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Publication Date:
2004

Permanent Link:
https://doi.org/10.3929/ethz-a-004784407

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Working Paper 04/32
April 2004

Economics Working Paper Series

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

The Dynamics of Economic Integration: Theory and Policy[§]

forthcoming in: *International Economics and Economic Policy*

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April 2004

Integration affects economic growth mainly through two different channels: The scale-effect channel and the factor-reallocation channel. In order to investigate both channels within a unifying framework, we employ a simple descriptive growth model. The scale-effect channel increases either the long-run growth rate or the level of the balanced growth path. The factor-reallocation channel is ambiguous. It is shown under which conditions this mechanism induces either a rise or a fall in the long-run growth rate. In addition, a number of policy conclusions are drawn.

Keywords: International trade; economic integration; economic growth; scale effects; factor reallocation

JEL Classification: F1 (Trade); O4 (Economic Growth)

[§]For helpful comments and suggestions we would like to thank Hannes Egli, Karen Pittel, Werner Röger and Sjak Smulders.

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1 Introduction

The issue of economic integration is high on the political agenda. Examples of formal processes of economic integration comprise the formation of the European Union (EU), the current enlargement of the EU by Eastern European countries, the North American Free Trade Agreement (NAFTA), the attempt to establish a Free Trade Area of the Americas (FTAA) and the Association of South East Asian Nations (ASEAN). Beside these regional integration processes, there is the tendency of global economic integration driven by the World Trade Organization (WTO). In addition, there is substantial informal integration which is due to technological progress in the transportation and communication sector.

Economic integration affects the participating economies in different ways. On the one hand, there are effects on the static allocation and hence direct effects on the income level. This aspect has been dealt with in the international trade literature. On the other hand, it is important to understand the dynamic implications of economic integration. This aspect was largely neglected for a long time but has recently experienced renewed attention in the wake of endogenous growth theory. In the meantime, there is a substantial literature dealing with the dynamic consequences of international trade on economic growth (e.g. Rivera-Batiz and Romer, 1991; Grossman and Helpman, 1991; Baldwin and Forslid, 2000). According to this literature, there are basically two major mechanisms through which economic integration affects the long-run evolution of an economy. First, we observe a "scale-effect channel" which relies on positive spill-over effects and increases the growth rate of the integrated economic area either permanently or temporarily. Second, there is a "factor-reallocation channel" which affects the share of resources allocated to the dynamic sector(s) of the economy and hence changes the growth rate. The models which underlie this strand of research are diverse and often quite complex. The paper at hand offers a concise survey of this literature. This is achieved by employing a simple descriptive growth model, which is used as a unifying framework.

The results of the empirical literature on the trade-growth nexus are mixed. Edwards (1998) and Dollar (1992) find evidence for a positive impact of international trade on growth. Concerning the European integration, Henrekson et al. (1997) find positive dynamic effects, while Vanhoudt (1999) rejects a positive impact on the growth rate. Badinger (2001) argues that the European integration has unfold a significant temporary growth effect. A more recent study which reports mixed evidence on the openness-growth relationship is Vamvadakis (2002).[1] We will argue that these ambiguous results are by no means surprising. According to our theoretical approach, they are explained by the fact that the two channels include different dynamic effects which can offset each other.

The rest of the paper is organized as follows. In Section 2, a simple descriptive growth model is set up. The scale-effect channel of economic integration on long-run growth is discussed in Section 3. In Section 4, the factor-reallocation channel is investigated. Finally, Section 5 provides a number of conclusions and some policy implications.

2 A descriptive growth model

In order to analyze the dynamic consequences of economic integration, we set up a descriptive growth model. The model is "descriptive" in the sense that we do not explicitly investigate the intertemporal consumption trade-off and consequently do not analyze the determinants behind resource allocation decisions. Instead, we simply assume that preferences and technology are such that the representative agent wishes to allocate a positive amount of resources to the dynamic sector. This is equivalent to saying that the growth condition is satisfied (i.e. the net marginal product of accumulable resource exceeds the time preference rate). In addition, we focus on the balanced growth equilibrium implying that the relative size of the consumption and the dynamic sector is constant. This framework allows us to analyze the major consequences of economic integration on long-run growth within a unifying framework.

The basic set-up is described by the following set of equations:

$$\dot{X} = b\ Z\ M_X^{1-\gamma}\ X_X^{\gamma} \tag{1}$$

$$Z = X^{\eta} \tag{2}$$

$$M_X = M - M_C \tag{3}$$

$$X_X = X - X_C, \tag{4}$$

where X denotes an accumulable resource (physical capital, technological knowledge, human capital), $\dot{X}$ the rate of change of X during a short period of time dt, M the amount of a primary resource (raw labor, land), X_X the amount of X allocated to the production of X, M_X the amount of M

[1] Baldwin (2000) provides a survey of the empirical literature on openess and growth.

allocated to the production of X and M_C the amount of M allocated to the production of consumption goods.[1] Both M_X and X_X denote private inputs. In equation (1), Z denotes a public input (technological knowledge or public infrastructure) as determined by equation (2). This equation represents either a spill-over relation or may be interpreted as the provision of a taxed-financed public good. Finally, $b > 0$ is a constant technology parameter, γ ($0 \leq \gamma \leq 1$) the elasticity of X in X-production, $1 - \gamma$ the elasticity of M in X-production and $\eta \geq 0$ gives the intensity of the spill-over effect.

