Growth Effects of Integration in Two-Sector Economies with Non-tradable Goods

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Abstract

This paper deals with the effects of economic integration in a 2x2x2 model of overlapping generations. We distinguish between a non-tradable and a tradable sector that use human and physical capital. As long as the sectors have different factor intensities, agents’ preferences for services and sectoral-TFPs disparities across countries influence the overall impact of economic integration. Since tradable good is used to accumulate physical capital, which is assumed to be perfectly mobile in an international context, traded-TFPs disparities are a crucial determinant of the growth effects of economic integration. By performing both a short and a long-term analysis, we show that integration leads to convergence in long-term growth rates in presence of cross-border externalities in human capital. This convergence can be accompanied by growth gains or looses for countries but does not presume of the short-term consequences.

JEL Classification: F15; J24; O41
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1 Introduction

The process of economic integration is a major challenge especially in Europe. Since 2004, European Union (EU) membership has grown from 15 to 28 countries and the analysis of the economic benefits of such enlargement is a crucial issue in the political agenda. As underlined by Kutan and Yigit (2007), integration shapes many aspects of an economy, which makes the evaluation of its overall impact a non-trivial question. From a theoretical point of view, static implications of economic integration have been largely documented through the standard trade
theory. Dynamical consequences of international trade on growth have been investigated for example by (Rivera-Batiz and Romer, 1991)\textsuperscript{1}. Our paper deals with economic integration in a context of an endogenous growth model.

A first aspect of economic integration lies in the mobility of capital between countries. Integrated economies do not longer need to save in order to invest, since foreign saving can be used in case of domestic saving shortfall. To investigate the impact of integration on economic growth, the question of human capital accumulation is an important issue. The standard assumptions concerning human capital accumulation are that human capital does not circulate between countries. Rather, economic integration may sometimes generate some cross-border externalities in human capital accumulation between countries (Michel and Vidal (2000)). In the original Michel and Vidal (2000) paper, domestic and foreign patience and altruism drive the effects of economic integration. They obtain that two countries can benefit from integration when cross-border externalities in human capital are high enough. The literature dealing with human capital accumulation and economic integration generally do not consider the existence of non-tradable production - even if it is widely admitted that education spending is a non-tradable good. Moreover, the consumption of non-traded goods represents a significant part of the aggregated consumption. Dotsey and Duarte (2008) underline that consumption of non-traded good represents about 40\% of US GDP whereas Berka and Devereux (2013) claim that 30\% of the aggregated consumption is non-tradable for European countries.

In this paper, we depart from the 2-country of Michel and Vidal (2000) setting distinguishing two sectors in the economy: a traded and a non-traded ones, to examine the short and the long-term effects of economic integration. This disaggregation allows us to consider sectoral TFPs disparities between countries and sectoral factor share. Such distinction is empirically relevant as recent studies underline that the TFP gaps between countries are sector-specific. For example, Hsieh and Klenow (2007) show that TFP gaps are higher in the investment goods sector. More precisely, they emphasize that less developed countries are particularly unproductive in producing manufactured tradable goods. They also show that sectoral factor shares vary considerably across sectors\textsuperscript{2}.

The presence of the non-tradable goods in our setting introduces a key variable for factor allocation in the economy: the price of the non-tradable goods in terms of the traded goods. This relative price determines the factor returns and finally the growth rate. Comparing our framework to the Michel and Vidal (2000) initial model, our contribution especially consists in three points. First, the transitional dynamics in the integrated economy is driven by both the dynamics of the relative price and the dynamics of the ratio of foreign over domestic education spending. As a result, the effects of economic integration may differ between the short and the long-run. When heterogeneous countries integrate, there is a transitional adjustment of the relative prices.

\textsuperscript{1}Rivera-Batiz and Romer (1991) focus on the pure scale effect of integration by considering trade between similar countries. They show that the increase in the flow of ideas, generated by integration, improves the productivity of research in both regions

\textsuperscript{2}For example, food has a labor share of only 0.62 while construction has a labor share as high as 0.79.
which affects the transitional dynamics of the growth rate. Such adjustment depends mainly on the initial cross-country tradable TFP gaps. We focus on the standard case where the traded sector is capital intensive\(^3\). In this way, a high-traded TFP country exhibits a high interest rate. Following integration, physical capital goes from the low-traded TFP to the high-traded TFP country. When the non-tradable sector is human capital intensive - like it is the case in developed countries - this entails a fall in the relative price of non-tradable good, and hence of the growth rate for the low-traded TFP. The transitional dynamics show that this effect is transitional and reduces across time.

