called ultimate owner sectors. Firms—and hence their real capital and land—are owned by either the government or households. We combine the corporate sector with the household sector.[12] There thus remain only two sectors: the private sector, on the one hand, and the government (the public sector), on the other (cf. Table 4.3). What is of interest to us is the wealth of the private sector and hence also the reciprocal relationship between the private and public sectors with respect to their claims and liabilities.

Fixed assets are supposed to be included in the national accounts at their current replacement costs. The objective is to record "fixed assets…at market prices if possible." Since, however, market prices do not exist for most capital goods, "purchasers' prices at acquisition reduced by the accumulated consumption of fixed capital" are used instead (Eurostat 2013, p. 175). In accordance with international agreements, the so-called perpetual inventory method is applied (Schmalwasser and Weber 2012, p. 944).[13] This involves attempting to derive the current value of the stock of fixed assets from the past investment in the goods in question. For this

[10]For purposes of simplification, we abstract here from the fact that the government's creditors also include firms (especially financial firms). In the next step of our analysis, it will be made clear why this is an acceptable and unproblematic simplification.

[11]Like in many other developed countries, in Germany, public sector net wealth has tended constantly to decline in recent decades (IMF 2018). Under the previous 1993 SNA, the public "capital ratio" in Germany was still around 58% in 1991 and fell to 1.3% by 2011. Public sector fixed assets and hence public sector net wealth are now greater again in Germany: among other reasons, due to the classification of R&D and military weapons systems as fixed capital in the 2008 SNA. In 2019, German public sector net wealth was 1,145 billion euros (Deutsche Bundesbank and Statistisches Bundesamt 2020).

[12]In the 2008 SNA, publicly owned companies are assigned not to the government sector, but to the corporate sector. Thus, for example, a publicly owned railway network is included in the balance sheet of the *non-financial corporations* sector (Schmalwasser and Weber 2012, p. 945). This has the consequence of overstating private sector wealth. On the other hand, among other things, valuables, inventories and natural assets are not included in the calculation of fixed assets in the official statistics. This results, conversely, in underreporting the actual wealth of the private sector.

[13]"Ideally, observable market prices should be used to value non-financial assets. However, nonfinancial assets depreciate in value over time due to their use in the production process, and secondhand markets, from which one could derive market prices for assets of different ages, are often nonexistent" (van de Ven and Fano 2017, p. 287).

Table 4.3 Consolidated sectors and wealth components

Private sector (P)	Government (G)
$K_p = K_H + K_F$	K_G
$L_P = L_H + L_F$	L_G
$\tilde{D}$	$-\tilde{D}$
V	
Σ 1–4 = NW_P	Σ 1–4 = NW_G

NW_P = Private Sector Net Wealth; NW_G = Public Sector Net Wealth
$NW_P + NW_G$ = National Net Wealth (NW)
Source Authors' own presentation

purpose, far-reaching assumptions about depreciation have to be made (ibid., pp. 934–938).

According to Piketty and Zucman (2014, p. 1269, footnote 13), the data on fixed assets reported in the 2008 SNA is essentially based on book values. Therefore, in what follows, we assume that the fixed assets and national wealth reported in the official balance sheets are determined according to the book value approach. Consequently, if market values diverge from book values, excess value (V) has also to be taken into account in calculating the net wealth of the private sector. Another way of determining the value of capital goods that is suitable for our purposes consists of assessing them according to their market prices. This renders it superfluous to report excess value separately.

The *World Inequality Database* was developed by a team led by Facundo Alvaredo, Tony Atkinson and Thomas Piketty. It provides data on the value of capital goods and national net wealth that has been established using the market price approach. We will rely on this data for a large part of our calculations in the present chapter. In the *Guidelines* on the concepts and methods employed in the World Inequality Database, the decision generally to use market prices to assess wealth is justified as follows: "The main rationale for looking at market-value national wealth is the possibility of measurement error for non-financial corporate assets and the view that stock market values might provide a more accurate evaluation of the 'real' value of corporations (which is far from clear)" (Alvaredo et al. 2017, p. 47, footnote 28).

Accordingly, in our analytical framework, we will use data for real capital and net wealth that has been established using the *market price approach*. To this end, we can draw on different variables on wealth from the World Inequality Database.