Equation (1) should be interpreted as a description of the dynamic sector of the economy. The "dynamic sector" is defined by the following properties. The growth rate of the accumulable resource produced by this sector pins down the growth rate of output. Moreover, a constant growth rate of this accumulable resource is usually achieved by holding the share of the private resources allocated to this sector constant. Hence, a constant share of the private inputs allocated to the dynamic sector leads to a constant growth rate of output.[2]

This formulation captures a large number of endogenous growth models. Specific examples of growth models which fit into this structure are Romer (1986), where X denotes physical capital and Z "knowledge" and Barro (1990) with X denoting physical capital and Z public infrastructure provided by the government. In addition, there is a number of two-sector growth models which can be represented by this framework. For instance, in Romer (1990) and Grossman and Helpman (1991, Chapter 3), X represents "technology" (measured by the number of blueprints), γ is equal to zero and Z denotes technological knowledge (or knowledge capital). Similarly, in Jones (1995) X represents "technology" ($\gamma = 0$) and Z is technological knowledge but the spill-over effect is restricted by $\eta < 1$ and, in addition, we have $g_M > 0$.[3] In Lucas (1988), X is (average) human capital while $\gamma = 1$ and $\eta = 0$.[4]

[1] In Section 4 we extend the basic framework to two consumption goods and two primary input factors.

[2] Moreover, for two-sector R&D-based growth models, Eicher and Turnovsky (1999, proposition 5) show that the long-run growth rate is exclusively determined by the structural characteristics of the sector which is not restricted to possess constant returns to scale in endogenous (private and public) resources.

[3] Eicher and Turnovsky (1999, Section 3) generalize the Jones (1995) model in that physical capital is allowed to be productive in R&D (labelled the "hybrid model").

[4] Since $\gamma = 1$, M does not enter the production function of the dynamic sector and consequently there is no scale effect in this model. The scale effect will be discussed extensively below.

The growth rate of X can be readily derived from (1), (2), (3) and (4) to read as follows:

$$g_X := \frac{\dot{X}}{X} = b \left(\frac{M_X}{M}\right)^{1-\gamma} M^{1-\gamma} \left(\frac{X_X}{X}\right)^{\gamma} X^{\eta+\gamma-1} \tag{5}$$

Holding M constant, equation (5) shows that growth of X (and hence the growth rate of output) ceases in the long run provided that $\eta + \gamma < 1$. In this case, the growth rate g_X decreases with X and hence any growth of X must lead to lower and lower growth rates. This holds true for the neoclassical growth model (e.g. Solow, 1956 and Koopmans, 1965), where $\eta = 0$ and $\gamma < 0$. If we relax the assumption according to which M must be constant, then long-run growth may be compatible with $\eta + \gamma < 1$. Indeed, Jones (1995) assumes $\gamma = 0$, $\eta < 1$ and $g_M > 0$ such that per capita income growth is positive.[5] Finally, it should be noticed that with $g_M = 0$ sustained growth requires $\eta + \gamma \geq 1$, where only $\eta + \gamma = 1$ leads to balanced growth and $\eta + \gamma > 1$ would imply a continuous acceleration of growth (Romer, 1986).

As has been already stated above, we focus on balanced growth paths with constant rates of growth. Hence, we assume that the allocation shares $\frac{M_X}{M}$ and $\frac{X_X}{X}$ are constant. Considering the conditions for a balanced growth path, two cases must be distinguished: (i) $g_M = 0$ and (ii) $g_M > 0$.

The case $g_M = 0$ requires $\eta + \gamma = 1$ for balanced growth to be feasible. In this case, equation (5) immediately gives the long-run growth rate of the economy under study as:

$$g_X = b \left(\frac{M_X}{M}\right)^{1-\gamma} M^{1-\gamma} \left(\frac{X_X}{X}\right)^{\gamma}. \tag{6}$$

Let us now turn to the second case, which is characterized by $g_M > 0$. For a balanced growth path to be feasible, the restriction $\eta+\gamma < 1$ must hold; in this case we have a so-called "semi-endogenous" growth model (Jones, 1995). Logarithmic differentiation of equation (5) and noticing that the allocation shares $\frac{M_X}{M}$ and $\frac{X_X}{X}$ must be constant along any balanced growth path yields the balanced growth rate:

$$g_X = \frac{1-\gamma}{1-\eta-\gamma}\, g_M. \tag{7}$$

[5] In Smulders and van de Klundert (1995), X is (firm specific) technological knowledge and the spill-over depends on the average stock of knowledge. In this case, the growth rate does not show the scale effect implication. Similarly, Segerstrom (1998) eliminates the scale effect by employing a so-called "difficulty function", which indicates that additional innovations become more difficult as the stock of existing ideas rises.