The second originality in our results, due to this two-sector structure, is that integration may be good for growth in the long-run - compared to autarky - even for impatient and low altruistic countries. We emphasize that the long-term consequences of integration on economic growth does not result only from the differences of time preferences and education preferences between countries. In Michel and Vidal (2000), integration is growth improving in the long-run for an economy with a relatively low capital intensity (due to a low saving rate for example) in autarky. This high-return domestic country will receive capital at the time of integration. This will drive up the domestic wage and give more incentive for domestic education. In our setting, saving and altruism matter but the preference for services play a crucial role as well in determining the effects of integration on growth. Such a domestic country with a relatively low capital intensity may have a high propensity to consume services. In this case, the relative price of the non-traded good will be relatively high compared to the foreign country. Assuming that the traded sector is capital intensive, this high relative price implies a low domestic return on capital and a high domestic wage. At the time of integration, capital will move from this low return domestic country to the high return foreign country. Because of integration, the domestic wage will decrease, giving less incentive for education in this domestic country. Under these circumstances, the domestic country, with a low relative capital intensity but a high propensity to consume services won’t benefit from integration in terms of long-run growth.

Our third contribution is to calibrate this model on European countries. We then illustrate that integration may be growth damaging in the short run, while it turns out to be growth improving in the long run. This phenomenon provides more tangible evidences that evaluate only the long-term impact of economic integration is not satisfactory, especially for policy recommendations. Authorities should pursue their efforts to promote student mobility, increasing then cross-border externalities, in order to guarantee long-term convergence between countries. However, in the short run, if countries are different, economic integration tends to reinforce disparities by damaging the low traded-TFP country.

The paper is structured as follows. Section 2 presents the model. Section 3 deals with autarky whereas Section 4 deals with integration introducing capital mobility between the two countries. A numerical illustration is provided in Section 5 and finally Section 6 concludes.

\(^3\)This assumption means through the Stolper-Samuelson theorem that the return on capital (wage) is a decreasing (increasing) function of the relative price.
2 The model

We consider a two-country model that is an extension of Michel and Vidal (2000) in which we introduce two production sectors: a tradable sector and a non-tradable sector. In line with (?), the tradable sector produces a manufacturing good which can be consumed or invested in physical capital while non-tradable sector produces services which can be either consumed or invested in human capital. We normalize the traded good price to unity. This two-sector production structure is a generalization of the standard two-sector setting in which one good is a pure consumption while the other is a pure investment good (Galor, 1992, Venditti, 2005). We assume that investment in physical capital is carried out only in tradable good because empirical evidences suggest that the import component of investment is important and larger than consumption (see Burstein et al., 2004). Since education spending is mainly supported by services in the OECD countries, it is assumed non-tradable.\footnote{There are few papers considering multi-sector models in an international environment with human and physical capital accumulation. Bond et al. (2003) and Hu et al. (2009) are important exceptions that study the dynamic effect of trade. In these papers education sector is non-tradable.} In this setting, the relative price of the non-traded good, $P_N$, denotes the domestic real exchange rate but also the price of human capital relative to physical capital.

The world consists of two countries which accumulate human capital and experiment endogenous growth. In what follows, we describe the home country economy. The foreign country economy is analogous and asterisks denote foreign country variables.

2.1 Production

The representative firm produces in two sectors: the tradable, and the non-tradable one. Production in the tradable ($Y_T$) and in the non-tradable ($Y_N$) sector resulting from two Cobb-Douglas production technologies, using two inputs, human capital $H$, and physical capital $K$. Let $K_i$ and $L_i$, $i = T, N$, be respectively the quantities of capital and labor used by sector $i$, production is given by

$$Y_T = A_T K_T^{\alpha_T} H_T^{1-\alpha_T}$$
$$Y_N = A_N K_N^{\alpha_N} H_N^{1-\alpha_N}$$

with $\alpha_T, \alpha_N \in (0, 1)$, $A_T > 0$ and $A_N > 0$. To fit empirical evidence (Ito et al., 1999), we consider:

Assumption 1. $\alpha_N < \alpha_T$.

