Chapter V

International Capital Flows and Economic Growth

V.1 Introduction and Overview

In the last chapters, we occasionally inquired how consumption, investment and the current account react to the fact that an economy's per-capita income increases over time. However, the growth process was considered as exogenous. In this chapter, we will take a closer look at the determinants of ***economic growth***, and we want to understand how the transition from financial autarky to financial integration affects the short-run and long-run evolution of an economy.

In the following section, we will start the analysis by presenting the ***neoclassical growth model***. This model postulates that the removal of investment barriers results in an equalization of national capital stocks and a convergence of national output levels. However, growth can only be sustained in the long run if labor productivity keeps growing, and while the neoclassical growth model explains output growth as a result of capital accumulation, the growth of labor productivity is assumed to be exogenous. This is clearly a shortcoming, and so later sections of this chapter will introduce the reader to theories of ***endogenous growth***. The unifying feature of the different variants of this paradigm is the attempt to explain the long-run increase of per-capita income by referring to the internal mechanics of the model, instead of evoking some external driving force. We will first describe the general principle underlying so-called ***AK-models***, and we will introduce learning-by-doing as one of several mechanisms that sustain long-run growth even if there is no exogenous technological progress. In a next step, we will describe technological progress as the result of research and development activities, and we will relate these activities to the decisions of profit-maximizing firms. For all these models, we will first present the formal framework that applies to a closed economy, and we will then discuss the theory's predictions on the consequences of removing barriers to international investment. Turning from theory to data, the last part of the chapter will be devoted to a review of the empirical evidence on the relationship between financial integration and economic growth.

V.2 The Neoclassical Growth Model for the Closed and the Open Economy

V.2.1 Motivation

In the two-period model of Section III.5 we showed that having access to the international capital market enables a country to realize investments that would have been associated with a drastic reduction of consumption under (financial) autarky. This increase of the capital stock raises second-period GDP above the level that would have been reached in isolation. Hence, in this simple framework financial integration potentially enhanced economic growth.

However, the positive growth effects of financial integration are not exhausted by a one-time increase of per capita income. In this section, we will therefore go beyond the two-period analysis of the third chapter and analyze the short-run and long-run consequences of capital-market access for the growth of national income and output levels. To accomplish this task, we will first consider the forces that drive growth in a closed economy. Once we have understood the mechanics of the neoclassical growth model, we will then explore how the financial integration of a hitherto autarkic economy influences capital flows and the evolution of the country's per capita income.

V.2.2 The Neoclassical Growth Model in a Closed Economy with an Exogenous Saving Rate

In this subsection, we will review the neoclassical growth model independently developed by Robert Solow (1956) and Trevor Swan (1956) which, due to its clear and intuitively simple structure, still represents the point of reference for all recent theories on long-run growth. The Solow-Swan model considers an economy that is closed for international asset trade, such that all domestic investment has to be financed out of domestic savings. For the current account balance and the relationship between savings and investment, this implies that $CA_t = 0$ and $I_t = S_t$ in every period. The economy employs physical capital and labor to produce a homogenous good, and uses the following Cobb-Douglas technology:[1]

(5.1) $$Y_t = K_t^{\alpha} \left(A_t L_t \right)^{1-\alpha}$$

[1] Note that the qualitative results of the Solow-Swan model do not hinge on this Cobb-Douglas specification, but generally hold for production functions that are characterized by constant returns to scale and a diminishing marginal productivity of capital.

While this production function is characterized by constant returns to scale in K and L, the marginal productivities of both factors are positive, but decreasing. The technology parameter A is ***labor-augmenting*** and determines the volume of ***effective labor*** AL that is used in production for a given employment of "raw" labor L. By assumption, the parameter A and the labor force L grow at the constant rates g and n, i.e.

$$A_{t+1} = \left(1+g\right) A_t \tag{5.2}$$

$$L_{t+1} = \left(1+n\right) L_t \tag{5.3}$$

We will call g the *rate of technological progress* and n the *population growth rate*[2]. As in Chapter III, the law of motion of the capital stock is given by

$$K_{t+1} = \left(1-\delta\right) K_t + I_t \tag{5.4}$$

In a (financially) closed economy, all investments have to be financed out of domestic savings. The key simplifying assumption of the Solow model is that individuals save a *constant* share of their current income, i.e.

$$S_t = s\, Y_t \tag{5.5}$$

with s representing the ***saving rate***. We thus deviate from the principle that consumption and saving decisions should be based on the explicit solution of intertemporal optimization problems. As we will demonstrate later, this simplification has no consequences for the model's key findings on the determinants of long-run growth. By combining equations (5.1) – (5.5), we arrive at

$$K_{t+1} - K_t = s\, K_t^{\alpha} \left(A_t\, L_t\right)^{1-\alpha} - \delta\, K_t \tag{5.6}$$

This equation illustrates the role of savings and capital accumulation for the growth process: the higher an economy's income in period t, the higher aggregate savings and investment. Higher investment, in turn, raises the capital stock and thus production in period $t+1$.

[2] By using this terminology, we will follow standard practice and identify *employment L* with the economy's *total population*. For the qualitative results of the model, this simplification is innocuous as long as the amount of labor offered by each worker and the share of workers in the total population remain constant.

In what follows, we will define the capital stock and output "per capita" as $k_t \equiv K_t / L_t$ and $y_t \equiv Y_t / L_t$, respectively. Moreover, the capital stock and aggregate output „per unit of effective labor" will be given by $\hat{k}_t \equiv K_t / (A_t L_t)$ and $\hat{y}_t \equiv Y_t / (A_t L_t)$. It is easy to show that output per unit of effective labor is a function of the capital stock per unit of effective labor:

$$(5.7) \qquad \hat{y}_t = \hat{k}_t^{\alpha}$$

Note that this function, like the function in (5.1), is characterized by a ***diminishing marginal productivity*** of – or "***diminishing returns***" to – ***capital***. By using (5.2), (5.3) and (5.7), and by defining $(1+z) \equiv (1+g)(1+n)$, we can derive the law of motion for the domestic capital stock per unit of effective labor:

$$(5.8) \qquad \hat{k}_{t+1} - \hat{k}_t = \frac{s}{1+z}\hat{k}_t^{\alpha} - \frac{(\delta + z)}{1+z}\hat{k}_t$$

This equation has a simple interpretation: if the saving rate and thus gross investment were equal to zero, the capital stock per unit of effective labor would gradually decrease over time. This would happen due to the rate of depreciation δ, but also because a given stock of capital would have to be distributed among more and more units of "effective labor". An *increase* of the capital stock per unit of effective labor can be observed if gross investment per unit of effective labor exceeds the shrinkage of $\hat{k}$ due to depreciation, population growth and technological progress.

In Figure 5.1, the change of the capital stock per unit of effective labor is represented as the difference between the curve $s\,\hat{k}_t^{\alpha} / (1+z)$ and the straight line $(\delta + z)\hat{k}_t / (1+z)$. The fact that this difference decreases as $\hat{k}$ becomes larger is due to the diminishing marginal productivity of capital: the additional output that is generated by raising the capital stock is always positive, but it becomes smaller the more capital is already used. Due to this property, there is one point at which the curve and the straight line in Figure 5.1 intersect. At this point, $\hat{k}_{t+1} - \hat{k}_t = 0$, i.e. there is a value $\hat{k}^{ss}$, at which the economy has reached a ***steady state***, such that the capital stock per unit of effective labor does not change any more.[3] This steady state is stable since, departing from any (strictly positive) initial value, $\hat{k}$ converges towards $\hat{k}^{ss}$.

[3] Of course, there is a second (trivial) steady state with $\hat{k} = 0$: in this case, output per unit of effective labor and savings are zero, and the capital stock per unit of effective labor remains at this level.

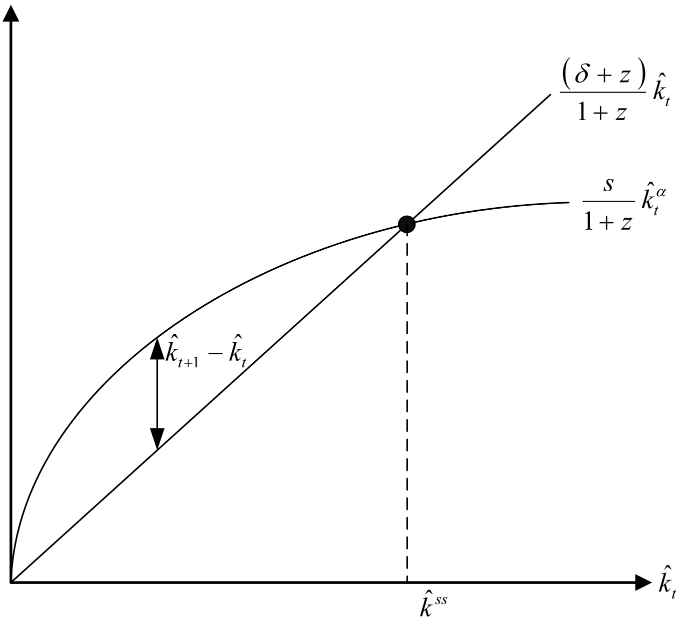


Figure 5.1: The evolution of the capital stock per unit of effective labor in the Solow-Swan model

Given our assumption on the production function, we can easily compute $\hat{k}^{ss}$ by setting $\hat{k}_{t+1} - \hat{k}_t$ on the left-hand side of (5.8) equal to zero and by solving the resulting expression for $\hat{k}$. This yields

(5.9) $$\hat{k}^{ss} = \left(\frac{s}{\delta + z} \right)^{\frac{1}{1-\alpha}}$$

Equation (5.9) allows us to identify the factors that determine the level of *output* per unit of effective labor in the steady state $\hat{y}^{ss} = \left(\hat{k}^{ss}\right)^{\alpha}$: while a higher saving rate (s) raises $\hat{y}^{ss}$, a higher rate of depreciation (δ), a higher population growth rate (n), and a higher growth rate of the technology parameter A (g) reduce $\hat{y}^{ss}$. If we define the *long run* as the phase that starts once an economy has reached the steady state, the economy's per capita income on the ***long-run growth path*** is given by $y_t^{LR} = A_t\,\hat{y}^{ss}$ [4]. In the data, we should thus find a positive

[4] Note that, strictly speaking, the steady state is never reached *exactly* in finite time. However, once enough periods have passed, the distance to the steady state becomes extremely small and can be ignored. Note also that the growth literature often describes a situation in

relationship between national saving and investment rates and per capita income levels. Figure 5.2 demonstrates that this hypothesis is supported by the empirical evidence. The scatterplot depicts the partial correlation between the logarithm of national investment shares and the logarithm of per capita GDP for a large number of countries.[5]

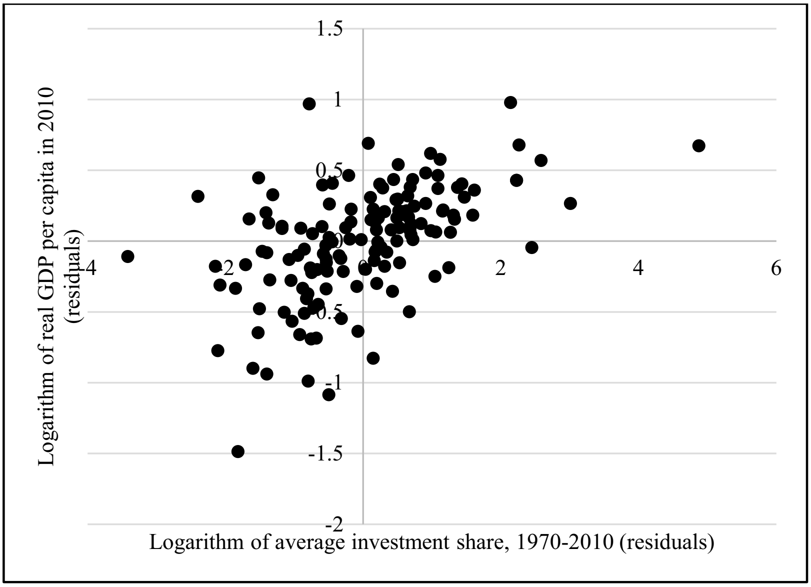


Figure 5.2: Average investment shares for 1970 – 2010, and per capita income levels in 2010. Source: Penn World Table 8.1 (Feenstra et al., 2015) and own computations.

which per capita income, per capita consumption etc. grow at the same rate as ***balanced growth***.