In the final analysis, private sector wealth (NW_P) in the OECD plus China region is thus:

$$NW_P = \tilde{K}_P + L_P + \tilde{D}$$

The meanings of the symbols are as follows: $\tilde{K}_P$: real capital of the private sector in market prices, L_P: land owned by the private sector, $\tilde{D}$: explicit net and implicit public debt.[14]

4.2.2 Data

For the purpose of determining the value of the real capital of the private sector in the OECD countries plus the People's Republic of China, we use data from the World Inequality Database (WID.world). The World Inequality Database is an extensive and freely accessible database containing information on income and wealth in many countries and, in some cases, over very long periods of time. It is based on the work of Thomas Piketty and his colleagues. The database became known, however, especially thanks to the data on the distribution of income and wealth that it makes available for numerous countries. In addition, data is also to be found for many countries on the current state and historical evolution of wealth and its components.[15] The data provided by the World Inequality Database is partly based on modified classifications from the 2008 SNA and/or the ESA 2010. These modifications were essentially developed by Piketty and Zucman (2013, 2014). We can see from Table 4.4 how the database defines the wealth concepts for particular sectors and the economy as a whole that are of relevance for us.[16]

In contrast to our approach, Piketty and Zucman include neither explicit nor implicit public debt in the wealth of households or the private sector. As usual in national accounts, they also do not count the consumer durables owned by households as wealth (Piketty and Zucman 2014, p. 1268).[17]

We associate the wealth components of the WID.world database with our definitions of the real capital (K) and land (L) of the private and the public sectors as shown in Table 4.5.

The total net wealth (NW) of a closed economy—such as the closed economy that the OECD plus China region roughly represents—thus corresponds to the sum of the net wealth of the private sector (PW) and the net wealth of the public sector (GW). Thus

[14]Because of a lack of suitable data, the excess value of the corporate sector can only be assigned to private persons. In fact, the excess value of publicly owned companies that are not listed on the stock exchange should be assigned to the government sector when the corporate sector is combined with the household sector. If the excess value of these companies is positive, then we are overestimating private wealth; if it is negative, then we are underestimating it—in both cases, however, only to a relatively small extent.

[15]The OECD database also contains data reflecting the wealth concepts of the 2008 SNA. Nonetheless, for numerous reasons, the WID.world concepts are more suitable for our purposes. On the differences between the 2008 SNA wealth concepts and those in WID.world, see Piketty and Zucman (2013), Bauluz (2017), Alvaredo et al. (2017), Zwijnenburg (2017).

[16]Detailed information on the wealth concepts is to be found in Piketty and Zucman (2013, 2014) and Alvaredo et al. (2017).

[17]Since both of the latter are elements of private wealth for us, we will include them.

Table 4.4 Definitions of wealth concepts in WID.world

Net wealth	Nonfinancial assets + financial assets − liabilities[a]
Private wealth	Net wealth of households[b] + net wealth of NPISH[c]
Corporate wealth	Net wealth of corporate sector[d]
	= Book value of national wealth − market value of national wealth
Government wealth	Net wealth of general government sector
Market value of national wealth	Private + government wealth
Book value of national wealth	Sum of all non-financial assets (= domestic capital)[e] of all domestic sectors + net foreign asset position
Non-financial assets	1. Produced tangible capital
	1.1. Fixed assets
	1.2. Inventories
	1.3. Valuables
	2. Non-produced tangible capital
	2.1. Land (land underlying residential buildings, land underlying non-residential buildings, other land)
	2.2. Subsoil assets
	2.3. Other natural resources
	3. Intangible capital
	3.1. Research & Development
	3.2. Intellectual property other than Research & Development
	3.3. Non-produced intangible capital (goodwill and marketing assets)

Notes
[a]Includes balance sheets equities
[b]Includes capital stock of corporations through the equity holdings of households
[c]NPISH (= non-profit institutions serving households)
[d]Positive (negative), if Tobin's $Q < 1$ ($Q > 1$)
[e]Produced and non-produced tangible capital + intangible capital (incl. nat. resources like land, subsoil assets etc.)
Source Authors' own presentation following Piketty and Zucman (2013)

Table 4.5 Private and public sector net wealth

	Private sector (P)	Government (G)
1. Produced tangible capital + intangible capital	K_P	K_G
2. Non-produced tangible capital	L_P	L_G
Net wealth (NW)	Σ 1–2 = PW	Σ 1–2 = GW

Source Authors' own presentation
The meanings of the symbols are as follows
K_P: real capital of the private sector in market prices; $K_{G:}$: real capital of the public sector in market prices; L_P: Private sector land; L_G: Public sector land; PW: Private wealth (net wealth of the private sector at market values, without public debt); *GW*: Government wealth (net wealth of the government sector at market values, without public debt); *NW*: (national) net wealth

$$PW = NW - GW$$

holds for the net wealth of the private sector and

$$\tilde{K}_p = NW - GW - L_p$$

for the real capital of the private sector in market prices.