Investment instantaneously transforms a unit of tradable good into a unit of installed capital and capital fully depreciates after one period. Both inputs are perfectly mobile between the two sectors provided that:

$$H_T + H_N \leq H, \quad K_T + K_N \leq K$$

(3)
$K$ being the total stock of physical capital and $H$ the total amount of human capital.

Let $k_i = K_i/H_i$ be the capital intensity of sector $i$, $h_i = H_i/H$ be the share of human capital allocated to sector $i$, $i = T, N$, and $k = K/H$ the physical to human capital ratio. Equations (2), (3) and (5) can be rewritten:

$$h_T + h_N \leq 1, \quad k_T h_T + k_N h_N \leq k$$

$$y_T = A_T k_T^{\alpha_T}$$

$$y_N = A_N k_N^{\alpha_N}$$

where $y_T$ and $y_N$ are the production per unit of human capital in each sector.

Denoting $w$ the wage rate, $R$ the gross rental rate of capital and $P_N$ the price of the non-tradable good, profit maximization over the two sectors implies that production factors are paid their marginal product:

$$R_t = \alpha_T A_T k_T^{\alpha_T - 1} = P_N \alpha_N A_N k_N^{\alpha_N - 1}$$

$$w_t = (1 - \alpha_T) A_T k_T^{\alpha_T} = P_N (1 - \alpha_N) A_N k_N^{\alpha_N}$$

From which we derive the physical to human capital ratios as functions of the price of the non-tradable good:

$$k_{Tt} = B(P_{Nt})^{\frac{1}{\alpha_T - \alpha_N}}$$

$$k_{Nt} = \frac{\alpha_N (1 - \alpha_T)}{\alpha_T (1 - \alpha_N)} B(P_{Nt})^{\frac{1}{\alpha_T - \alpha_N}}$$

$$w_t = (1 - \alpha_T) A_T k_T^{\alpha_T} = P_N (1 - \alpha_N) A_N k_N^{\alpha_N}$$

And thus the input prices are:

$$w_t = (1 - \alpha_T) A_T B^{\alpha_T} P_{Nt}^{\frac{\alpha_T}{\alpha_T - \alpha_N}} \equiv w(P_{Nt})$$

$$R_t = \alpha_T A_T B^{\alpha_T - 1} P_{Nt}^{\frac{\alpha_T - 1}{\alpha_T - \alpha_N}} \equiv R(P_{Nt})$$

### 2.2 Consumption, savings and children’s education

The economy consists, in each country, of a sequence of three life periods. In the second period of his life, each individual gives birth to $1 + n$ children so that population grows at rate $n$. We assume the population growth rate is the same in the two countries. Each generation born in period $t$ consists of $N_t$ identical individuals who make decisions concerning consumption, children’s education, and savings. During childhood, individuals make no decision: their consumption is included in their parent’s consumption. They are reared by their parents who decide on their level of educational attainment. When adult, they work and receive the market wage,
consume, save, and rear their own children. When old they retire, and consume the proceeds of their savings.

Individuals care about their children’s education. They exhibit a kind of paternalistic altruism whereby they value their child’s human capital. Our modeling of intergenerational altruism follows Gloom and Ravikumar (1992) who assume that the parental bequest is the quality of education received by their children. The preferences of an individual belonging to generation \( t \) are represented by:

\[
U(c_t, d_{t+1}, h_{t+1}) = (1 - \beta) \ln c_t + \beta \ln d_{t+1} + \gamma \ln h_{t+1}
\]  

(11)

where \( c_t, d_{t+1} \) and \( h_{t+1} \) are respectively consumption when adult, consumption when old, and the child’s human capital; \( \beta \in ]0, 1[ \) denotes individuals’ thrift and \( \gamma \) is the altruism factor.

When adult, each agent born at \( t \) supplies inelastically \( h_{t+1} \) units of efficient labor. The level of human capital of each adult depends on his parent’s decision on education during his childhood:

\[
h_{t+1} = b_t e_t^a
\]

(12)

where \( b_t \) is an externality, \( e_t \) the amount of resources a parent devotes to his child’s education, and \( a \in ]0, 1[ \) the elasticity of the technology of human capital formation.