Provided that there is only one accumulable resource, which is produced using the same technology as consumption, final output can be written as:

$$Y = \dot{X} + C = b\ Z\ M_X^{1-\gamma}\ X_X^{\gamma} + b\ Z\ M_C^{1-\gamma}\ X_C^{\gamma} = b\ M^{1-\gamma}\ X^{\gamma+\eta}, \tag{8}$$

and the growth rate of final output is, accordingly, given by:

$$g_Y = (1-\gamma)\ g_M + (\gamma+\eta)\ g_X. \tag{9}$$

Next, we compare the growth rates before integration (the growth rate under autarky) to the growth rate of the integrated economies (the growth rate under free trade). Specifically, to derive the dynamic impact of opening an economy to trade, we analyze the equilibrium obtained in a hypothetical "integrated world economy", see Dixit and Norman (1980, chapter 4). In this reference point, goods, factors and knowledge are assumed to be fully mobile. The decisive insight is to observe that the result for the integrated economy is reproduced through free goods trade under certain conditions. In general, these conditions are that factor prices are equalized and preferences are internationally identical and homothetic. In the dynamic context, we have additionally to assume that Z in (1) and (2) is an international public good, see Grossman and Helpman (1991, p. 183). Then, the trading equilibrium replicates the integrated world equilibrium for our descriptive growth model, even when the input factors M and X are internationally immobile. This will be assumed throughout the paper. With Z as an international public good, growth rates are equal in all trading economies. The impact of trade and growth can thus simply be derived from comparing the growth rate under autarky to growth in the integrated world economy.

In the case of Z being a national public good, factor prices are not equalized; the same holds true for large international differences in factor endowments. In these cases, factors have an incentive to be internationally mobile. The dynamic effects of capital and labor mobility under these conditions are treated in Smulders (2004) and Bretschger (2001b), respectively. In general, Z can be viewed as (i) a national public good, which is available within the border of the economic area under study (usually within a state); (ii) an international public good, which is available within an integrated economy (a free trade area) and (iii) a global public good, which is available everywhere on the globe irrespective of any barriers.[6] In order to focus on

[6] Jones (2002) investigates an R&D-based growth model in which technological knowledge represents a global public good.

the two integration channels mentioned in the introduction, we will restrict the analysis to the second case.

Considering the determinants of the long-run growth rate on the right-hand side of equation (6) shows that economic integration may affect the long-run growth rate either via the size of the relevant economic area as measured by M or via the intersectoral allocation of resources as captured by $\frac{M_X}{M}$ and $\frac{X_X}{X}$. In what follows we will, accordingly, distinguish two channels through which economic integration influences long-run growth:

1. The scale-effect channel: The scale (size) of the integrated economic unit may affect the speed of long-run economic growth. We label this property the "first-order scale effect". In addition, it might be the case that the level of the balanced growth path increases with the size of the relevant economic unit. This property is denoted as "second-order scale effect".

2. The resource-reallocation channel: The share of resources allocated to the dynamic sector may be affected by economic integration. The specific role of the dynamic sector in the economy implies that this resource reallocation has an effect on the long-run rate of growth.

In what follows, we will investigate the different channels using the descriptive growth model set up above.

3 The scale-effect channel

Most applied reports on economic integration contain the proposition "bigger is better". This phrase expresses the view that there is a positive scale effect on long-run economic growth. In the following, this statement is qualified with the help of our approach.

In this section, we assume that the economies under study are perfectly identical, i.e. we impose symmetry. Each trading economy is assumed to be fully specialized in the production of a country-specific consumer good C. This simplifying assumption allow us to abstract from a change in relative prices and induced resource reallocations from the consumption goods sector to the dynamic sector (or vice versa). An appropriate interpretation is that the analysis mainly applies to the integration between similar countries. In the subsequent section we relax this assumption and extend the analysis of economic integration between unequal economies.

Let us at first consider the different scale effects implied by the general model set up in Section 2. The case $g_M = 0$ requires $\eta + \gamma = 1$ for balanced growth to be feasible and positive. In this case, equation (5) immediately gives the long-run growth rate of the economy under study as (restated for convenience):

$$g_X = b \left(\frac{M_X}{M} \right)^{1-\gamma} M^{1-\gamma} \left(\frac{X_X}{X} \right)^{\gamma}. \tag{10}$$

The scale effect is represented by the term $M^{1-\gamma}$ in equation (10). The larger the amount of the primary resource M, the higher is the long-run growth rate. We label this effect the first-order scale effect. Moreover, the right-hand side of equation (5) in Section 2 immediately points to the (necessary) conditions for a first-order scale effect. First, there is a primary input M (measuring the scale of the economy) which can be productively employed in the dynamic sector producing the accumulable resource X, i.e. $1-\gamma > 0$.[7] Second, as assumed in deriving equation (10), the productivity of the resource X in X-production (comprising private and/ or public effects) must be sufficiently large, i.e. $\eta + \gamma \geq 1$. Since we focus on balanced growth paths, we exclude the case $\eta + \gamma > 1$. In summary, the general set-up employed here points to two conditions which must hold for the presence of a first-order scale effect: (i) $1 - \gamma > 0$ and (ii) $\eta + \gamma = 1$.

The economic intuition behind the first-order scale effect is that a larger amount of the primary resource M enables an economy to produce more of the accumulable resource X. Moreover, the accumulation of X rises the productivity of the primary resource M. Provided that the impact of X on the productivity of M (which may occur either via positive spill-over effects or via private effects) is sufficiently large (i.e. $\eta + \gamma = 1$), this positive feedback mechanism generates a first-order scale effect. As a consequence, a rise in the size of the economy fosters long-run economic growth.