[5] This ***partial scatterplot*** accounts for the simultaneous influence of population growth, depreciation and technological progress on the level of per capita income, and for the potential correlation of these variables with the investment share. To produce this graph, we first regressed the logarithms of per capita income and of the investment share on the logarithm of the population growth rate (plus a constant). The scatterplot shows the residuals from these two regressions. Note that, since it focuses on a closed economy, the Solow-Swan model treats the saving rate and the investment rate as equal, and emphasizes the influence of the saving rate on per capita income. However, when interpreting Figure 5.2, we have to be aware that this correlation does not necessarily prove a causal relationship, and that there are good reasons to believe that the saving rate – and thus the investment rate – is a function of per capita income. If one neglects the potential endogeneity of the saving rate, one risks overrating the effect of s on a country's per capita income.

The fact that output per unit of effective labor is constant once the economy has reached the steady state also implies that the evolution of per capita *income* on the long-run growth path is only determined by the (exogenous) rate of technological progress – i.e., with $\hat{y}^{ss}$ being constant, $y_t^{LR} = A_t \, \hat{y}^{ss}$ grows at the rate g.

Until the capital stock per unit of effective labor has reached the steady state – i.e. in the *short run* – the growth rate of per capita income is higher than g if the economy approaches the steady state from an initial value that is smaller than $\hat{k}^{ss}$. By rephrasing (5.8), we arrive at

(5.10) $$\frac{\hat{k}_{t+1} - \hat{k}_t}{\hat{k}_t} = \frac{s}{1+z} \hat{k}_t^{\alpha - 1} - \frac{\delta + z}{1+z}$$

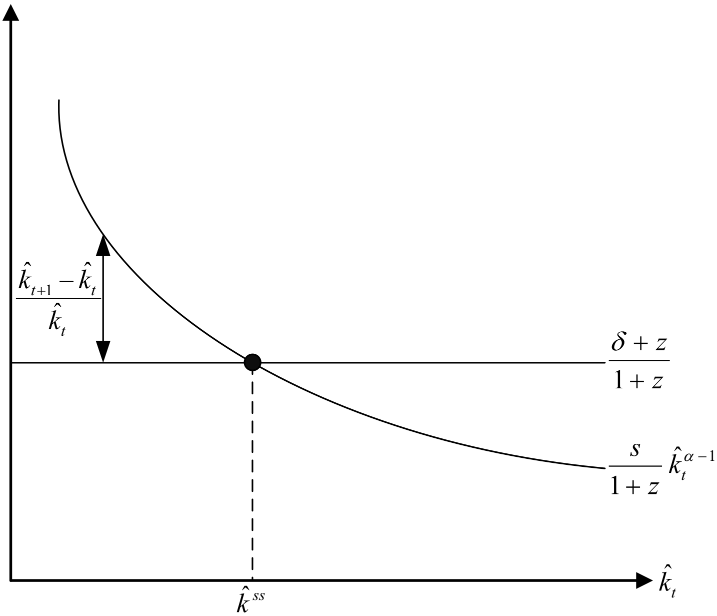
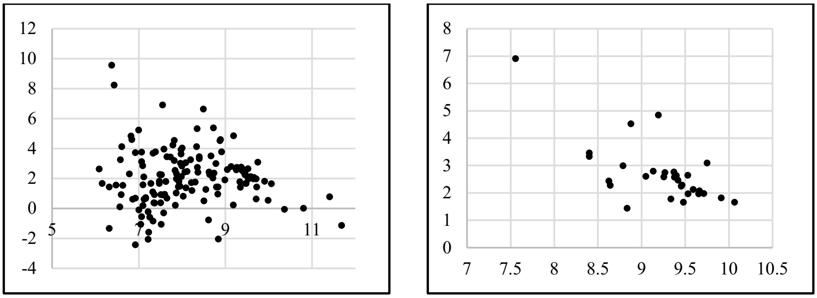


Figure 5.3 : Conditional convergence in the Solow-Swan model

As suggested by Figure 5.3, the increase of $\hat{k}$ – and thus the growth rate of per capita income – is the higher, the farther away the capital stock per unit of effective labor is located from its steady-state level $\hat{k}^{ss}$. Hence, the Solow-Swan model implies that countries that start from a lower income position relative to their respective steady state exhibit higher growth rates. Box 5.1 confronts this hypothesis with the empirical evidence.

Box 5.1: Absolute and Conditional Convergence

A superficial reading of the Solow-Swan model suggests that countries with a lower initial per capita income should exhibit higher output growth rates in subsequent years. This follows from the assumption that the production function is characterized by a diminishing marginal productivity of capital – i.e. that the additional output generated by a growing capital stock is the higher, the lower the initial capital stock. The left-hand side of Figure B5.1 shows that this ***absolute convergence hypothesis*** is not supported by the data: while there are many countries that were poor in 1970 and enjoyed high growth rates in the subsequent four decades, there is also a large number of countries that were poor in 1970 but hardly grew at all between 1970 and 2010.



All countries Only OECD countries

Figure B5.1: Countries' real per capita GDP in 1970 (in natural logarithms, horizontal axis) and the average growth rate of GDP between 1970 and 2010 (vertical axis). Source: Penn World Table, version 8.1 (Feenstra et al., 2015) and own computations.

A second look at Figure 5.3 shows that this observation does not contradict the Solow-Swan model, which postulates that the growth rate of the capital stock does not just depend on $\hat{k}_t$, but on the distance of this value to the steady-state $\hat{k}^{ss}$. The steady-state, in turn, depends on the country-specific saving rate, the population growth rate etc. Only if these parameters are roughly similar in the countries that are considered – i.e. if the *ceteris paribus condition* is satisfied – one should expect to see a strong empirical relationship between countries' initial per capita incomes and their subsequent growth rates. This ***conditional convergence hypothesis*** can be tested in two ways: one can try to comply with the ceteris-paribus condition by explicitly accounting for the factors that determine the position of the steady state. Alternatively, one can restrict the focus to a group of countries that is sufficiently homogeneous to justify the presumption of roughly similar fundamental parameters. The right-hand side of Figure B5.1 shows the result of the second strategy: the scatterplot only considers OECD economies and demonstrates that, for this relatively homogeneous group, the (negative) relationship between countries' per capita income in 1970 and their average growth rate between 1970 and 2010 was much stronger than for the entire sample.

V.2.3 The Neoclassical Growth Model of a Closed Economy with an Endogenous Saving Rate

One important shortcoming of the Solow-Swan model is its assumption of a constant saving rate which is not explicitly derived from individuals' intertemporal optimization. To explore the consequences of endogenous saving decisions on the model's results, we continue to consider a closed economy which, however, is populated by a representative consumer (RC) who maximizes his utility over an infinite horizon.[6] We assume that the size of the population does not change (i.e. $n = 0$) and that RC's instantaneous utility function is logarithmic:

$$(5.11) \qquad U_t = \sum_{s=t}^{\infty} \beta^{s-t} \ln C_s$$

RC uses the technology given by (5.1) to generate output, and the capital stock evolves as described by (5.4). For simplicity, we set the rate of depreciation δ equal to zero. Because of the closed-economy assumption, we have $I_t = S_t = Y_t - C_t$. The new feature of the model is that aggregate savings S_t are not necessarily a constant share of current income, but that they reflect consumption choices which are derived from the maximization of (5.11). By substituting the law of motion for the capital stock into the objective function and taking the derivative with respect to K_{t+1}, we arrive at the intertemporal Euler equation

$$(5.12) \qquad C_{t+1} = \beta \left[1 + \alpha \, K_{t+1}^{\alpha-1} \left(A_{t+1} \, L_{t+1} \right)^{1-\alpha} \right] C_t$$

[6] This variant of the neoclassical growth model goes back to the contributions of Ramsey (1928), Cass (1965), and Koopmans (1965).

Following the convention to write a variable X *per unit of effective labor* as $\hat{x}_t \equiv X_t / (A_t L_t)$, we can transform (5.12) into

$$\text{(5.13)} \qquad \frac{\hat{c}_{t+1}}{\hat{c}_t} = \frac{\beta\left(1+\alpha\,\hat{k}_{t+1}^{\alpha-1}\right)}{1+g}$$

The law of motion for the capital stock can be written as

$$\text{(5.14)} \qquad \hat{k}_{t+1} - \hat{k}_t = \frac{\hat{k}_t^{\alpha} - \hat{c}_t - g\,\hat{k}_t}{1+g}$$

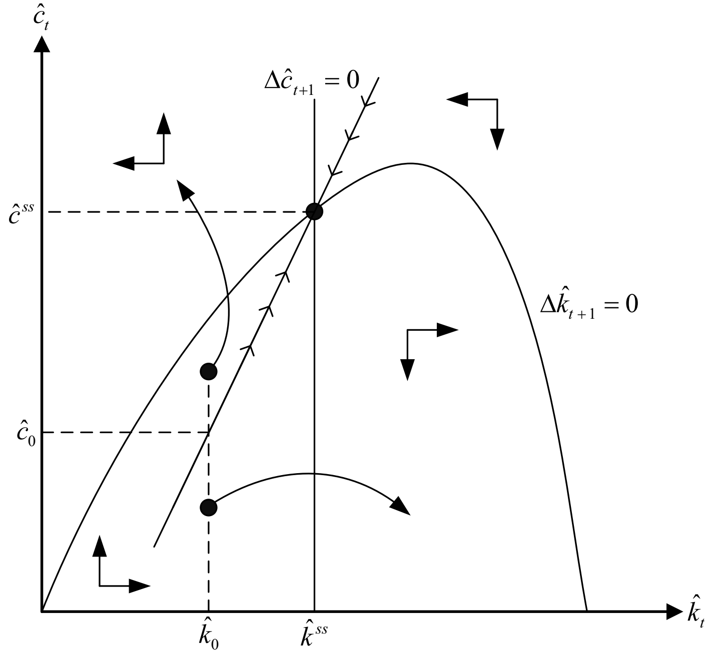


Figure 5.4: Steady state and adjustment dynamics in the neoclassical growth model with an endogenous saving rate.

The equations (5.13) and (5.14) represent a system of difference equations whose dynamic properties can be analyzed with the help of the ***phase diagram*** in Figure 5.4: using the notational convention $\Delta x_t \equiv x_{t+1} - x_t$, the ***demarcation lines*** $\Delta\hat{k}_{t+1} = 0$ and $\Delta\hat{c}_{t+1} = 0$ depict those points, at which $\hat{k}$ and $\hat{c}$ do not change. Since $\Delta\hat{c}_{t+1} = 0$ implies that $\hat{c}_{t+1}/\hat{c}_t = 1$, we can determine the $\Delta\hat{c}_{t+1}$-demarcation line by setting the left-hand side of (5.13) equal to one and by solving for $\hat{k}_{t+1}$. This gives the vertical line in Figure 5.4. By equating $\hat{k}_{t+1} - \hat{k}_t$ in (5.14) to zero, we can solve for $\hat{c}_t$ as a function of $\hat{k}_t$. This function is depicted as the $\Delta\hat{k}_{t+1} = 0$-demarcation line in Figure (5.4). The point of intersection of the two demarcation lines describes a constellation for which $\Delta\hat{c}_{t+1} = 0$ and $\Delta\hat{k}_{t+1} = 0$. This is the steady state of the system.

The adjustment dynamics are described by the arrows whose direction can be determined by taking derivatives of (5.13) and (5.14) with respect to $\hat{k}_{t+1}$ and $\hat{c}_t$. Since $\hat{c}_{t+1}/\hat{c}_t$ decreases in $\hat{k}_{t+1}$, consumption falls in the region to the right of the $\Delta\hat{c}_{t+1} = 0$-demarcation line – the arrows point downward – and increases to the left of the demarcation line. Accordingly, $\hat{k}$ increases in the region below the $\Delta\hat{k}_{t+1} = 0$-curve – the arrows are pointing to the right – and decreases in the region above this curve. This exposition indicates the direction into which consumption and capital move from an arbitrary initial value $\hat{k}_0, \hat{c}_0$. If $\hat{k}_0$ and $\hat{c}_0$ are very low to start with, both values increase over time. If, at the beginning, $\hat{k}_0$ is *below* the steady state while $\hat{c}_0$ is above the $\Delta\hat{k}_{t+1} = 0$-curve, consumption increases while the capital stock declines.