Let \( x = c, d \) denote individual consumption at each period of life, \( x_N \) and \( x_T \) be respectively the spending allocated to non-traded and traded goods. Instantaneous preferences over the two goods are defined according to:

\[
x = x_T^{\mu} x_N^{1-\mu}
\]

(13)

with \( \mu \in (0, 1) \). We denote \( \pi \) the consumer price index in terms of traded good. Adults distribute their earnings that consist of labor income, \( w_t h_t \), among own consumption spending, investment in child’s education, and savings, \( s_t \),

\[
w_t h_t = \pi_t c_t + P_{Nt} e_t + s_t
\]

(14)

As expenditures in human capital \( e_t \) is a non-tradable good, it is assumed to be in terms of services. Thus, \( P_{Nt} \) represents also the relative price of education services. When old, individuals retire and consume the proceeds of their savings:

\[
R_{t+1} s_t = \pi_{t+1} d_{t+1}
\]

(15)

An individual born in period \( t - 1 \) is endowed with \( h_t \) units of human capital at the beginning of adulthood, and chooses \( e_t \) and \( s_t \) so as to maximize his life-cycle utility (11) under his budget constraints (12), (14) and (15). An individual’s optimal choice is characterized by the first order conditions:
\[-\frac{1 - \beta}{\pi_t c_t} + \frac{\beta R_{t+1}}{\pi_{t+1} d_{t+1}} = 0 \quad (16)\]
\[-\frac{1 - \beta}{\pi_t c_t} + \gamma a = 0 \quad (17)\]

and
\[c_{Tt} = \mu \pi_t c_t\]
\[P_{Nt} c_{Nt} = (1 - \mu) \pi_t c_t \quad (18)\]

Equation (16) characterizes the optimal allocation of consumption for an individual over his lifetime. Equation (17) gives the optimal investment in the offspring’s human capital. An adult reduces his consumption spending until his loss equates the increment in the utility he derives from his child’s level of human capital out of altruism. Equations (18) give the static allocation of consumption spending between the two goods.

Plugging (14) and (15) into (16) and (17) yields:
\[s_t = \frac{\beta}{1 + \gamma a} w_t h_t \quad (19)\]
\[e_t = \frac{\gamma a}{P_{Nt}(1 + \gamma a)} w_t h_t \quad (20)\]

As usual in overlapping generation models with paternalistic altruism, savings increase with individual’s thrift and decrease with altruism. The more altruistic parents are, the more they invest in their offspring’s education.

2.3 Cross-border external effects in human capital

Throughout the analysis, foreign variables are denoted by an asterisk. We assume cross-border externalities in human capital formation. An individual’s investment in his child’s human capital generates a positive externality for his country’s fellows. Such externalities can be view as international spillovers in education resulting from international student mobility.\(^5\) For example, a visiting student can transfer his knowledge to students in the host country and reversely, a visiting student can acquire specific learning competences when studying aboard.

\(^5\)The global population of internationally mobile students more than double from 2.1 millions in 2000 to 4.5 millions in 2011. According to the European commission, around 4.5 % of all European students receive Erasmus grants at some stage during their higher education studies.
We assume an externality of the form:

\[ b_t = b(p\bar{e}_t + p^*\bar{e}_t^*)^{\lambda}e_t^{1-a-\lambda} \]
\[ b_t^* = b^*(p\bar{e}_t + p^*\bar{e}_t^*)^{\lambda}e_t^{1-a-\lambda} \]

where \( b > 0, \lambda \in [0, 1-a] \), \( p = N/(N+N^*) \) and \( p^* = 1-p \). Since population grows at the same rate in the two countries, \( p \) and \( p^* \), the shares of each country in the world population, are constant. We denote respectively \( \bar{e}_t \) and \( \bar{e}_t^* \) the average levels of investment in children’s human capital in the home and the foreign country. Since individuals are identical within each country, in equilibrium: \( e_t = \bar{e}_t \) and \( e_t^* = \bar{e}_t^* \). The magnitude of these cross-border external effects is given by \( \lambda \). The term \((p\bar{e}_t + p^*\bar{e}_t^*)^{\lambda}\) is intended to capture the strength of international spillover of knowledge. The higher \( \lambda \), the more the home country benefits from the foreign country’s private expenditures in education.