Let us turn to the second case, which is characterized by $g_M > 0$. For a balanced growth path to be feasible, the restriction $\eta + \gamma < 1$ must hold. In this case, the balanced growth is given by equation (7) (restated below):

$$g_X = \frac{1-\gamma}{1-\eta-\gamma}\, g_M.$$

Although the result displayed above does not imply what is usually labelled a scale effect (i.e. no first-order scale effect), there is nevertheless a

[7] This does not hold true for the Lucas (1988) model and, hence, this model is not spurred by the scale effect implication.

scale effect in the sense that the level of the balanced growth path is positively related to the size of the relevant economic area as measured by M. We label this effect the "second-order scale effect".[8] Even when the permanent growth rate of an economy is not affected by a first-order scale effect, welfare can increase considerably due to higher income levels.

We now analyze the dynamic consequences of economic integration by using the reference point of the integrated world economy as stated above. Consider k economies which are perfectly identical. This means that there is no incentive for international goods trade. The growth rate of every single economy under autarky is given by equation (10). In an integrated area comprising k economies, the output of the dynamic sector within a single economy (indexed by i) is given by:

$$\dot{X}_i = b\left(\frac{M_{X,i}}{M_i}\right)^{1-\gamma} M_i^{1-\gamma}\left(\frac{X_{X,i}}{X_i}\right)^{\gamma}\left(\sum_{i=1}^{k} X_i\right)^{\eta} X_i^{\gamma}. \tag{11}$$

Notice that with Z representing an international public good $Z_i = \left(\sum_{i=1}^{k} X_i\right)^{\eta}$ holds for each single country. By employing the symmetry assumption (i.e. $\sum_{i=1}^{k} X_i = kX$) and taking equation (10) into account, the growth rate of the world economy, that is the growth rate of each economy under integration, becomes:[9]

$$g_X^{int} = k^{\eta} g_X^{aut}. \tag{12}$$

According to (12), the integrated economy grows at a rate which is by a factor $k^{\eta} \geq 1$ larger than the growth rate under autarky. The reason behind this result lies neither in goods trade nor in the increased number of consumers but in the fact that an integrated economy can use the common pool of the public good, i.e. $Z_i = (kX)^{\eta}$. We thus have a first-order scale effect, the strength of which is given by the factor k^{η}. Obviously, the higher the number of economies joining an integration k and the larger the spill-over effect η, the stronger is the growth enhancing effect of economic integration.

On the other hand, assuming $\eta + \gamma < 1$ (as in the so-called "semi-endogenous growth models") there is a second-order scale effect.[10] This can

[8] Jones (2003) uses the expressions "weak" and "strong" scale effects.

[9] For details see the supplement to this paper, which is available at www.wif.ethz.ch/resec/people/tsteger/dyn_int_supplement.pdf.

[10] The expression semi-endogenous growth model refers to the fact that public policy is

be readily recognized by focusing on the growth rate of a single economy as given by equation (5), which is restated for convenience:

$$g_{X_i}^{aut} = b \left(\frac{M_{X_i}}{M_i}\right)^{1-\gamma} M_i^{1-\gamma} \left(\frac{X_{X_i}}{X_i}\right)^{\gamma} X_i^{\eta+\gamma-1}. \tag{13}$$

Provided that $\eta + \gamma < 1$ (i.e. in semi-endogenous growth models), we have to assume that $g_M > 0$ in order to explain sustained growth. Moreover, along a balanced growth path, the rate of growth of $M_i^{1-\gamma}$ must equal the rate of decay of $X_i^{\eta+\gamma-1}$ such that the right-hand side of equation (13) is constant. Assume now that such an economy joins an integration. The growth rate immediately after integration is given by:

$$g_{X_i}^{int} = b \left(\frac{M_{X_i}}{M_i}\right)^{1-\gamma} M_i^{1-\gamma} \left(\frac{X_{X_i}}{X_i}\right)^{\gamma} k^{\eta} {X_i}^{\eta+\gamma-1}. \tag{14}$$

Hence, immediately after joining the integration, we have the same result as for the endogenous growth model above, namely $g_X^{int} = k^{\eta} g_X^{aut}$. The expression exhibits that the growth rate initially jumps by the factor k^{η}. Moreover, equation (14) shows that an economic integration has the same effect as a positive and permanent shock to the productivity parameter b. However, since we have assumed that $\eta + \gamma < 1$, this increase in the growth rate is temporary. Assuming the population growth rate to be unaffected by integration, the economy converges to a new balanced growth path with the same long-run growth rate but grows at a higher level.

It has to be emphasized that this second-order scale effect may be very strong. More precisely, assume that $\eta + \gamma$ is only marginally smaller than unity. In this case, ${X_i}^{\eta+\gamma-1}$ vanishes very slowly over time and the growth rate remains above its pre-integration level for a long period of time.

At this stage, it is worth considering the empirical evidence on the scale effect. There are both time series and cross-sectional studies. Kremer (1993) argues that there is a positive scale effect at the level of the world when considering the very long run (one million B.C. until present). Jones (1995) argues that the number of scientists increased significantly in the U.S.A., while the growth rate of total factor productivity fell over the last 50 years.

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ineffective with respect to the long-run growth rate (Jones, 1995). However, there is also a generation of non-scale growth models which still bear the implication that public policy can affect long-run growth (e.g. Young, 1998; Peretto, 1998; Howitt, 1999).