As shown in Figure 5.4, the system is saddle-path stable, i.e. for a given initial capital stock $\hat{k}_0$, there is only *one* consumption level $\hat{c}_0$ that guarantees convergence to the steady state. The path on which $\hat{c}$ and $\hat{k}$ approach the steady state is the ***saddle path***. In order to justify why, for a given $\hat{k}_0$, RC chooses the consumption level that puts him onto the saddle path, we can discuss what would happen if this were not the case. If initial consumption were too high (as depicted by the upper initial point in Figure 5.4), $\hat{k}$ would shrink over time until the economy's entire capital stock would be used up, forcing consumption to be zero. If, by contrast, initial consumption were too low (as at the lower initial point depicted in Figure 5.4), $\hat{k}$ would increase strongly and eventually converge to a position that would also imply $\hat{c} = 0$.[7] None of these developments can be desirable from the point of view of RC. He therefore chooses the consumption level $\hat{c}_0$ in period 0 that guarantees convergence to the steady state.

If we assume that agents' behavior is driven by intertemporal optimization rather than a rigid saving rate, we arrive at some important normative conclusions: in particular, it is not possible in such a framework that the saving rate –

[7] In formal terms, such an evolution can be excluded by invoking a transversality condition which – as in Section III.7 – prevents an exaggerated capital accumulation.

as compared to the social optimum – is too high.[8] With respect to the short-run and long-run determinants of economic growth, however, this variant of the neoclassical growth model does not differ too strongly from the Solow-Swan model: during the economy's convergence to the steady state, income increases are predominantly due to the accumulation of physical capital. Once the economy is in the steady state, income per capita and consumption per capita grow at the (exogenous) rate of technological progress g.

V.2.4 Financial Integration and Economic Growth in the Neoclassical Model

Our presentation of the neoclassical growth model has so far focused on a closed economy, where all investment had to be financed out of domestic savings. In order to explore the effects of moving from financial autarky to financial integration, we consider a world that consists of two countries (H and F), which use the following technologies to produce a homogenous good:

$$Y_t^H = \left(K_t^H\right)^{\alpha}\left(A_t^H L_t^H\right)^{1-\alpha} \tag{5.15}$$

$$Y_t^F = \left(K_t^F\right)^{\alpha}\left(A_t^F L_t^F\right)^{1-\alpha} \tag{5.16}$$

We follow the closed-economy Solow-Swan model by assuming that individuals in both countries save a constant share of their income. Moreover, we assume that these saving rates do not differ across countries, i.e. $s^H = s^F = s$. However, starting in period 0 – the period in which both countries eliminate barriers to international capital movements – national savings may differ from aggregate investment, and the countries' current accounts need no longer be balanced. For country H, we can write

$$CA_t^H = s\,Y_t^{GNI,H} - I_t^H \tag{5.17}$$

where $Y_t^{GNI,H}$ denotes *gross national income* in country *H*, i.e. the sum of GDP and net primary income from abroad.[9] Depending on the country's net international investment position, the latter may be positive or negative. For simplicity, we assume that the depreciation rate δ equals zero. Moreover, we assume that increasing or reducing the capital stock in a country is not associated with ad-

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[8] By contrast, an economy described by the Solow-Swan model can suffer from ***dynamic inefficiency***, i.e. a constellation in which both the short-run and the long-run level of consumption per capita could be increased by a reduction of the saving rate.

[9] Since we abstract from international transfers, secondary income is zero and GNI coincides with gross national disposable income GNDI.

justment costs. The latter assumption implies that, for all periods $t > 0$, the marginal product of capital in both countries has to be equal to the world interest rate r^W:

$$(5.18) \qquad \alpha\left(K_t^H\right)^{\alpha-1}\left(A_t^H L_t^H\right)^{1-\alpha} = r_t^W = \alpha\left(K_t^F\right)^{\alpha-1}\left(A_t^F L_t^F\right)^{1-\alpha}$$

This expression implies that both countries exhibit the same capital stock per unit of effective labor in all periods following the dismantling of investment barriers, i.e.

$$(5.19) \qquad \hat{k}_t^H = \hat{k}_t^F \quad \text{for } t = 1, 2, ...$$

The equalization of capital stocks per unit of effective labor implies that, starting in period 1, the output levels per unit of effective labor are equalized as well.[10] Hence, in this model financial integration results in an *immediate convergence* of countries' GDP per unit of effective labor!

What does this mean for the current account of country H in period 0? By using (5.4) with $\delta = 0$, we can conclude from (5.17) that

$$(5.20) \qquad CA_0^H = s\, Y_0^H - \left(\hat{k}_1^H\, A_1^H\, L_1^H - K_0^H\right)$$

Note that the difference between GDP and GNI is irrelevant in period 0 since, at that point in time, countries have not yet accumulated any foreign assets or liabilities. Starting in period 1, the "global" capital stock per unit of effective labor, which we denote by $\hat{k}_t^W$, equals $\hat{k}_t^H$ and $\hat{k}_t^F$. To describe the evolution of $\hat{k}_t^W$, we combine (5.20) with the equilibrium condition $CA_t^H + CA_t^F = 0$:

$$(5.21) \qquad \hat{k}_{t+1}^W = \frac{s\, Y_t^H + K_t^H + s\, Y_t^F + K_t^F}{A_{t+1}^H L_{t+1}^H + A_{t+1}^F L_{t+1}^F} \qquad \text{for } t = 0, 1, 2, ...$$

Recall that $\hat{k}_1^W = \hat{k}_1^H = \hat{k}_1^F$. By substituting (5.21) for $\hat{k}_1^H$ into (5.20), we get

$$(5.22) \quad CA_0^H = \frac{L_0^H\, L_0^F\left[\left(1+z^F\right)A_0^F\left(s\, y_0^H + k_0^H\right) - \left(1+z^H\right)A_0^H\left(s\, y_0^F + k_0^F\right)\right]}{\left(1+z^H\right)A_0^H\, L_0^H + \left(1+z^F\right)A_0^F\, L_0^F}$$

where we have once more used the definition $\left(1+z^i\right) \equiv \left(1+g^i\right)\left(1+n^i\right)$ for $i = H, F$. As in Section V.2.2, the variable y_0^i denotes *per capita* output, while

[10] If varying the capital stock is associated with adjustment costs, the process of convergence is slowed down. In this case, the cross-country equalization of capital stocks does not happen immediately, but occurs in the long run.

k_0^i denotes the capital stock *per capita* – the ***capital intensity*** – of country i in period 0. To interpret this expression, we start by assuming that the two countries neither differ with respect to the technology parameter A nor with respect to their population growth rates (n) or rates of technological progress (g). In this case, all differences in countries' output per capita result from different capital intensities in period 0, and we can simplify equation (5.22) as follows:

$$(5.23) \qquad CA_0^H = \frac{L_0^H \, L_0^F \left[\left(s\, y_0^H + k_0^H\right) - \left(s\, y_0^F + k_0^F\right)\right]}{L_0^H + L_0^F}$$

This equation suggests that country H exhibits a current account *deficit* in period 0 if it is poorer than country F. In this case, capital flows from the rich to the poor country. This result is driven by two forces: first, the poorer country has lower savings. Second, investment is higher in the country that starts out with the lower capital stock per capita. More specifically, the diminishing marginal productivity of capital implies that, with identical technology parameters and population growth rates, the country with the lower initial capital stock per capita is the more attractive location for investment.

The unambiguous relationship between a country's relative income position and its current account balance disappears if we allow for differences in technology parameters and population growth. As we can infer from equation (5.22), a lower population growth rate, a lower initial level of the technology parameter A, and a lower rate of technological progress g reduce capital inflows and thus raise the current account balance of country H in period 0. Again, this is due to cross-country differences in the marginal productivity of capital. For example, if country H's low output in period 0 is not only caused by a low capital stock, but by a low level of productivity, this reduces the return to capital and thus the attractiveness for international investment.

Box 5.2: Does Capital Flow in the Right Direction?

Equation (5.22) suggests that we should expect those countries to attract more foreign capital and to exhibit larger current account deficits which are characterized by lower initial per capita incomes and faster technology growth. Do the data support this conjecture?

In a famous paper published in 1990 („Why doesn't Capital Flow from Rich to Poor Countries?"), Robert Lucas highlighted that the theoretical relationship between per capita income levels and capital flows was in blatant contrast to reality. In line with equation (5.22), he then pointed at the role of productivity differences – driven, e.g., by cross-country gaps in workers' skills – as a potential reason for the rather modest North-South capital flows observed at that time. This argument reverberates in a paper by Francesco Caselli and James Feyrer (2007) who argue that, indeed, the marginal productivity of capital in poor countries is not higher than in rich countries. An alternative explanation of the "***Lucas puzzle***" sticks to the notion that capital is more productive in poor countries, but highlights the fact that, then as now, explicit and implicit barriers to international investment prevent agents from fully exploiting return differences. There is, indeed, ample evidence that political instability and insecure property rights act as a powerful impediment to international investment.

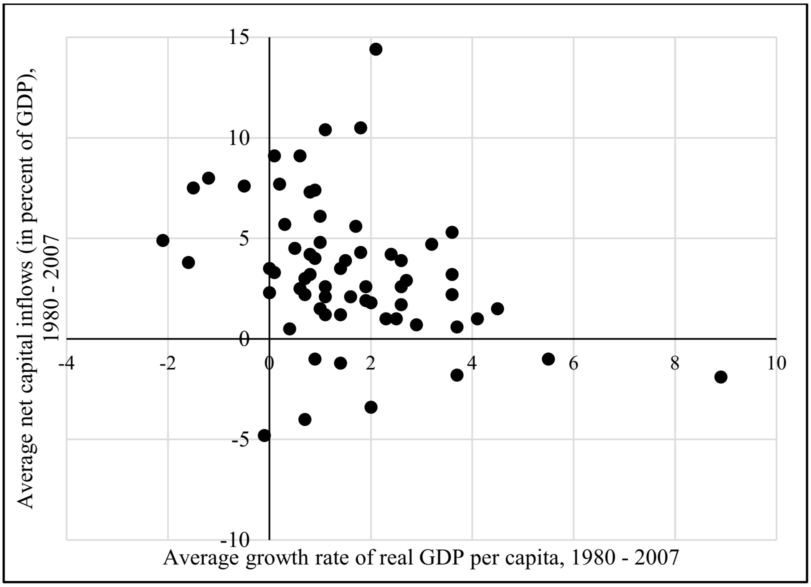

Figure B5.2: Average growth rates of real GDP per capita and average net capital inflows (in percent of GDP), 1980 to 2007. Net capital inflows are measured as the current account balance times minus one. Source: Alfaro et al. (2012).

In a recent contribution, Pierre-Olivier Gourinchas and Olivier Jeanne (2013) point at another dimension along which the neoclassical model's prediction on international capital flows seems to fail empirically. While equation (5.22) indicates that capital should flow to countries which are characterized by high growth rates, Gourinchas and Jeanne demonstrate that the correlation between countries' productivity growth and their current account deficits is *positive*, suggesting that the relationship between growth and *net capital inflows* is *negative*. As the authors demonstrate, this surprising empirical observation does not disappear even if one controls for other potential determinants of international capital flows. Figure B5.2 illustrates the "***allocation puzzle***" established by Gourinchas and Jeanne by depicting the simple relationship between the growth rates of GDP per capita and net capital inflows for a large number of countries. Indeed, the data do not seem to support the neoclassical model.

However, this reading of the facts has recently been challenged in a paper by Laura Alfaro, Sebnem Kalemli-Özcan and Vadym Volosovych (2014). These authors point out that, when taking equation (5.22) to the data, one has to be aware of the fact that, especially for poor countries, a large share of capital inflows are driven by the decisions of governments and international institutions. As a consequence, the large current account deficits of slowly growing economies reflect aid flows, concessionary loans, and other sovereign-to-sovereign transactions rather than private firms' and individuals' inability (or unwillingness) to act as suggested by the neoclassical model. After purging the data of public capital flows, Alfaro et al. (2014) demonstrate that private international investment is, indeed, attracted by countries with higher productivity growth rates.