On the basis of these relationships, we will, in the next section, determine the value of private sector real capital in the OECD plus China region.

4.2.3 Determining the Value of Real Capital

For the purpose of determining the value of the real capital of the private sector in the OECD plus China region, we use data from the World Inequality Database (WID.world). The OECD plus China region that we are considering comprises 35 countries altogether: 34 OECD countries and the People's Republic of China.[18] The WID.world database contains data with which we can calculate real capital for 19 countries. They are: Australia, Denmark, Germany, Finland, France, Greece, Italy, Japan, Canada, Mexico, the Netherlands, Norway, Spain, Sweden, South Korea, the Czech Republic, the USA, the UK and the People's Republic of China. The share of these 19 countries in total consumption in the whole OECD plus China region is around 90%. The greater part of the region is thereby covered, such that the calculations for these 19 countries can roughly stand for the region as a whole.

The methodology and data for most of the countries in the WID.world database are based on the original studies by Piketty and Zucman (2013, 2014) and an update by Bauluz (2017). More recent data for countries of relevance for us comes from Waldenström (2017) for Sweden, Piketty et al. (2017) for the People's Republic of China, and Blanco et al. (2018) for Spain.

2015 is the reference year for our empirical calculations in this chapter and the following ones. We have chosen this year for two reasons. Firstly, data is available from statistical offices for 2015 on the present value of entitlements to social security retirement benefits. This data provides a good basis for our being able to estimate implicit public debt in Chap. 6.2. We want later to combine the main wealth components that are calculated in this chapter and in the empirical parts of the following two chapters. Since, if possible, the results should refer to the same year, we likewise calculate the values for real capital and land for 2015. Secondly, the chosen reference year is also a highly suitable year for data comparison, since no severe recession, which could have distorted the data, took place in 2015 in the group of countries under investigation.

For the reasons presented above, we relate the value of real capital not, as is customarily done, to the flow variable gross domestic product, but rather to the flow

[18]We include all the OECD countries that had joined the OECD by 2015 among the OECD countries (cf. Sect. 3.11).

variable total consumption. By "total consumption"—or, in what follows, also simply "consumption"—we understand the sum of the expenditures for the consumption of households (private consumption) and for the consumption of the state (public consumption) that were undertaken in the respective reporting year: i.e., for our purposes, in 2015. Thus, we will say, for instance, that the value of real capital in Japan corresponds to 2.58 times or 258% of (total) consumption in 2015.

In a first step, the value of national wealth in market prices (in WID.world terminology, "market value national wealth") is extracted from the database for each of the above-mentioned 19 countries. The value of national wealth is given in the respective national currency (LCU) (see Table 4.6, column A). The balance of domestic claims and liabilities vis-à-vis the rest of the world (net foreign assets) is subtracted from the national wealth (cf. column B).[19] We thus obtain overall national non-financial assets or net wealth (column C). Column D lists general government non-financial assets in the individual countries. We subtract the latter from the national non-financial assets, in order to arrive at the non-financial assets of the private sector (column E). In the WID.world database, land is reported in two data series (1. private land underlying dwellings and 2. private agricultural land); data for 2015 is not available for all countries, however. For some countries, we had to rely on data from prior years. If information was lacking on the value of land (which is the case for China, Canada, Italy and Great Britain), the figures in question were supplemented by estimates based on the average values for the countries for which the data in question is available.