Backus et al. (1992) conduct cross-sectional studies using different measures for the scale of an economy (e.g. aggregate GDP; manufacturing output; number of scientists, engineers and technicians; R&D expenditure) deriving mixed results. Overall, the evidence on the first-order scale effect is mixed.[11]

On the other hand, there is a clear empirical evidence in favor of second-order scale effects. Specifically, employing a dynamic growth accounting model advocated by Temple (1999), Badinger (2001) investigates the consequences of economic integration in Europe from 1950 until 2000 for economic growth. By distinguishing explicitly between global integration (the GATT process) and regional integration (the formation of the European Union) the author rejects a permanent growth effect of economic integration (first-order scale effect) but finds solid empirical support for a temporary growth effect (second-order scale effect): "*If no integration had taken place since 1950, GDP per capita of the EU would be approximately one fifth smaller today. In terms of growth this implies that without integration, the average growth rate per annum over the period 1950 to 2000 would have been lower by 0.4 percentage points. Our results suggest that the bulk of these effects (70 to 90 percent) can be traced back to increases in efficiency (technology-led growth), while integration-induced investment-led growth played only a rather small role.*" Badinger (2001, p. 26). It should be noticed that the stated reasoning is perfectly in line with the theory laid out above.

4 The factor-reallocation channel

4.1 Unequal economies

In the previous section, we have considered the dynamic consequences of economic integration of perfectly symmetric economies. The symmetry assumption allows to isolate the scale effect and to abstract from other channels, which may affect long-run growth. However, a number of important economic consequences of economic integration (or globalization) results from asymmetries between the economies under study. Differences in factor endowments induce a change in relative goods and factor prices. These price changes cause a myriad of factor substitutions associated with a process of intersectoral reallocation of resources. Specifically, consider two asymmetric economies that join an integration such that trade in goods is completely

[11] A comprehensive summary of the empirical evidence on the scale effect can be found in Jones (2003).

liberalized but factors are still immobile across international borders (this is the standard set-up considered in trade theory). As a consequence of trade in goods, relative goods prices change. According to the standard Heckscher-Ohlin theory of international trade, every economy specializes in the production of the good which uses the relatively abundant factor intensively. A shift in the composition of the demand for input factors in turn induces a change in relative factor prices. Finally, and most importantly, if the price of the factor used intensively in the dynamic sector changes, the induced process of factor reallocations affects the dynamic sector and hence long-run growth.

These mechanisms have been discussed in the literature on trade and growth (Grossman and Helpman, 1990; Grossman and Helpman, 1991, Chapter 4 and 5; Baldwin and Forslid, 2000). The underlying general equilibrium models are, however, quite complex since the analysis must deal with an endogenous growth model of an open economy producing two traded goods and employing two input factors. In what follows, we use the descriptive growth model set up above to study the determinants of factor reallocations and the resulting growth effects in response to economic integration.

We apply the method of Jones (1965) to analyze the determinants of factor reallocations from the consumption good sectors to the dynamic sector (or vice versa). On this occasion, we consider two consumption goods, which are labelled C and D and are produced in both countries. In order to apply the Jones (1965) procedure, we must have a model which is "static" in a technical sense, meaning that the economic structure along the balanced growth path can be described by a set of static equations. At the economic level, the model still describes a dynamic economy. This requirement is perfectly in line with our focus on the long-run consequences of economic integration. Therefore, we formulate the model in stationary variables, which are constant along the balanced growth path.

4.2 Basic factor-reallocation equation

In this section, the basic factor-reallocation equation is derived. The economic interpretation is then given in Section 4.3. The technically less interested reader may want to read this section less carefully; nonetheless, the basic set-up and the notation should be noticed.

With respect to output technologies we assume the following functional forms: $\dot{X} = bM_{1X}X$, $C = (\varepsilon_1 M_{1C}^{\frac{\sigma_c}{\sigma_c-1}} + \varepsilon_2 M_{2C}^{\frac{\sigma_c}{\sigma_c-1}})^{\frac{\alpha(\sigma_c-1)}{\sigma_c}} X^{1-\alpha}$ and $D =$

$(\varepsilon_1 M_{1D}^{\frac{\sigma_d}{\sigma_d-1}} + \varepsilon_2 M_{2D}^{\frac{\sigma_d}{\sigma_d-1}})^{\frac{\beta(\sigma_d-1)}{\sigma_d}} X^{1-\beta}$ with $0 \leq \varepsilon_1, \varepsilon_2, \alpha, \beta \leq 1$ and $\sigma_c, \sigma_d > 0$.[12] Since it is instructive to consider two types of private inputs, we distinguish between skilled labor M_1 and unskilled labor M_2, which are supplied in fixed quantities. The constant elasticity of substitution between M_1 and M_2 in C production is σ_c and in D production is σ_d. We define the following scale-adjusted variables $x := \frac{X}{\exp(g_X t)}$, $c := \frac{C}{\exp(g_C t)}$, $d := \frac{D}{\exp(g_D t)}$, where g_X, g_C, and g_D denote the long-run growth rate of the respective variable. By construction, the scale-adjusted variables (x, c, d) are constant along the balanced growth path. After conducting an appropriate adjustment of scale, we get the following system of equations (details are contained in the supplement to this paper):

$$g_X = bM_{1X} \tag{15}$$

$$c = (\varepsilon_1 M_{1C}^{\frac{\sigma_c}{\sigma_c-1}} + \varepsilon_2 M_{2C}^{\frac{\sigma_c}{\sigma_c-1}})^{\frac{\alpha(\sigma_c-1)}{\sigma_c}} x^{1-\alpha} \tag{16}$$

$$d = (\varepsilon_1 M_{1D}^{\frac{\sigma_d}{\sigma_d-1}} + \varepsilon_2 M_{2D}^{\frac{\sigma_d}{\sigma_d-1}})^{\frac{\beta(\sigma_d-1)}{\sigma_d}} x^{1-\beta}. \tag{17}$$