How do the two economies evolve once we move beyond period 1? As we have seen above, capital stocks (per unit of effective labor) are immediately equalized when countries move from financial autarky to financial integration, i.e. for all periods starting in $t=1$ we have $\hat{k}_t^H = \hat{k}_t^F = \hat{k}_t^W$. We can thus relate the development of national output levels to the evolution of the global capital stock. In order to determine the time path of $\hat{k}^W$, we use (5.21), taking into account that $K_t^i = \hat{k}^i A_t^i L_t^i$ and $\hat{k}^i = \hat{k}_t^W$ for $i = H, F$. This yields

$$(5.24) \qquad \hat{k}_{t+1}^W - \hat{k}_t^W = \frac{s}{\Omega_t}\left(\hat{k}_t^W\right)^{\alpha} - \frac{\Omega_t - 1}{\Omega_t}\hat{k}_t^W$$

with $$\Omega_t = \left(1+z^H\right)\phi_t^H + \left(1+z^F\right)\left(1-\phi_t^H\right)$$

and $$\phi_t^H = \frac{A_t^H L_t^H}{A_t^H L_t^H + A_t^F L_t^F}$$

We can easily show that

$$(5.25) \qquad \lim_{t\to\infty}\Omega_t = \begin{cases} \left(1+z^H\right), & \text{if } \left(1+z^H\right) \geq \left(1+z^F\right) \\ \left(1+z^F\right), & \text{if } \left(1+z^H\right) < \left(1+z^F\right) \end{cases}$$

Taking into account our assumption that $\delta = 0$, equation (5.24) closely resembles equation (5.8), with Ω_t eventually converging to either $\left(1+z^H\right)$ or $\left(1+z^F\right)$. Hence, the evolution of the global capital stock per unit of effective labor is driven by the very forces that we have already identified in our presentation of the (closed-economy) Solow-Swan model. The intuition behind this fact is straightforward: in the neoclassical model, financial integration brings about an immediate equalization of capital stocks (per unit of effective labor) across countries, which also prevails in all subsequent periods. In the medium run, the evolution of the global economy is determined by the population growth rates and the rates of technological progress in both economies. In the long run, however, the country where the amount of effective labor increases at a lower rate becomes less and less important – be it, because it has the lower population growth rate or because labor productivity does not increase as fast as in the other country. If $\left(1+z^H\right) \geq \left(1+z^F\right)$, the long-run evolution of $\hat{k}^W$ eventually mimicks a closed economy that is characterized by a population growth rate n^H and a rate of technological progress g^H.

As we have just shown, the removal of investment barriers between two countries results in an immediate equalization of capital stocks per unit of effective labor. If both countries have access to the same technology $\left(A_t^H = A_t^F\right)$ this implies that they have the same GDP per capita in the period following the move from financial autarky to financial integration. Hence, the model predicts an *immediate* convergence of output levels per capita! This result, however, should not mask the fact that the countries' *income* levels – defined as *gross national income* per capita – will remain different. The reason is that a share of the additional output produced in the initially poorer country represents capital income that accrues to inhabitants of the initially richer country. The initial increase of GNI is therefore smaller than the initial increase of GDP. Nevertheless, the poorer country benefits from capital imports: while a share of the domestic capital income is reclaimed by foreign investors, the higher capital stock raises the real wage received by domestic workers.

V.3 Endogenous Growth: AK Models

V.3.1 Motivation

The critical assumption of the neoclassical growth model stipulates that capital generates positive, but diminishing returns. As a result of this assumption, the capital stock (per unit of effective labor) converges to a stationary level, and long-run growth is only driven by exogenous technological change. In addition, the decreasing marginal productivity implies that poorer countries exhibit higher growth rates *ceteris paribus*. In the 1980s, the empirical support for the convergence hypothesis seemed increasingly questionable. Moreover, researchers felt uneasy about the fact that the neoclassical growth model could not really *explain* long-run growth, but had to refer to *exogenous* technological progress instead. Against this background, the goal of the ***New Growth Theory***, which started to emerge in the late 1980s, was to develop models in which long-run growth was not driven by an exogenous force, and which were able to explain the – observed or alleged – absence of international income convergence.

The central idea that links the different approaches of the New Growth Theory is that the marginal productivity of capital does not decrease, and that the aggregate production function is linear in the capital stock. While the various strands of that paradigm differ in the microeconomic mechanisms that motivate a linear production function, the common principle can be summarized by a simple feedback mechanism. The key idea of this mechanism is that effective labor supply directly or indirectly depends on a country's income or capital stock. Hence, in general terms, the aggregate production function looks as follows:

$$(5.26) \qquad Y_t = F\left(K_t, h(K_t)L_t\right) \quad \text{with } h'\left(K_t\right) > 0$$

Note that we have deliberately omitted a time-variant technology parameter whose growth represented exogenous technological progress in the Solow-Swan model. For the production function in (5.26), the accumulation of capital has two effects: as in the neoclassical growth model, the diminishing marginal productivity of capital kicks in as the capital stock increases. At the same time, however, the higher capital stock acts like labor-augmenting technological change, thus *raising* the marginal productivity of capital. If both effects exactly compensate each other, the aggregate production function turns linear in the capital stock. In this case, we can write $y_t = A\,k_t$, with A being a constant (!) measure of productivity.

As demonstrated by Figure 5.5, combining such an assumption on the aggregate production function with an exogenous saving rate results in a model that does not have a (non-trivial) steady state. Instead, if the condition $s\,A > \delta + n$ is satisfied, the economy's per capita capital stock and income grow in the long run without being driven by an exogenous force, and the (long-run) growth rate of per capita income is given by the difference $\left(s\,A - \delta - n\right)$. Note that, unlike in the neoclassical growth model, the saving rate does not only affect the level of an economy's per capita income, but also its long-run growth rate.

In the following subsection we will consider the ***learning-by-doing model*** of Paul Romer (1986) as an example for such an ***AK model***. To better understand the forces at work, we will first consider the equilibrium in a closed economy.

In a next step, we will then look at the consequences of dismantling barriers to international investment.

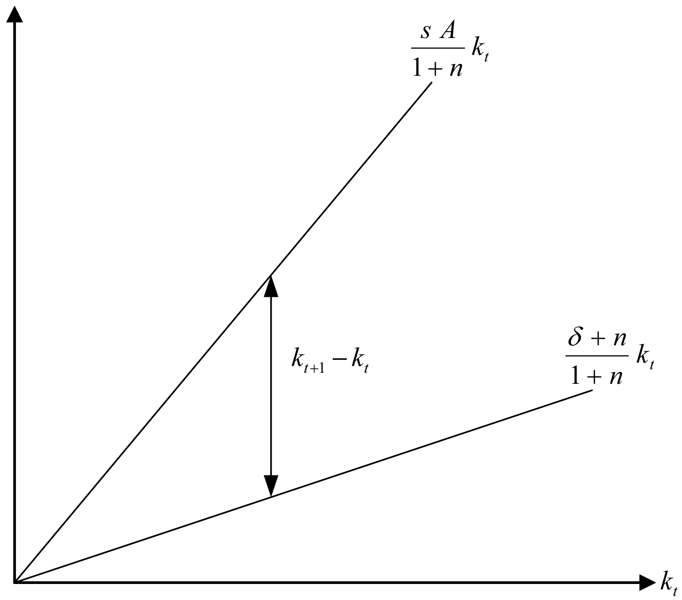

Figure 5.5 : The evolution of the capital-labor ratio in the AK model.

V.3.2 Learning-by-Doing in a Closed Economy

We consider an economy that is populated by L identical individuals each of whom owns a firm whose production contributes to the country's homogeneous output. Individuals maximize their lifetime utility over an infinite time horizon, and their instantaneous utility is assumed to be logarithmic as in (5.11). In period t, individual i produces his income in his own firm, using the following technology:

(5.27) $$Y_t^i = A\left(K_t^i\right)^{\alpha}\left(K_t L_t^i\right)^{1-\alpha},$$

with K_t^i denoting the capital stock employed by individual i, and L_t^i denoting his labor input. For simplicity, we set the labor input equal to one for all individuals, i.e. $L_t^i = 1$. The special feature of the production function in (5.27) is that the output generated does not only depend on the firm's „own" capital stock K_t^i, but also on the economy's *aggregate* capital stock K_t. One way to motivate this relationship is to invoke ***learning-by-doing effects***, through which a high national capital stock raises the qualification and productivity of workers in each individual firm.

As in previous models, the evolution of the capital stock owned by individual i is determined by the difference between income and consumption. By substituting the law of motion of K_t^i into the objective function as in Subsection V.2.3, and by taking the derivative with respect to K_{t+1}^i, we arrive at the following intertemporal Euler equation:[11]

$$(5.28) \qquad \frac{C_{t+1}^i}{C_t^i} = \beta \left[1 + \alpha\, A \left(K_{t+1}^i \right)^{\alpha-1} \left(K_{t+1} \right)^{1-\alpha} \right]$$

Since all individuals are assumed to be identical, they choose the same time path of consumption and the same capital-labor ratio in each period, i.e. $K_{t+1}^i = K_{t+1}/L$ for all i, with $K_{t+1} = \sum_i K_{t+1}^i$. By combining this result with (5.28), we can derive the growth rate of per capita consumption:

$$(5.29) \qquad \frac{C_{t+1}^i}{C_t^i} = \beta \left(1 + \alpha\, A\, L^{1-\alpha} \right)$$

Hence, the growth rate of per capita consumption – and thus income – is *constant*. This is due to the structure of the aggregate production function. Given the specification in (5.27), raising the firm-specific capital stock not only increases the output of an individual firm, but also the productivity of all *other* firms. Because of this ***external effect***, the marginal productivity of capital remains constant, and since individuals adjust their saving behavior to this marginal productivity, consumption, capital and output per capita grow at a constant rate.[12]

Equation (5.29) suggests that the growth rate of per capita income is proportional to the population size. This ***scale effect*** results from the assumption that it is the *aggregate* capital stock that affects the productivity of individual firms.

[11] Note that this derivative reflects the assumption that the individual firm does not account for the effect on the aggregate capital stock when choosing the optimal value of K_{t+1}^i. Note also that, since all individuals are assumed to share identical preferences, factor endowments and technologies, we can ignore the existence of a capital market. In equilibrium, the return on any security would have to equal the marginal productivity of capital in each firm, and would therefore be redundant.

[12] We can use (5.5) and (5.29) as well as the fact that consumption and the capital stock grow at the same rate to derive individuals' saving rate. This saving rate is greater than zero if $\left(1-\beta\right)/\beta < \alpha\, A\, L^{1-\alpha}$, which requires that individuals are not too impatient – i.e. that the discount factor β is sufficiently large – and that the productivity parameter A is not too low.

If we assumed, by contrast, that the external effect hinges on the capital stock *per capita* (K/L), the influence of the population size on the growth rate would vanish.

The external effect, which generates endogenous growth in this version of the AK model, also implies that – compared to the social optimum – the growth rate is too low. Since individuals do not take into account the effect of their own capital accumulation on the productivity of other firms, they decide to save and invest *too little*. This can be shown by contrasting their decentralized choices with the behavior of an economy in which saving and investment choices are made (or coordinated) by a single individual that takes into account the interdependencies between individual firms. Under such circumstances, the law of motion of the capital stock is given by

$$K_{t+1} - K_t = A\,L^{1-\alpha}\,K_t - C_t\,, \tag{5.30}$$

and the maximization of lifetime utility by a representative individual results in the following growth rate of consumption and income:

$$\frac{C_{t+1}}{C_t} = \beta\left[1 + A\,L^{1-\alpha}\right] \tag{5.31}$$

The finding that the growth rate of per capita income, which emerges in a decentralized equilibrium, is too small is common to models of the New Growth Theory. It follows from the fact that individuals' choices depend on the private return to capital, and that this private return is smaller than the social return.