As already mentioned above, most countries do not include consumer durables in non-financial assets in their balance sheets. This is also the case for the WID.-world database. Since in our view, such goods are to be regarded as assets, we have added them in. In Germany and France, consumer durables represent about ten percent of the total fixed assets of the economy as a whole (Deutsche Bundesbank and Statistisches Bundesamt 2020; van de Ven and Fano 2017). In the USA, this figure is significantly higher (Hautle 2016, Table 3.5).[20] Since information on the total value of consumer durables is available only for a small minority of the 19 countries, we have made a conservative estimate and only added a supplement of one percent to the countries' fixed assets for the value of consumer durables. Column F lists fixed assets plus consumer durables minus the value of land in the

[19]According to the Balance Sheets for Institutional Sectors of the Bundesbank and the Federal Statistical Office (Deutsche Bundesbank und Statistisches Bundesamt 2020), Germany had 1,180 billion euros in net foreign assets in 2015. Our table, on the other hands, shows 1351 billion euros. For Germany's "international investment position," the database uses Bundesbank figures that diverge from the other data sources. In the view of Piketty and Zucman (2013, pp. 71–72), the Federal Statistical Office underestimates Germany's net foreign assets. National wealth in market prices and the non-financial wealth of the private sector could in fact be considerably greater using the Bundesbank figures. In the authors' view, the underestimation could represent up to 20% of national income.

[20]In 2013, the value of consumer durables amounted to about 22% of the value of the non-financial assets of the household sector in the USA, 13.3% in Japan, 12.6% in Canada, 5.3%, in Australia, and 14.5% in Germany (Board of Governors of the Federal Reserve System 2020; OECD 2019b; Deutsche Bundesbank and Statistisches Bundesamt 2020).

Table 4.6 Private real capital in the OECD plus China region, 2015

	A	B	C	D	E	F	G	H	I	J
			= A–B		= C–D		= F / I			= G / H
	Total national wealth	Net foreign assets	Total non-financial assets	Government non-financial assets	Private sector non-financial assets	Private sector non-financial assets (minus land, plus consumer durables)	Private sector real capital	Total consumption	Conversion factor	Private sector real capital
Country	Billions LCU	Billions LCU	Billions LCU	Billions LCU	Billions LCU	Billions LCU	Billions Int'l $	Billions Int'l $	LCU in Int'l $	In years of consumption
Australia	9,722.5	−886.9	10,609.4	2,061.2	8,654.3	4,953.5	3,360.4	829.1	1.47	4.05
Canada	8,741.9	234.1	8,507.8	872.3	7,720.6	5,184.6	4,154.3	1,252.1	1.25	3.32
Czech Republic	14,407.3	−1,074.4	15,481.7	5,696.7	9,939.8	8,793.0	692.2	230.1	12.70	3.01
Denmark[a]	7,621.0	797.0	6,824.0	923.6	5,968.6	4,309.8	588.1	197.2	7.33	2.98
Finland[a]	836.1	7.2	828.9	155.1	682.0	5,63.3	620.9	181.2	0.91	3.43
France[a]	10,871.8	−191.3	11,063.1	1,931.9	9,241.8	6,227.8	7,703.1	2,117.0	0.81	3.64
Germany	11,377.0	1,351.7	10,025.3	1,747.7	8,377.8	6,126.8	7,875.9	2,851.6	0.78	2.76
Greece	728.6	−218.5	947.1	115.4	841.2	841.2	1,332.5	261.0	0.63	5.11
Italy[b]	7,866.5	−338.4	8,204.9	479.1	7,807.8	5,156.6	6,982.5	1,785.2	0.74	3.91
Japan	2,642,741.4	351,336.0	2,291,405.4	689,088.4	1,625,231.0	1,048,967.9	10,139.9	3,929.5	103.45	2.58
Korea	9,293,346.7	−74,725.4	9,368,072.1	2,585,794.7	6,875,958.2	4,226,225.7	4,929.3	1,173.4	857.37	4.20
Mexico[c]	72,357.5	−5,958.3	66,399.2	6,004.2	60,395.0	61,059.0	7,333.6	1,537.8	8.33	4.77
Netherlands[b]	2,937.7	404.4	2,533.3	577.5	1,981.1	1,375.7	1,700.9	589.4	0.81	2.89
Norway	17,321.4	5,741.8	11,579.6	1,797.2	9,898.2	6,948.1	699.7	209.8	9.93	3.34
Spain	5,590.7	−972.2	6,562.9	850.4	5,778.1	3,074.5	4,641.7	1,224.0	0.66	3.79
Sweden[a]	19,743.3	111.7	19,631.6	3,678.9	16,149.0	13,113.2	1,481.4	336.2	8.85	4.41

(continued)

Table 4.6 (continued)