The economy under study can be considered to produce three "goods", i.e. the growth rate g_X (which pins down g_C and g_D), indicating the slope of the balanced growth path, and two tradeable consumption goods c and d, which yield the level of the balanced growth path (in terms of C and D). This set of equations captures the intertemporal consumption trade-off. The system of equations (15), (16) and (17) represents in fact a static system, which allows us to apply the methodology of Jones (1965) to conduct a convenient comparative static analysis.[13]

Once more, equation (15) indicates that the consequences of economic integration on the long-run growth rate must be due to permanent changes in the factor input M_{1X}. Hence, we focus on the determinants of a change in M_{1X} due to economic integration. Beside a change in the overall stock of M_1 (the scale effect), a change in the intersectoral allocation pattern affects M_{1X}. This factor-reallocation effect is governed by a change in the factor rewards of skilled labor w_1 and unskilled labor w_2, which can be calculated by again using the integrated world equilibrium.

By defining the input requirement for one unit of the respective output $a_{1j} := \frac{M_{1j}}{j}$ for $j = c, d, g_X$, one may state the economy's resource constraints

[12] To simplify matters, X is assumed to represent a public input. It could also represent a private input.

[13] Since we treat factor prices w_1 and w_2 as exogenous, the model under study should be considered as a partial equilibrium framework.

as follows:

$$M_1 = a_{1c}c + a_{1d}d + a_{1x}g_X \tag{18}$$

$$M_2 = a_{2c}c + a_{2d}d + a_{2x}g_X. \tag{19}$$

Expressing (18) in percentage terms yields:[14]

$$\widehat{M_1} = \lambda_{1c}(\widehat{a}_{1c} + \widehat{c}) + \lambda_{1d}(\widehat{a}_{1d} + \widehat{d}) + \lambda_{1x}(\widehat{a}_{1x} + \widehat{g}_X). \tag{20}$$

where λ_{1j} for $j = c, d, g_X$ denote factor shares, i.e. $\lambda_{1j} := \frac{a_{1j}\ j}{M_1} = \frac{M_{1j}}{M_1}$ for $j = c, d, g_X$. By noting that $\widehat{M}_{1x} = \widehat{a}_{1x} + \widehat{g}_X$ (resulting from $a_{1x} = \frac{M_{1x}}{g_X}$) and $\widehat{M_1} = 0$ (i.e. the economy-specific amount of skilled labor is assumed to be constant) it follows that the preceding equation can be expressed as (see mathematical supplement for details):

$$\widehat{M}_{1x} = -\frac{\lambda_{1c}}{\lambda_{1x}}(\widehat{a}_{1c} + \widehat{c}) - \frac{\lambda_{1d}}{\lambda_{1x}}(\widehat{a}_{1d} + \widehat{d}). \tag{21}$$

Equation (21) shows that the (proportional) change in M_{1X} results from factor reallocations between the dynamic sector and the consumption goods sectors. Specifically, the first term indicates a reallocation between the c-sector and the dynamic sector, while the second term points to reallocations between the d-sector the dynamic sector. Moreover, every reallocation effect comprises two components: The first component consists in a substitution effect as indicated by $\widehat{a}_{1c}$ and $\widehat{a}_{1d}$, whereas the second component represents an output effect as indicated by $\widehat{c}$ and $\widehat{d}$. We will now analyze the determinants behind the reallocation effect in more detail.

The first step is to express $\widehat{a}_{1c}$ ($\widehat{a}_{1d}$) and $\widehat{c}$ ($\widehat{d}$) in terms of exogenous variables. Let us start with $\widehat{a}_{1c}$ ($\widehat{a}_{1d}$). Minimization of unit cost ($a_{1c}w_1 + a_{2c}w_2$) yields $\widehat{a}_{1c}\theta_{1c} + \widehat{a}_{2c}\theta_{2c} = 0$ and hence we get $\widehat{a}_{2c} = -\frac{\theta_{1c}}{\theta_{2c}}\widehat{a}_{1c}$, where $\theta_{1c} := \frac{a_{1c}\ w_1}{p_c}$ and $\theta_{2c} := \frac{a_{2c}\ w_2}{p_c}$.[15] Moreover, the elasticities of substitution can be expressed as $\sigma_c := \frac{\widehat{a}_{1c} - \widehat{a}_{2c}}{\widehat{w}_2 - \widehat{w}_1}$ and $\sigma_d := \frac{\widehat{a}_{1d} - \widehat{a}_{2d}}{\widehat{w}_2 - \widehat{w}_1}$. Substituting $\widehat{a}_{2c}$ in $\sigma_c(\widehat{w}_2 - \widehat{w}_1) = \widehat{a}_{1c} - \widehat{a}_{2c}$ (resulting from the preceding definition) finally yields (the same reasoning applies to $\widehat{a}_{1d}$; see the appendix for details):

$$\widehat{a}_{1c} = -\theta_{2c}\sigma_c(\widehat{w}_1 - \widehat{w}_2) \tag{22}$$

$$\widehat{a}_{1d} = -\theta_{2d}\sigma_d(\widehat{w}_1 - \widehat{w}_2). \tag{23}$$

[14] This is achieved by totally differentiating equation (18).