Box 5.3: Human Capital, Productive Government Spending, and Endogenous Growth

As mentioned above, the common feature of "New Growth" models is a feedback mechanism that prevents the returns to capital from diminishing as countries become richer. In the Romer model (1986), this property was due to learning-by-doing effects. Another mechanism that can bring about endogenous growth results from the interaction of ***physical capital*** and ***human capital*** – with human capital describing the stock of knowledge and productive skills of an economy's labor force. If we include human capital H_t as a further input, we can write an economy's aggregate production function as follows:

$$Y_t = K_t^{\alpha}\,H_t^{\beta}\,(A_t\,L_t)^{1-\alpha-\beta}$$

Note that with this specification, both types of capital are subject to diminishing returns. However, the marginal productivity of physical capital increases if the stock of human capital grows bigger, and vice versa. If human capital accumulation depends on current income, an increase of the physical capital stock, while reducing the marginal product of K, also contributes to an expansion of the human capital stock, which works against diminishing returns. As long as $\alpha + \beta < 1$, the economy nevertheless converges to a steady state, and long-run growth can only be explained by referring to exogenous technological change. However, if $\alpha + \beta = 1$, the two effects of capital accumulation compensate each other, and the long-run aggregate production function is of the AK-type.

A third way of arriving at a linear aggregate production function is to follow Robert Barro (1990) in assuming that productive government spending – interpreted as the costs of providing a public infrastructure – acts like labor-augmenting technological progress. With G denoting the volume of government spending, the production function can be written as

$$Y_t = K_t^{\alpha} \left(G_t \, L_t \right)^{1-\alpha}$$

We assume that, in every period, government spending is financed by raising taxes on current income. With τ denoting the tax rate, this implies $G_t = \tau_t \, Y_t$. By substituting this government budget constraint into the production function and rearranging terms, we arrive at

$$Y_t = \left(\tau_t \, L_t \right)^{\frac{1-\alpha}{\alpha}} K_t$$

As in the other mechanisms that motivate the AK model, physical capital exhibits diminishing returns *ceteris paribus*. At the same time, however, an increase of the capital stock – and the associated expansion of income – raises tax revenues, enabling the government to increase productive spending. This raises the marginal productivity of capital and, for the specification chosen by Barro, the aggregate production function is linear.

V.3.3 Financial Integration and Endogenous Growth

What are the consequences of moving from financial autarky to financial integration if the aggregate production function is characterized by a constant marginal productivity of capital – due, e.g., to learning-by-doing effects as described in the previous subsection? As we will show, the answer to this question crucially depends on whether the learning-by-doing externalities are constrained by national borders, or whether the productivity of a country's firms is also influenced by the global capital stock.

Once again, we consider a world that consists of two economies (H and F). The transition from autarky to financial integration allows individuals in H and F to offer their savings in terms of physical capital to foreign firms. This is attractive as long as the marginal productivity of capital in the foreign economy is greater than the marginal productivity in the domestic economy. We assume as before that the population size in country H $\left(F\right)$ amounts to a constant value L^H $\left(L^F\right)$, and that every individual offers one unit of labor, i.e. $L_t^{i,H} = L_t^{i,F} = 1$. If the marginal productivity of the (firm-level) „private capital stock" in country H only depends on the aggregate capital stock in H, the production function of the individual firm looks as in Subsection V.3.2:

$$(5.32) \qquad Y_t^{i,H} = A^H \left(K_t^{i,H}\right)^{\alpha} \left(K_t^H\right)^{1-\alpha}$$

In this case, the marginal productivity of capital of a firm in country H is given by $\alpha A^H \left(L^H\right)^{1-\alpha}$, while it is $\alpha A^F \left(L^F\right)^{1-\alpha}$ in country F.[13] This, however, implies that the removal of barriers to international investment has extreme consequences: if $A^H \left(L^H\right)^{1-\alpha}$ is greater than $A^F \left(L^F\right)^{1-\alpha}$, the total volume of global savings will focus on investments in country H. In country F, by contrast, production will shut down completely. If $A^H \left(L^H\right)^{1-\alpha} < A^F \left(L^F\right)^{1-\alpha}$ the exact opposite will occur. Hence, an equilibrium with strictly positive production in both countries is only possible if $A^H \left(L^H\right)^{1-\alpha} = A^F \left(L^F\right)^{1-\alpha}$. In this case, the distribution of the global capital stock among countries H and F is indeterminate.

The consequences of financial integration are less dramatic if we allow for ***international spillovers*** – i.e. if the productivity of the inputs used by domestic firms not only depends on the domestic, but also on the foreign capital stock. We can describe such a constellation by rewriting the firm-specific production function as follows:

$$(5.33) \qquad Y_t^{i,H} = A^H \left(K_t^{i,H}\right)^{\alpha} \left(K_t^H + \varphi K_t^F\right)^{1-\alpha}$$

with the parameter $\varphi \geq 0$ reflecting the extent to which the foreign capital stock affects the productivity of domestic firms. If we write the analogous production

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[13] To show this, we have to take the derivative of $Y_t^{i,H}$ with respect to $K_t^{i,H}$, taking into account that, in equilibrium, $K_t^{i,H} = K_t^H / L^H$.

function for country F, an equilibrium with financial integration in which neither of the two countries attracts the entire global capital stock is characterized by

$$(5.34) \qquad \alpha\, A^H \left(\frac{K_t^H}{K_t^{i,H}} + \varphi \frac{K_t^F}{K_t^{i,H}} \right)^{1-\alpha} = \alpha\, A^F \left(\varphi \frac{K_t^H}{K_t^{i,F}} + \frac{K_t^F}{K_t^{i,F}} \right)^{1-\alpha}$$

This expression implicitly defines the domestic capital stock per capita in country H relative to the capital stock per capita in country F. By defining $h_t \equiv K_t^{i,H} / K_t^{i,F}$ and taking into account that $K_t^H = L^H\, K_t^{i,H}$ and $K_t^F = L^F\, K_t^{i,F}$, we can rewrite (5.34) as

$$(5.35) \qquad \frac{a^H - l^F}{\varphi} h_t = h_t^2 - a^H\, l^F ,$$

with $l^F \equiv L^F / L^H$ reflecting the relative population size in country F, and $a^H \equiv \left(A^H / A^F \right)^{1/(1-\alpha)}$ defining the relative productivity parameter in country H.

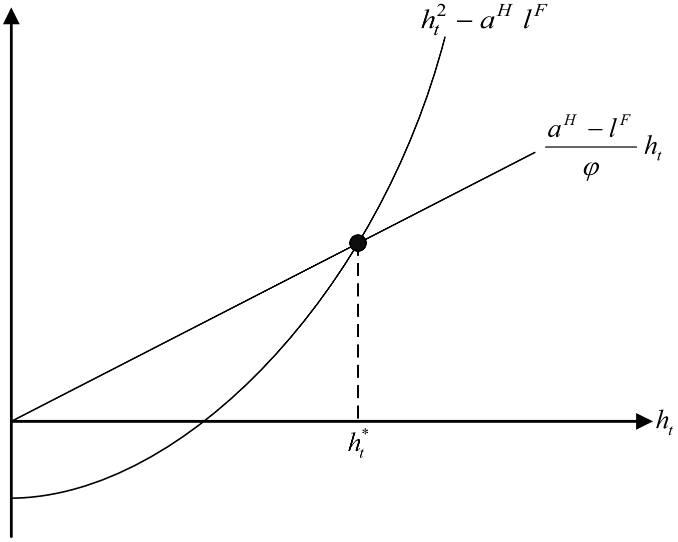

Figure 5.6: The relative capital stock in country H $\left(h_t \equiv K_t^{i,H} / K_t^{i,F} \right)$ in an AK-model with financial integration.

In Figure 5.6, the left-hand side of (5.35) is depicted for the case that $l^F < a^H$ as a straight line with a positive slope. The relative per capita capital stock in equilibrium (h_t^*) is determined as the intersection of this line with the parabola on the right-hand side of (5.35). As long as $\varphi > 0$, there is a strictly positive, but finite value of h_t^* that solves (5.35). That is, none of the two countries experiences a complete exodus of capital. If $l^F = a^H$, the solution of (5.35) implies $h_t^* = l^F$: regardless of φ, both countries exhibit the same capital stock in equilibrium. If $\varphi = 1$, i.e. if the global capital stock influences the productivities of domestic firms regardless of its distribution across countries, we have $h_t^* = a^H$. In this case, the relative capital stock only depends on relative productivity levels.

V.3.4 International Diversification and Growth

As we have shown in the previous subsection, the volume and direction of international capital flows is indeterminate if the marginal productivity of capital in countries H and F is identical, i.e. if $\alpha A^H \left(L^H\right)^{1-\alpha} = \alpha A^F \left(L^F\right)^{1-\alpha}$. However, if A^H and A^F are stochastic, and if country-specific fluctuations of these productivity parameters are not perfectly correlated, there is a *diversification motive* that may drive international capital flows despite identical average returns. That is, by purchasing foreign assets, agents can reduce consumption risk. How this possibility affects growth depends on the consequences of diversification for aggregate savings. As shown by Devereux und Smith (1994), and, more recently, by Coeurdacier and Rey (2015), financial integration may result in a lower growth of per capita income since the reduced risk possibly lowers (precautionary) savings, which has a negative effect on the long-run growth rate. However, this view ignores the possibility that international diversification provides an incentive to choose a production structure that is characterized by a higher risk, but also a higher return. Elaborating on this argument, Obstfeld (1994) shows that the possibility to diversify country-specific risks may increase aggregate productivity and thus result in a higher growth rate.

V.4 Endogenous Technological Change

V.4.1 Motivation

The learning-by-doing model that we introduced in Section V.3 explains endogenous growth as a consequence of an external effect: while the capital stock of every individual firm is subject to diminishing returns, the aggregate production function is linear in the economy-wide capital stock, since firm-specific investments raise labor productivity in all firms. With this finding, the main goal of endogenous growth theory seems to be achieved – namely, to explain long-run growth without having to refer to exogenous technological change as a driving force. Despite this impressive achievement, however, we are still facing an important shortcoming: the ***innovation process*** – i.e. the emergence of new knowledge – cannot be analyzed in this framework. This makes it hard to assess which institutional framework and political choices are conducive to technological progress and thus to long-run growth.

This critique is the point of departure for a number of contributions which explain technological progress by analyzing the microeconomic processes that drive the development of new products and production methods. This literature distinguishes between ***horizontal innovations*** and ***vertical innovations***: while models of horizontal innovation relate productivity increases to an expansion of the goods spectrum – i.e. the emergence of new products that do not necessarily replace the existing ones – models of vertical innovation focus on the development of better versions of already existing products. Both strands of the literature share some important features with respect to their basic modelling approach and their results. However, there are also some notable differences. In particular, vertical innovations imply a process of market entry and displacement in the sense of Joseph Schumpeter's (1934) ***creative destruction***, which does not exist in a model of horizontal innovation.

In this section, we start by presenting a simplified version of the model developed by Paul Romer (1990), which focuses on the role of horizontal innovation and explains technological change as resulting from an increasing diversity of "intermediate inputs". In the following section, we will then turn to a model of vertical innovation. As in previous parts of this chapter, we will first consider the process of innovation and growth in a closed economy, and subsequently discuss the consequences of opening a country for international goods and asset trade.

V.4.2 Horizontal Innovation and Growth

We consider an economy where a representative firm uses labor and intermediate goods to produce a homogeneous "final good" (FG), which will be used as a numéraire and whose price we therefore set equal to one. The firm uses the following technology:

$$Y_t = \left(L_t^Y\right)^{1-\alpha} \sum_{j=1}^{A_t} \left(x_t^j\right)^{\alpha} \tag{5.36}$$

In this expression, Y_t represents the amount of the final good produced, L_t^Y represents employment in the FG firm, A_t the number of differentiated intermediate goods (IG) in period t, and x_t^j the amount of the intermediate good j that is used in the production of the final good. To demonstrate the role of A_t for the labor productivity in the "FG sector", we assume that, in a symmetric equilibrium, an equal amount of all intermediate goods is used – i.e. $x_t^j = x_t$ for all j – and that the representative firm has to comply with the resource constraint $A_t \, x_t = X_t$.[14] By substituting this constraint into the production function (5.36), we arrive at

$$(5.37) \qquad Y_t = X_t^{\alpha} \left(A_t \, L_t^Y \right)^{1-\alpha}$$

This equation succinctly illustrates the role of horizontal innovation for economic growth: for a given value of X_t, a higher number of intermediate goods acts like labor-augmenting technological change. The economic explanation of this relationship runs as follows: the more the production process is based on a differentiated set of intermediate goods, the more an economy benefits from ***increasing returns to specialization,*** and the higher the productivity of labor at the final production stage. Technological progress – i.e. a growing value of A – is thus interpreted as an increasing number of intermediate goods, and the model analyzes the mechanisms behind the emergence of these new goods.