	A	B	C	D	E	F	G	H	I	J
			= A–B		= C–D		= F / I			= G / H
	Total national wealth	Net foreign assets	Total non-financial assets	Government non-financial assets	Private sector non-financial assets	Private sector non-financial assets (minus land, plus consumer durables)	Private sector real capital	Total consumption	Conversion factor	Private sector real capital
Country	Billions LCU	Billions LCU	Billions LCU	Billions LCU	Billions LCU	Billions LCU	Billions Int'l $	Billions Int'l $	LCU in Int'l $	In years of consumption
UK	9,608.0	−302.6	9,910.7	1,089.4	8,920.4	55,188.6	9,450.0	2,305.9	0.69	4.10
USA	75,580.1	−5,613.1	81,193.2	15,094.7	66,910.4	6,542.8	55,188.6	14,907.2	1.00	3.70
China	440,383.8	9,493.3	302,083.0	45,636.7	259,467.2	200,766.8	57,901.3	10,447.8	3.47	5.54
Total OECD							128,875.1	35,917.6		3.59
Total OECD plus China							186,776.4	46,365.4		4.03

Sources
Column A WID.world (2019). Market-value national wealth
Column B WID.world (2019). Net foreign assets
Column D WID.world (2019). Government non-financial assets
Column F WID.world (2019). WID.world (2019). Private land underlying dwellings; Private agricultural land
Column H World Bank (2019). World Development Indicators, Final consumption expenditure (current LCU)
Column I World Bank (2019). World Development Indicators, PPP conversion factor (GDP) (LCU per international $)
Authors' own calculations

Notes
[a]2014
[b]2013
[c]Data source for non-financial assets: OECD (2019a)
Land values partially estimated (China, Canada, Italy, UK)
LCU: Local currency unit

broader sense (including natural resources). This category of wealth corresponds to what we understand by private real capital.

Our objective in this chapter is to determine the total value of real capital in the OECD plus China region as expressed in years of total consumption. In order to achieve this objective, the values listed in the respective local currencies have to be converted into purchasing-power-adjusted "international dollars." Column G provides the real capital in international dollars. In total, the real capital in the 18 OECD countries listed came to around 128.9 trillion international dollars in 2015. Including China, the value of the real capital in the group of countries as a whole came to 186.8 trillion international dollars. Column H contains total consumption for 2015 in international dollars. The value of total consumption, consisting of the consumption of households and public consumption, came to 46.4 trillion international dollars in the OECD plus China region (without China: 35.9 trillion international dollars).

Column J shows the ratio of real capital to total consumption. The figures vary between the different countries: sometimes to a considerable extent. For the OECD countries, they range from 2.6 for Japan to 5.1 for Greece. As compared to the average for the OECD countries, the figure for China, at 5.5 times consumption, is considerably higher. On the one hand, there could be objective reasons for this, but, on the other hand, as experience shows, data collection errors in the database cannot be entirely ruled out either. In general, there is substantial uncertainty regarding the quality of economic data for China.[21]

4.2.4 The Value of Private Real Capital

In 2015, the value of real capital in Germany was nearly 2.8 times total annual consumption. In France, the corresponding figure was 3.8 times. In Germany, the value of real capital owned by firms is relatively low in comparison to other countries at a similar level of development. Van de Ven and Fano (2017, p. 411) explain this by the nature of so-called Rhenish capitalism, in which the participation of banks is relatively significant, while financing via capital markets does not play as great a role as elsewhere.

Our figures match the results of similarly oriented investigations (e.g., Piketty 2014). For France, the OECD also established a figure of 355% of gross domestic product for non-produced assets (van de Ven and Fano 2017). In light of a somewhat different system of classification with respect to wealth categories, the figures calculated, using the WID.world data, for French real capital (i.e., in relation to total annual consumption, which accounts for approximately 77% of French Gross Domestic Product) appear to be entirely plausible. The same holds for

[21]Piketty et al. (2017), from whom the data used for China originally comes, drew on official balance sheets and other national statistics of the People's Republic of China for their calculations (Piketty et al. 2017, pp. 11–13). Li and Zhang (2017) make clear the challenges involved in designing and compiling balance sheets for China.

Australia, for which we have calculated a figure of approximately four times total consumption in 2015, whereas the OECD arrives at a figure of 344% of gross domestic product (van de Ven and Fano 2017, Table 8.1).

On average, real capital in the OECD plus China region represented 4.03 times total consumption in 2015. As a look at the statistics shows, China raises the average for the region. Without China, real capital amounted to 3.59 times annual consumption in 2015.

We thus find that, according to our calculations, private wealth in the form of real capital in the OECD plus China region comes to approximately four times total consumption.

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