[15] Minimization of unit cost is implied by profit maximization.

We now turn to $\widehat{c}$ ($\widehat{d}$). Under perfect competition in the final output sector (consumption goods sector), the following relation must hold: $p_c = a_{1c}w_1 + a_{2x}w_2$. Totally differentiating this equation (and dividing by p_c) one can readily derive:

$$\widehat{p}_c = \theta_{1c}\widehat{w}_1 + \theta_{2c}\widehat{w}_2 \tag{24}$$

From $p_c c = const.$, which holds due to the scale-adjustment, it follows that (the same reasoning applies to $\widehat{d}$):[16]

$$\widehat{c} = -\widehat{p}_c = -\theta_{1c}\widehat{w}_1 - \theta_{2c}\widehat{w}_2 \tag{25}$$

$$\widehat{d} = -\widehat{p}_d = -\theta_{1d}\widehat{w}_1 - \theta_{2d}\widehat{w}_2 \tag{26}$$

Choosing M_1 as the numeraire such that $w_1 = 1$ and $\widehat{w}_1 = 0$ and inserting equations (22), (23), (25) and (26) into (21) finally gives (see the supplement for details):

$$\widehat{M_{1x}} = -\sum_{j=c,d} \frac{\lambda_{1j}}{\lambda_{1x}}(\sigma_j - 1)\theta_{2j}\widehat{w}, \tag{27}$$

where $w := \frac{w_2}{w_1}$. Equation (27) decomposes a change in M_{1x} ($\widehat{M_{1x}}$) into two reallocation effects: the reallocation between the c-sector and the dynamic sector or between the d-sector and the dynamic sector.

4.3 Economic interpretation

We now discuss the economic intuition behind the basic factor-reallocation equation (27). We compare again the integrated world economy with the economy under autarky to obtain the effects of trade on long-run growth. To explain the basic mechanism, we assume that, as an example, w falls ($\widehat{w} < 0$) in the course of economic integration. The term $(\sigma_j - 1)$ for $j = c, d$ indicates that the direction of the reallocation depends critically on whether the elasticities of substitution in both consumption good sectors σ_j ($j = c, d$) are bigger or smaller than unity.[17] This is due to the fact that a decrease in w ($\widehat{w} < 0$) unfolds two effects with regard to M_{1j} ($j = c, d$) and hence with respect to M_{1x}. First, since consumption goods become less expensive (in relation to g_X) the demand for and the production of c and d rises.[18]

[16] We can consider the system in scale-adjusted variables as a description of a static economy. For such a "static economy", equilibrium is defined by the constancy of the endogenous variables; this, of course, also applies to p_c. Hence it follows that $p_c c = const.$

[17] In addition, notice that $\lambda_{1j}, \sigma_j, \theta_{1j}, \theta_{2j} \geq 0$ for $j = c, d, g_X$.

[18] Notice that a fall in w means that unskilled labor becomes cheaper compared to skilled labor. Moreover, since c and d use unskilled labor M_2 intensively, c and d become less expensive in relation to g_X.

This output effect increases the amount of M_1 allocated to the c-sector and the d-sector (i.e. M_{1c} and M_{1d} rise). Full employment then immediately implies that M_{1x} falls. In addition, a decrease in w induces a substitution of M_1 by M_2 in c-production and d-production. This substitution effect leads to a decrease in M_{1j} ($j = c, d$) and hence an increase in M_{1x}. The overall effect of a falling w on M_{1x}, therefore, depends on the size of the elasticities of substitution. More specifically, if $\sigma_j < 1$ ($j = c, d$), the output effect dominates the substitution effect and hence M_{1x} falls.

The analysis of the factor reallocation channel points to the fact that the Heckscher-Ohlin logic can be applied to the analysis of the long-run growth effects of economic integration. From the perspective of an economy which is relatively abundantly endowed with skilled labor, economic integration means that $w = \frac{w_2}{w_1}$ falls (unskilled labor becomes cheaper relative to skilled labor). This change in the relative factor price induces both an output effect (M_{1j} rises and M_{1x} falls) and a substitution effect (M_{1j} falls and M_{1x} rises). Provided that skilled and unskilled labor are poor substitutes in the consumption goods sector ($\sigma_j < 1$), the reallocation effect leads to a decrease in skilled labor allocated to the dynamic sector and, as a consequence, growth decreases as well.

Overall, the partial equilibrium framework employed above has demonstrated an important general result of the literature on endogenous growth and trade according to which international trade may reduce the growth rates of the economies involved (Grossman and Helpman, 1990).

In addition, this strand of the literature draws the conclusion that international trade leads to coincidence in growth rates. It should be noted that the growth rate coincidence in response to international trade critically relies on the assumption of spill-over being international in scope. If, on the other hand, the spill-over is completely national, then there may be divergence in growth rates, despite of international trade (see Feenstra, 1996).