We assume that each IG firm is the only supplier of its good, but that production requires the possession of a *blueprint*, which is generated in a separate ***research and development ("R&D") sector***. The production function in the R&D sector is given by the following expression:

$$(5.38) \qquad A_{t+1} - A_t = \theta \, A_t \, L_t^R$$

The evolution of the amount of intermediate goods is thus determined by employment in research and development $\left(L_t^R \right)$ and an exogenous parameter θ, but also by the amount of existing intermediate goods. This is the second important component of the model: developing a new blueprint not only raises productivity in the FG sector, but also enhances future innovation. Using a famous quote by Isaac Newton, Jones and Vollrath (2013: 102) label this relationship the ***"standing-on-shoulders"-effect***.[15] It captures the notion that every

[14] Such a constraint could be due to the fact that the production of one unit of the intermediate good uses one unit of a factor of production whose aggregate supply is given by X_t.

[15] In a letter to a colleague, the English physicist Isaac Newton (1634-1727) once explained the emergence of an important result by pointing out that he had been standing "on the shoulders of giants".

innovative effort benefits from the stock of productive ideas that has been accumulated before.

For the model, the specification of the R&D production function has two important implications: first, the growth rate of A is constant for given employment in the R&D sector – i.e. there is endogenous growth, with the "standing-on-shoulders" effect adopting the role of the "learning-by-doing" effect from the AK model. Moreover, there is possibly a role for growth-enhancing government interventions, since the individual researcher only focuses on the private return of his innovation without accounting for the fact that he potentially facilitates future innovation.

So far, our formal framework very much looks like a further variant of an AK model. And, indeed, the growth rate of per capita income can easily be derived when the employment in the R&D sector (L^R) is exogenously determined. However, the important contribution of the Romer model (1990) is to *endogenize* the sectoral allocation of labor, and to explicitly model firms' incentives to spend resources on innovative activities.

The structure of the economy is described by Figure 5.7. The incentive to innovate in the R&D sector crucially depends on the price that an IG-firm is willing to pay for a new blueprint. This willingness to pay is, in turn, determined by the profits that can be reaped by selling an additional intermediate good. The size of these profits depends ultimately on the FG firm's demand. To derive innovative activity in equilibrium, we proceed as follows: first, we determine labor demand of the FG firm as well as its demand for a typical intermediate product j. Knowing this demand, we can then determine the optimal price and the optimal output of an IG firm. The resulting profit can be used to compute the price of a blueprint. In a last step, we will derive the allocation of the country's total labor force to the FG sector and the R&D sector respectively. When doing this, we will use the fact that, with perfect labor mobility, both sectors have to pay the same wage.[16]

[16] The assumption of perfect intersectoral labor mobility is based on the notion that any worker can be employed in production *or* in R&D. This fairly implausible assumption can be relaxed by associating the intersectoral mobility of labor with adjustment costs. In the long run, however, such a model would behave as the one described in this section.

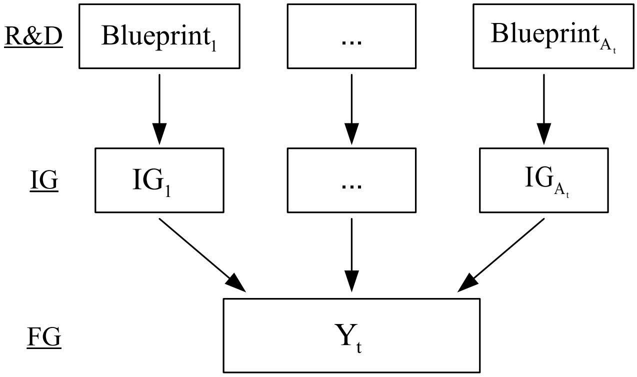

Figure 5.7: The sectoral structure of the Romer model (1990). At time t, the representative firm in the final goods (FG) sector uses A_t intermediate goods which are supplied by individual firms in the intermediate goods (IG) sector. The production of an intermediate good requires the possession of a blueprint that has been developed in the research-and-development (R&D) sector.

The demand of the FG firm for labor and a typical intermediate good j can be determined by taking a derivative of the production function (5.36) with respect to L_t^Y and x_t^j, and by setting these derivatives equal to the wage paid in the FG sector $\left(w_t^Y\right)$ and the price of the intermediate good p_t^j:

$$(5.39) \qquad (1-\alpha)\sum_{j=1}^{A_t}\left(x_t^j\right)^{\alpha}\left(L_t^Y\right)^{-\alpha} = w_t^Y$$

$$(5.40) \qquad \alpha\left(x_t^j\right)^{\alpha-1}\left(L_t^Y\right)^{1-\alpha} = p_t^j$$

We assume that to produce one unit of output in period t, an IG firm has to rent exactly one unit of the final good, for which it has to pay the interest rate r.[17] Since the firm enjoys monopoly power, it chooses the amount supplied x_t^j in order to maximize its profit, taking into account the negative relationship between price and demand, as expressed by (5.40). Solving this optimization problem yields

$$(5.41) \qquad p_t^j = \frac{r}{\alpha}$$

[17] To simplify our exposition, we consider this interest rate as an exogenous variable. Romer (1990), by contrast, relates it to the optimization of a representative consumer.

Hence, IG firms charge a ***markup*** $1/\alpha$ over their marginal costs *r*. By substituting this price into (5.40) we arrive at

$$(5.42)\qquad x_t^j = \left(\frac{\alpha^2}{r}\right)^{\frac{1}{1-\alpha}} L_t^Y$$

which shows that an IG firm's supply is proportional to the employment in the FG sector. By substituting (5.42) into the production function (5.36), we can determine the output of final goods produced in period t:

$$(5.43)\qquad Y_t = \left(\frac{\alpha^2}{r}\right)^{\frac{\alpha}{1-\alpha}} A_t\, L_t^Y$$

The growth rate of Y is thus determined by the growth rates of A and L^Y, with the development of A being determined by employment in the R&D sector $L_t^R = L_t - L_t^Y$. For the sake of simplicity, we assume that population size is constant – i.e. $L_t = L$ – and we *conjecture* that this also holds for employment in the FG sector, i.e. $L_t^Y = L^Y$.[18] By combining (5.41) and (5.42) with the fact that the profit of firm j is given by $\pi_t^j = \left(p_t^j - r\right)x_t^j$, we can derive

$$(5.44)\qquad \pi_t^j = \left(1-\alpha\right)\alpha^{\frac{1+\alpha}{1-\alpha}}\left(\frac{1}{r}\right)^{\frac{\alpha}{1-\alpha}} L^Y$$

Note that profits in the IG-sector are constant, i.e. $\pi_t^j = \pi^j$. Moreover, they depend on market size, as represented by employment in the FG sector $\left(L^Y\right)$. This observation will become important once we discuss the consequences of moving from autarky to free trade.

Having determined the profit of a typical IG firm, we are now in a position to determine the price of a *blueprint*. Under perfect competition, this price P_t^R reflects IG firms' willingness to pay, which depends on the present value of all profits that can be reaped from using a blueprint. We assume that a blueprint purchased in period t starts generating profits in period $t+1$. Using the exogenous interest rate r for discounting, we can thus compute the price of a blueprint as

[18] We will later confirm this conjecture.

$$(5.45) \qquad P_t^R = \sum_{s=t+1}^{\infty} \left(\frac{1}{1+r} \right)^{s-t} \pi^j = \frac{\pi^j}{r}$$

The wage paid to workers in the R&D sector mirrors the marginal value product of labor in that sector, i.e. the product of labor's marginal productivity θA_t and the price P_t^R at which a blueprint can be sold. Due to the perfect intersectoral mobility of labor, this wage has to equal the wage paid in the FG-sector, which can be computed by combining (5.39) and (5.42). We therefore must have

$$(5.46) \qquad \left(\frac{1}{r} \right)^{\frac{1}{1-\alpha}} (1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} L^Y \theta A_t = (1-\alpha) A_t \left(\frac{\alpha^2}{r} \right)^{\frac{\alpha}{1-\alpha}}$$

By solving this equation for L^Y, we get $L^Y = r / (\alpha \theta)$, i.e. a constant value. If we combine this result with the labor-market equilibrium condition $L^Y + L^R = L$, we can derive employment in the R&D sector. This, in turn, determines the growth rate of A and thus the growth rate of per capita income, which is

$$(5.47) \qquad g = \theta L - \frac{r}{\alpha}$$

The expression in (5.47) has a straightforward interpretation: an increase of θ – i.e. a higher productivity of labor in the R&D sector – has a positive effect on the growth rate of per capita income. The influence of L reflects the role of market size: the greater the labor force, the higher the FG sector's demand for intermediate goods, and the higher therefore firms' profits in the IG-sector. High profits, in turn, drive up the prices of blueprints and thus the incentive to engage in R&D. The interest rate, by contrast, has a negative effect, since it lowers the present value of future profits in the IG sector and thus reduces L^R.

V.4.3 Vertical Innovation, „Creative Destruction", and Growth

In the Romer model (1990), "horizontal innovation" raises the number of distinct intermediate goods and labor productivity. It is thus the increasing complexity and differentiation of the production process that potentially gives rise to the ongoing growth of GDP per capita.

Alternatively, we can interpret the growth process as the result of "vertical innovation". In this case, it is not the *number* of intermediate products, but their *quality* that increases over time, and that gives rise to endogenous growth. Such a mechanism can be described by using a framework that resembles the Romer model in many respects. Following Aghion and Howitt (2005), we specify the production function in the FG sector as follows:

$$(5.48) \qquad Y_t = \left(L^Y\right)^{1-\alpha} \sum_{j=1}^{m} \left(A_t^j\right)^{1-\alpha} \left(x_t^j\right)^{\alpha}$$

with m representing the (fixed) number of intermediate products. In every period t, the FG-firm uses the "best variant" of every intermediate product. This best variant is characterized by the highest productivity A_t^j. The variable A_t^j varies over time as a result of successful innovations, with the latter depending both on the resources devoted to R&D and on a stochastic component, i.e.

$$(5.49) \qquad A_t^j = \begin{cases} \gamma\, A_{t-1}^j & \text{with probability } \theta\, f\left(N_t^j\right) \\ A_{t-1}^j & \text{with probability } \left(1-\theta\, f\left(N_t^j\right)\right) \end{cases}$$

We assume that $\gamma > 1$, $\theta > 0$, $f' > 0$. The variable N_t^j represents the amount of final goods used for research and development in sector j. As in the Romer model, the incentive to devote resources to R&D activities whose outcome is stochastic depends on the perspective of reaping monopoly profits in the future: a successful innovator is able to produce the best variant of the intermediate product at a lower cost than his potential competitors.[19] More specifically, Aghion and Howitt (2005) assume that the average costs of an innovating firm are one unit of the final good, while a potential competitor has to incur average costs of $\chi > 1$. The innovating firm will thus charge a price of χ and reap the following profit in period t:

$$(5.50) \qquad \pi_t^j = \left(\chi - 1\right) x_t^j$$

The demand for the best variant of intermediate good j is determined by the condition that the marginal product of that good in the FG sector – i.e. the derivative of (5.48) with respect to x_t^j – has to equal its price χ. By combining the resulting expression with (5.50), we can derive the profit of a successfully innovating firm:

$$(5.51) \qquad \pi_t^j = \left(\chi - 1\right)\left(\frac{\alpha}{\chi}\right)^{\frac{1}{1-\alpha}} A_t^j\, L^Y$$

[19] Note, however, that such an advantage only exists for one period. In the following period, there may be another firm that manages to come up with the best variant. Hence, unlike in the Romer model (1990), innovation does not guarantee a monopoly rent for the entire future.