The analysis above was based on a standard spill-over relation, which assumes that intertemporal spill-over effects result from the accumulation of the accumulable resource only. In contrast, one could sensibly argue that the spill-over on X accumulation results also from usual business activities approximated by C and D. The spill-over relation equation (2) may then be accordingly expressed as $Z = C^{\alpha} D^{\beta} X^{\eta}$. In this case, it can be shown that the condition for the dominance of the substitution effect ($\sigma_c > 1$) is attenuated and given by $\sigma_c > 1/(1 + \alpha + \beta)$ (Bretschger, 2001a). Thus as soon as $\alpha, \beta > 0$, the integration of a skilled labor rich country with an unskilled labor abundant country is less likely to entail negative growth effects.

5 Policy implications

There are a number of policy implications with respect to economic integration and long-run growth. These follow from the analysis of the scale effect and the factor reallocation effect.

Policy implications resulting from the scale effect

The analysis of economic integration based on theoretical growth models points to the fact that there are scale effects associated with economic integration. Whether these scale effects are first-order scale effects or second-order scale effects is largely an empirical matter. In fact, there is some evidence against first-order scale effects but solid empirical support for second-order scale effects. Since the speed of convergence towards the new balanced growth path (i.e. the post-integration balanced growth path) can be fairly low, the second-order scale effect may be strong.[19]

The relation $g_X^{int} = k^{\eta} g_X^{aut}$ indicates that the scale effect is larger, the higher the number of countries joining an integration k and the stronger the spill-over effect η; this applies to both first-order and second order scale effects. The first determinant is clearly under control of public policy. To some extent this implication might appear trivial but it is worth being noted that the scale effect is a clear argument for worldwide economic integration instead of regional integration. In the context of policy reports, the scale of an economy is often measured by the number of consumers, which is considered as a proxy for the size of the market. Other measures for the scale of an economy are the overall stock of the primary input (labor or human capital).[20] It is important to realize that the relevant scale in this context is the stock of the factor used intensively in the dynamic sector and not a general measure of economic size.

On the other hand, the strength of the spill-over effect (being a technology parameter) is usually considered as not being under control of public

[19] In this respect it should be noted that lowering the speed of convergence would strengthen the second-order scale effect.

[20] Human capital should not be viewed as a primary resource but instead as an accumulable input factor. Nonetheless, in Romer (1990) there is a primary input denoted as human capital. Moreover, in empirical studies the number of scientists and the level of GDP have also been used as measures of the macroeconomic scale (Backus et al., 1992).

policy.[21] Nonetheless, there is an important point to notice at this stage. The scale effect resulting from theoretical growth models should be interpreted as the potential benefit of economic integration, which is not realized automatically simply by removing formal barriers of exchange (goods, ideas, people).[22] Instead, economic integration probably represents only a necessary condition for taking full advantage of the scale effect. It appears appropriate to assume that individuals need to actively acquire the benefits associated with the "spill-over effect". Put differently, the spill-over effect can be considered as a technological opportunity of taking advantage of activities conducted by other agents. In this perspective, there are costs associated with the exploitation of the spill-over effect. The government should accordingly aim at reducing the costs of taking full advantage of the spill-over effect. Examples are communication networks, language training, exchange programmes etc. In this respect there is a clear requirement for future research investigating the individual costs and incentives for taking advantage of international spill-overs.

Policy implications resulting from factor reallocations

The analysis of the factor reallocation channel points to the fact that economic integration may reduce the amount of resources devoted to the dynamic sector in some of the participating economies. As a consequence, the long-run growth rate in the economies under study decreases. More specifically, provided that the consumption goods sector exhibits an elasticity of substitution between skilled and unskilled labor smaller than unity and the trading partner is abundantly endowed with unskilled labor, a reallocation of skilled labor from the dynamic sector to the consumption goods sector results. Whether the conditions mentioned above are fulfilled need to be checked empirically.

The factor reallocation channel is instructive from a theoretical perspective since it shows the possibility of a reduction in the growth rate due to economic integration. As demonstrated, the magnitude of this effect is ambiguous. Nevertheless, empirical estimates of the elasticity of substitution show that this parameter may well lie below unity when the difference of qualification between the two types of labor is large (e.g. Hamermesh, 1993, Chapter 3). There is, of course, a symmetric effect going on in the economy of the trading partner. Moreover, an economy joining an integration and experiencing a slowdown in the growth rate need not be worse of in terms

[21] The parameter η stems from the spill-over technology.

[22] Rivera-Batitz and Romer (1991) distinguish between trade in goods and flow of ideas.

of welfare. This is due to a favorable terms of trade effect, which allows the slowly growing economy to import the goods produced by the fast-growing trading partner at continuously falling prices.

The analysis above supposes that full employment holds. In the long-run, this assumption might be considered as justified. In the medium term, however, there are considerable doubts, especially in the case of continental Europe. If the full employment condition is not met, a decrease in the labor demand of one sector is not exactly offset by an increase in the labor demand of the other sector. For a skilled-labor rich economy, this would mean that labor released from the dynamic sector is not fully integrated in consumer goods production.

The simple framework used above points to the fact that the intersectoral allocation of (skilled) labor is important for long run growth. The sectoral structure of an economy is heavily influenced by public policy. Therefore, the question arises how economic integration might change the policies that aim at the sectoral structure of an economy. Considering the case of the enlargement of the European Union, there is the chance of a reconstruction of those policies that aim at a conservation of the economic structure. This strategy should clearly foster economic growth in the long run.

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