The optimal amount of resources devoted to R&D is implicitly defined by the condition that the increase of expected profits from marginally raising N_t^j equals one, the price of the final good that is used in R&D. To explicitly derive this optimum, Aghion and Howitt (2005) choose the following specification for the „innovation function“ f:

$$f\left(N_t^j\right)=\sqrt{\frac{2\,N_t^j}{\gamma\,A_{t-1}^j}} \tag{5.52}$$

This function increases in N_t^j, but it decreases in $\gamma\,A_{t-1}^j$. That is, the better the version of good j in period t-1, the higher the amount of resources that is required to be successful.[20]

Using the optimality conditions mentioned above, we can compute the expected productivity increase in industry j. In a symmetric equilibrium, this value is the same across industries, which defines the average growth rate of per capita income:[21]

$$g=\theta^2\left(\chi-1\right)\left(\frac{\chi}{\alpha}\right)^{\frac{1}{\alpha-1}}\left(L^Y\right)\left(\gamma-1\right) \tag{5.53}$$

This expression can be used to identify the determinants of long-run growth: what matters is, of course, the productivity of the R&D sector as represented by the parameter θ, and the extent of productivity gains associated with successful innovation $\left(\gamma\right)$. Moreover, the profits rewarding a successful innovation are important. In the model of Aghion and Howitt (2005) this aspect is represented by the difference $\chi-1$.[22] And finally, the average growth rate is proportional to the labor force L^Y. Once more, this result reflects the fact that market size determines the size of profits and thus the incentive to innovate.

Many of these results are reminiscent of the Romer model (1990). Both approaches highlight the prominent role of innovating firms' (temporary) monopoly position for the growth process. However, there are also important differences between the frameworks. As emphasized by Aghion and Howitt (2005), an acceleration of growth in a model of vertical innovation results in a shorter lifetime of firms. This sheds light on the potential for conflict that exists in a model of "creative destruction": if incumbent companies' profits are annihilated

[20] Aghion and Howitt (2005: 72) label this relationship the "fishing-out-effect".
[21] The appendix of this chapter explains how to derive this expression.
[22] The growth rate g increases in χ if $\chi<1/\alpha$. We have implicitly assumed that this condition is satisfied since a successful innovator would otherwise charge the monopoly price $1/\alpha$ instead of χ.

by innovating firms, the former have an incentive to reduce the speed of innovation, e.g. by calling for barriers to market entry.[23]

Box 5.4 further develops this argument and shows that the institutional environment – i.e. the quality of public regulation and the reliability of the legal system, but also the extent of corruption and the security of property rights – has an important influence on income and growth.

Box 5.4: Institutions and Prosperity

For many strands of growth theory, the incentive to save and invest plays an important role: in the Solow model, a low saving rate reduces per-capita income, and in the AK model it even lowers the long-run growth rate. In the models of Romer (1990) as well as Aghion and Howitt (2005), the perspective to earn future profits as a reward for current expenses is of crucial importance for firms' efforts to innovate.

An unfavorable political or institutional environment, where property rights are ill-defined or ill-defended, lowers expected returns and is therefore likely to reduce income and welfare. The scatterplot in Figure B5.4 documents that this conjecture is supported by empirical evidence: the horizontal axis shows a measure that reflects the ***quality of institutions*** in the year 2012 for a broad sample of countries. This measure is an average of six indicators that have been developed by Kaufmann et al. (2007), and that are published by the World Bank. The individual indicators assess the quality of institutions according to different criteria, covering the control of corruption, government effectiveness, political stability and absence of violence/terrorism, overall regulatory quality, the rule of law as well as voice and accountability. They are defined on a scale between -2.5 and 2.5, with higher numbers indicating a more favorable institutional environment. Apparently, the average of the indicators is positively correlated with the logarithm of countries' per capita income in the year 2012. Of course, in order to interpret this correlation as a causal effect, one has to make sure that Figure B5.4 is not just driven by the fact that more prosperous countries can afford better institutions. This problem of identification is still the topic of an intensive scientific debate. In an important survey article published in 2005, Daron Acemoglu, Simon Johnson and James Robinson summarize the empirical evidence arguing that causality runs from the quality of institutions to economic prosperity. However, as with most important economic questions, it is unlikely that their contribution has put a definite end to the discussion.

[23] These mechanics are analyzed in Parente and Prescott (2002).

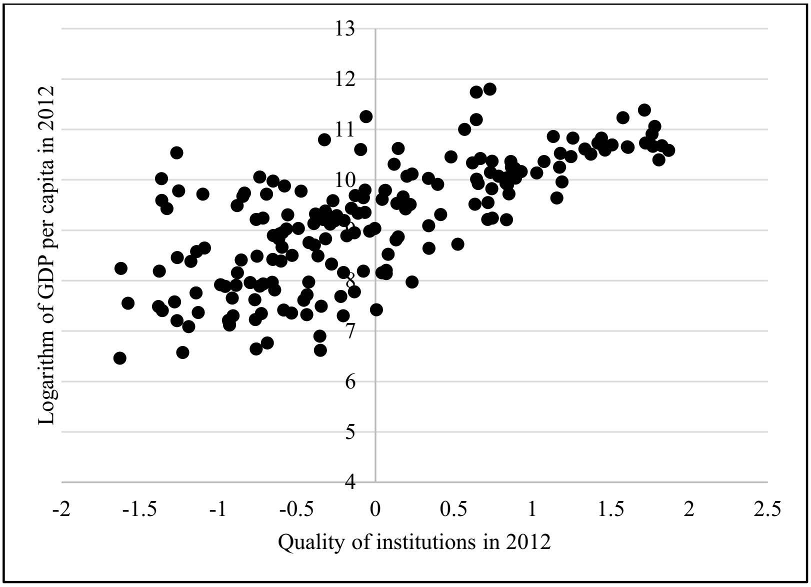

Figure B5.4: The quality of institutions and per capita income in 2012. The quality of institutions is the average of the WGI indicators on the control of corruption, government effectiveness, political stability and absence of violence/terrorism, regulatory quality, rule of law as well as voice and accountability. The data on GDP per capita are in international dollars. Sources: World Bank (Worldwide Governance Indicators and World Development Indicators).

V.4.4 Endogenous Technological Change in Open Economies

What are the consequences of moving from autarky to free trade in an economy in which endogenous technological change is driven by the forces described above? The answer to this question depends on the resulting change of the interest rate, but also on how free trade affects the market structure and the extent of international technology spillovers.

We consider the effects of integrating the goods and financial markets of two economies that are described by the Romer model (1990). For the time being, we assume that integration does not result in redundancies, i.e. there is no intermediate product that is produced in both countries. In such an environment, the following effects are at work: possibly, financial integration changes the interest rate, which affects the present value of future profits, the incentive for research and development, and thus the growth rate. Moreover, the trade-induced expansion of market size raises profits of IG-firms and thus the marginal value product of labor in the R&D sector. At the same time, the higher number of available intermediate goods raises the productivity of labor in the FG sector. In order to show that, in the Romer model (1990), the two effects cancel each other out, we use a modified version of equation (5.46):

$$\begin{aligned}(5.54)\qquad &\left(\frac{1}{r}\right)^{\frac{1}{1-\alpha}}(1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}}\left(L^{Y,H}+L^{Y,F}\right)\theta\, A_t^H\\ &=(1-\alpha)\left(A_t^H+A_t^F\right)\left(\frac{\alpha^2}{r}\right)^{\frac{\alpha}{1-\alpha}}\end{aligned}$$

The larger market size, which results in higher demand and greater profits, is represented by the term $\left(L^{Y,H}+L^{Y,F}\right)$ on the left-hand side. On the right-hand side, the higher wage in the R&D sector is matched by a higher wage in the FG-sector, whose increase is driven by productivity increases due to a greater number of intermediate products. If $L^{Y,F}=\phi\, L^{Y,H}$ and $A_t^F=\phi\, A_t^H$ with $\phi>0$, equation (5.54) coincides with the no-arbitrage condition for the labor market in a closed economy, as given by (5.46). This implies that an expansion of market size and a rising variety of intermediate products increases the *income levels* of both economies, but not the long-run growth rate of the countries' per capita incomes.

This changes if we allow for ***international technology spillovers***, such that the productivity of labor in the R&D sector not only depends on product variety in the home country, but also – at least partially – on product variety abroad, i.e.

$$(5.55)\qquad A_{t+1}^H-A_t^H=\theta\left(A_t^H+A_t^F\right)L_t^{R,H}$$

In this case, opening up the economy has an unambiguously positive effect on the growth rate. This is due to an indirect effect on the production function in the R&D sector as given by (5.38) and to the greater employment in this sector.

The consequences of goods and capital market integration for economic growth are less clear-cut once we drop the assumption that every IG-firm keeps its monopoly position under free trade. Since the perspective of future profits is the key reason for a firm to spend resources on R&D, the incentive to innovate decreases once competition intensifies. More specifically, a decline of profits in the model above results in a declining price of blueprints. The lower marginal value product of labor in the R&D sector reduces L^R and thus the growth rate.

The (static) welfare gains that are usually associated with opening up an economy for international trade may thus be dampened by negative effects on growth. However, Aghion und Howitt (2006) point out that this argument neglects the possibility that incumbent firms do not engage in innovation *despite*, but *because of* intensifying competition. In a model with vertical innovation, the incentive to strive for quality improvements peters out once a firm achieves permanent market dominance. By contrast, if domestic firms are exposed to international competition, they have an interest to stabilize their technological advantage through innovation. By fostering this ***escape-entry-effect***, free trade can enhance innovative activities and thus economic growth.

Finally, opening up an economy for trade may reduce economic growth if country-specific FG sectors differ in the intensity at which they make use of innovative intermediate products. In an important contribution, Gene Grossman and Elhanan Helpman (1991) distinguish between a „high technology sector", which relies on intermediate products, and a „low technology sector", which only employs labor. If technology spillovers are purely *intra*national, free trade can induce a country to specialize in the "wrong sector". This reduces the speed of innovation, and the backward technology level reinforces the pattern of – harmful! – specialization. If, by contrast, there are *inter*national technology spillovers, such that the home country benefits from foreign innovations, this situation does not occur.

V.4.5 Innovation and Imitation

In the models of Romer (1990) as well as Aghion and Howitt (2005), technological progress is driven by the innovations of profit-maximizing firms, and there may be a diffusion of knowledge across national borders. However, the mechanics of such a technology diffusion are not analyzed in detail. A simple model of this process is based on the assumption that firms devote resources either to the exploration and development of completely new products, or to the ***imitation*** and ***implementation*** of existing technologies. In their analysis, Aghion and Howitt (2006) start by defining the ***global technology frontier*** $\overline{A}_t$. Through imitation, a country i approaches this frontier, i.e.

$$A_{t+1}^i - A_t^i = \overline{A}_t - A_t^i \tag{5.56}$$

Alternatively, firms can devote resources to innovation in order to *change* existing technologies and to contribute to a *shift* of the global technology frontier. In this case, we have

$$A_{t+1}^i - A_t^i = \left(\gamma - 1\right) A_t^i \ , \tag{5.57}$$

with $\gamma > 1$. If we denote the (exogenous) frequency of innovations in a country by μ_n and the (exogenous) frequency of imitations by μ_m, the growth rate of the technology level in country i can be written as

$$(5.58)\qquad \frac{A_{t+1}^i - A_t^i}{A_t^i} = \mu_n\left(\gamma - 1\right) + \mu_m\left(\frac{\overline{A}_t}{A_t^i} - 1\right)$$

This result has an important implication: the higher the ratio $\left(\overline{A}_t / A_t^i\right)$ – i.e. the more backward the technology level in country i relative to the global technology frontier at time t – the more effective imitation is relative to innovation. As emphasized by Aghion and Howitt (2006), this "advantage of backwardness" is important for the design of institutions that are conducive to economic growth: countries that are far away from the technology frontier benefit from concentrating on the implementation of existing technologies – a strategy that contributed to rapid growth in Asian economies in the second half of the 20th century. Countries and regions that have caught up with the global technology frontier – e.g. the economies in Europe – are likely to achieve higher growth rates if they move from imitation to innovation.

V.4.6 Globalization and Growth: Empirical Evidence

The past sections have brought forward several theoretical arguments suggesting that opening up goods and capital markets enhances economic growth – in particular, in developing and emerging countries. While there is quite strong evidence that trade openness is beneficial for growth[24], it is a challenge to identify the *growth effects of financial integration*. This is one of the main results of a study published by M. Ayhan Köse, Eswar Prasad, Kenneth Rogoff and Shang-Jin Wei in 2009. The authors start by arguing that observed capital flows provide a much more reliable picture of a country's true integration into international financial markets than information about administrative barriers to international investment etc. Based on this argument, they use the sum of external assets and liabilities relative to GDP as a measure of ***financial globalization***. The average value of this measure between 1985 and 2004 is then related to countries' average growth rates during that interval.

Figure 5.8 repeats the exercise, using data from 1985 to 2010. As in Köse et al. (2009), the result is rather sobering: being integrated into the global capital market does not seem to be correlated with rapid economic growth. This result holds even if one controls for other potential growth determinants.

[24] See Baldwin (2004), Winters (2004), Noguer and Siscart (2005), Wacziarg and Welch (2008), but also Rodriguez and Rodrik (2001) for a critical view.

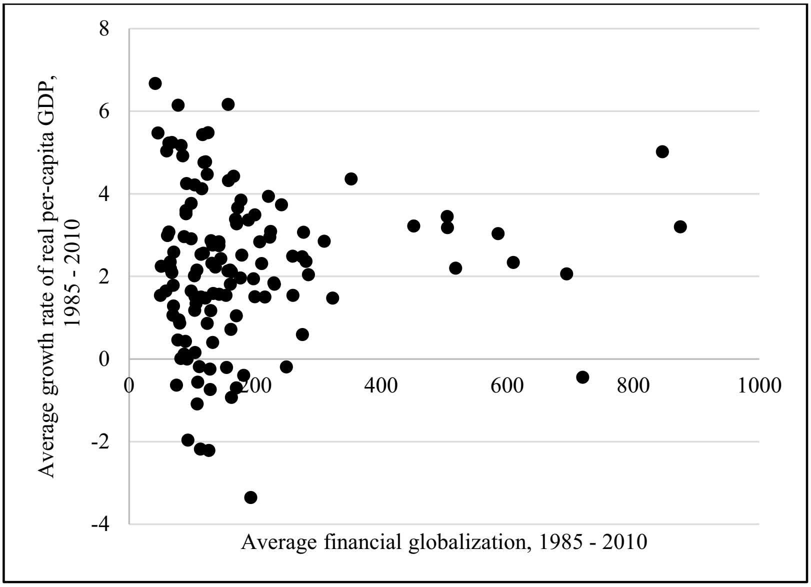

Figure 5.8: Average degree of financial globalization (international assets and liabilities relative to GDP, averages for 1985 – 2010) and average growth rates of real per capita income between 1985 and 2010 (in percent). As in Köse et al. (2009) we omit countries with an extremely high degree of financial globalization (e.g. Hongkong or Luxembourg). Sources: Updated and extended version of dataset constructed by Lane and Milesi-Ferretti (2007) and Penn World Table 8.1, series rgdpo (see Feenstra et al., 2015).

Of course, there are several possible objections to this result. For example, one can criticize the measure of financial integration used by the authors or the time interval considered. Thus, Henry (2007) emphasizes that, according to the neoclassical growth model, the dismantling of investment barriers affects the *level* of a country's capital stock and per capita income, but not its *long-run growth rate*. Hence, the empirical results are not necessarily in contrast with the model's predictions. Two further arguments are brought forward by Köse et al. (2009): first, the relationship between financial integration and growth does not have to be linear. It is quite plausible that there are certain minimal requirements with respect to the institutional and political environment that have to be met for financial globalization to unfold its beneficial effect on growth. Moreover, there are signs that being integrated into the international capital market is associated with ***collateral benefits***, e.g. a more rapid development of the financial sector, but also better economic policies. Since these effects take time to materialize, it is no surprise that it is hard to find a clear relationship over the rather short time span of twenty years.

A more pessimistic view is brought forward by Dani Rodrik and Arvind Subramanian (2009) who argue that the true problem of most developing countries is an *investment constraint* rather than a *savings constraint* – i.e. it is not the lack of available financial resources that holds back growth, but the lack of profitable investment opportunities. To make matters worse, financial integration may turn out to be detrimental for investment activities and capital accumulation since, by raising price and wage levels, it may reduce the international competitiveness of domestic firms.[25]

A general conclusion which emerges from this literature is that an overly aggregate view on the relationship between financial globalization and macroeconomic performance is unlikely to deliver any meaningful results: different types of capital flows differ in their risk properties, their impact on firms' productivity and their vulnerability to exogenous shocks. Moreover – and as argued by Köse et al. (2009) – the impact of these flows on macroeconomic performance depends on the recipient country's institutional environment. In particular, the structure of the banking system, and the extent and quality of financial market regulation etc. make a huge difference. Hence, while the excitement about the benefits of financial globalization that dominated the 1990s has given way to a much more sober and critical view – intensified, in particular, by the disastrous experience of the financial crisis of 2008/2009, which highlighted the perils of international financial linkages – it would be equally misguided to completely abandon the view that an integrated international capital market can bring about a more efficient and beneficial allocation of resources.

V.5 Summary and Outlook

In this chapter, we presented some canonical models of economic growth, starting with the neoclassical model that emphasizes the importance of capital accumulation, and continuing with models of endogenous growth that explain the steady increase of per capita incomes without relying on exogenous technological progress. While our initial presentation of these models always focused on a closed economy, we then explored the effects of international financial inte-

[25] More specifically, Rodrik and Subramanian (2009) argue that capital inflows are likely to result in a real appreciation of the domestic currency, which eventually reduces a country's net exports. In Chapter VII, we will consider the real exchange rate in more detail.

gration. Most theories suggest that a removal of investment barriers is potentially growth-enhancing – be it because it accelerates capital accumulation, be it because it supports the international transfer of technological knowledge. However, these optimistic theoretical predictions meet rather sobering empirical evidence: international capital flows to those countries who need them most urgently seem to be much lower than predicted. Moreover, the empirical relationship between financial integration and growth is weak, at best.

In order to understand this discrepancy between theory and empirical evidence, it is necessary to drop the assumption of a perfect international capital market. Recent history abounds with examples where phases of rapidly increasing capital inflows ended in financial crises and serious economic downturns. The potential occurrence of such crises explains why financial integration is by no means a sufficient condition for higher long-run growth. Moreover, financial vulnerability raises foreign investors' reluctance to engage in an economy and shapes the structure of countries' external liabilities. Against this background, the following chapter will take a first step towards exploring the determinants of financial crises, and it will analyze how such insights can help to assess the sustainability of observed current-account deficits.

V.6 Keywords

AK-model
Allocation puzzle
Conditional convergence
Creative destruction
Endogenous growth
External effect
Horizontal innovation
Human capital
International spillovers
Learning by doing
Lucas puzzle
Neoclassical growth model
Phase diagram
Quality of institutions
Research and development
Scale effect
Solow-Swan model
Steady state
Technological progress
Vertical innovation

V.7 Literature

Jones and Vollrath (2013) offer an excellent introduction to the theory and empirics of economic growth. A more technical approach is adopted in the graduate textbooks of Aghion and Howitt (1999), Barro and Sala-i-Martin (2003) as well as Acemoglu (2009). The current state of knowledge on individual aspects of economic growth is surveyed in the recent volumes of the Handbook of Economic Growth (Aghion und Durlauf, 2005 and 2014). Coeurdacier and Rey (2015) explore the medium and long-run consequences of financial integration in a model that accounts for the effect on both returns and risk. Köse et al. (2010) review the relationship between financial globalization, economic policies, and macroeconomic performance. Bumann et al. (2013) perform a meta-analysis of studies that analyze the relationship between financial liberalization and economic growth.

V.8 Exercises

5.1. Poverty traps. We adopt the structure of the Solow model in Subsection V.2.2. However, we assume that the technology parameter A is constant, and that individuals have to realize a minimal (subsistence) level of consumption $\tilde{c}$. As a consequence, savings are given by the following function:

$$S = \begin{cases} s\left[Y-\tilde{c}\,L\right] & \text{if } Y>\tilde{c}\,L \\ 0 & \text{if } Y\leq\tilde{c}\,L \end{cases}$$

a) Provide an economic interpretation of this function.
b) Use a graph to show that such a saving function can result in multiple steady states.
c) How does the initial level affect the subsequent time path of the capital stock? Provide an economic interpretation.
d) Identify measures that could help an economy to escape from a "poverty trap", i.e. a vicious circle of low income, low savings, and low growth.

5.2. Distributional and growth effects of international investment. We consider a world that consists of two countries, H and F . Omitting time subscripts we write the production function of country H as $Y^H=\left(K^H\right)^\alpha\left(L^H\right)^{1-\alpha}$, and the production function of country F as $Y^F=\left(K^F\right)^\alpha\left(L^F\right)^{1-\alpha}$. For simplicity, we assume that the saving rate, the rate of depreciation and the population growth rate are zero in both countries. The initial capital stock per capita in country c $\left(c=H,F\right)$ is given by $k^c=K^c\,/\,L^c$, with $k^H>k^F$.

a) Which country has the higher per capita income in the initial situation? In which country does (physical) capital have the higher marginal productivity?

b) What are the consequences of removing barriers to international investment if we assume that the international capital market functions perfectly?
c) What are the consequences of removing barriers to international investment
…for the returns to capital in the two countries?
…for real wages in the two countries?
d) Show analytically that, after a removal of barriers to international investment, global per capita income is higher than before.

5.3. Human capital and endogenous growth. A country's aggregate production function is given by $Y_t = K_t^{\alpha}\left(H_t L_t\right)^{1-\alpha}$, with H_t representing the aggregate stock of „human capital" in period *t*. We assume that $H_t = \gamma Y_t$ with $\gamma > 0$.

a) Show that this aggregate production function is not characterized by a diminishing marginal productivity of physical capital.
b) Provide an interpretation for this relationship.

5.4. Government spending and endogenous growth. In Box 5.3, we have shown that productive government spending can generate endogenous growth. Does this imply that growth is the higher, the higher the tax rate τ? What additional effects do you have to take into account to answer this question?

5.5. Are the gains from international financial integration elusive? In a seminal paper, Pierre-Olivier Gourinchas and Olivier Jeanne (2006) use a variant of the infinite-horizon neoclassical growth model to argue that a move from financial autarky to financial integration results in rather scant welfare gains, which are equivalent to a permanent one percent (!) increase of consumption. Compare the growth process in a closed-economy version of this model to the evolution of a financially open economy to intuitively grasp the essence of the Gourinchas/Jeanne idea. Try to come up with counter-arguments.

V.9 Appendix

V.9.1 Deriving the Average Growth Rate in the Aghion-Howitt Model of Vertical Innovation

In order to derive the average growth rate shown in (5.53), we start by defining the expected productivity growth associated with the emergence of a better variant of intermediate good *j*. Using (5.49) and (5.52), we can show that this is given by

(A5.1) $$\mathrm{E}\left(\frac{A_t^j - A_{t-1}^j}{A_{t-1}^j}\right) = (\gamma - 1)\,\theta\sqrt{\frac{2\,N_t^j}{\gamma\,A_{t-1}^j}}$$

To determine the amount of resources devoted to innovation, we combine (5.51) and (5.52) and write down the expected profit of an innovating firm:

(A5.2) $$\mathrm{E}\left(\pi_t^j\right) = \theta\sqrt{\frac{2\,N_t^j}{\gamma\,A_{t-1}^j}}\,(\chi - 1)\left(\frac{\alpha}{\chi}\right)^{\frac{1}{1-\alpha}} A_t^j\, L^Y - N_t^j$$

Setting the derivative with respect to N_t^j equal to zero and re-arranging terms yields

(A5.3) $$\theta\sqrt{\frac{2\,N_t^j}{\gamma\,A_{t-1}^j}} = \theta^2\,\frac{A_t^j}{A_{t-1}^j}\,\frac{\chi - 1}{\gamma}\left(\frac{\alpha}{\chi}\right)^{\frac{1}{1-\alpha}} L^Y$$

Noting that $A_t^j / A_{t-1}^j = \gamma$ and combining (A5.3) with (A5.1) yields the expression on the right-hand side of (5.53). This is the expected growth rate of productivity that is associated with an improving quality of intermediate good *j*. Due to the symmetry built into the model, this is also the average growth rate of the entire economy.