In equilibrium, human capital depends both on domestic and foreign investment in education and on cross-border externality in human capital formation:

\[ h_{t+1} = b_t e_t^a = (p\bar{e}_t + p^*\bar{e}_t^*)^{\lambda}e_t^{1-\lambda} \]

Let \( \rho_t = e_t^*/e_t \) be the ratio of foreign over home average investment in children’s human capital and \( g_t = h_{t+1}/h_t - 1 \) the economy growth rate. Using equations (20), (22) and finally (8), we obtain:

\[ 1 + g_t = \frac{\gamma ab}{(1+\gamma a)} B^{a_T} P_N^{\frac{\alpha N}{\alpha_T}} (p + p^*\rho_{t-1})^\lambda \]

2.4 The non-tradable market clearing condition

Since there exists a non-traded good, we should consider a market clearing condition for that good:

\[ Y_{Nt} = N_t c_{Nt} + N_{t-1}d_{Nt} + N_t e_t \]

This equation simply states that production equals total consumption in non-traded goods. We can rewrite this condition with only wage, interest factor and physical to human capital ratios:

**Lemma 1.** The home country non-tradable market clearing condition can be written

\[ \frac{w_t}{1+\gamma a} ((1-\mu) (1-\beta) + \gamma a) + \frac{R_t (1-\mu) \beta P_{Nt-1}}{(1+\mu)\gamma ab(p + p^*\rho_{t-1})^{\lambda}} = P_{Nt} A_N Dk_T^{\alpha_N-1}(k_t - k_{Tt}) \]

With \( D = \frac{\alpha_N (1-\alpha_T)}{\alpha_N - \alpha_T} \).  

**Proof.** See Appendix 7.1 ■

It can be noted that expression \( D \) is the same for both countries as we assume home and foreign technologies have identical elasticities of substitution between production factors.
3 Autarky

As we first consider autarky, we rule out any interactions between countries. Investments in human capital in one country do not result in an external effect that enhances the formation of human capital in the other (\(\lambda = 0\)). The human capital externality depends only on the average level of education. From equation (21), we have with \(\lambda = 0\): \(b_t = b\gamma^{-1-a}\). From equation (22), since individuals are identical, social returns on human capital investment are constant in equilibrium \(h_{t+1} = be_t\).

Young people’s savings finance the following period’s physical capital:

\[
K_{t+1} = H_{t+1}k_{t+1} = N_t s_t
\]  

(26)

The labor market clears:

\[
H_t = N_t h_t
\]  

(27)

Combining (19), (20), (22), (26) and (27), we obtain the next period equilibrium physical to human capital ratio:

\[
k_{t+1} = \frac{\beta}{b(1+n)\gamma a} P_{Nt}
\]  

(28)

which depends on \(P_{Nt}\), the price of human capital relative to physical capital in the current period \(t\). Using equations (7) and (8) with non-tradable market clearing condition (25), we obtain:

\[
\frac{1}{B} \frac{\alpha_T}{1 - \alpha_T} \frac{1}{\alpha_T} \frac{\alpha_N - \alpha_T}{\gamma a} \frac{(1 - \beta)(1 - \mu) + \gamma a}{\alpha_T} \frac{k_t}{P_{Nt}}
\]  

(29)

From equations (28) and (29) we finally obtain the dynamic equation characterizing equilibrium paths:

\[
P_{Nt+1} = \left( \frac{\beta}{B b(1+n)\gamma a 1 - \alpha_T \frac{\alpha_N - \alpha_T}{\gamma a} \frac{(1 - \beta)(1 - \mu) + \gamma a}{\alpha_T} P_{Nt}} \right)^{\alpha_T - \alpha_N}
\]  

(30)

**Definition 1.** We define a balanced growth path (BGP) as an equilibrium where all per capita variables grow at the same and constant rate. This equilibrium path is such that the relative price is constant and defined by \(P_{Nt+1} = P_{Nt} = \bar{P}_N\).

We then compute the autarkic growth rate \(\bar{g}^A\) on the balanced growth path.

**Lemma 2.** The autarkic growth factor on the balanced growth path is:

\[
1 + \bar{g}^A = \frac{\gamma ab}{1 + \gamma a} (1 - \alpha_T) A_T B^{\alpha_T} \bar{P}_N^{\frac{\alpha_N}{\alpha_T - \alpha_N}}
\]  

(31)
with

\[ \bar{P}_N^A = \left[ \frac{\beta}{b(1+n)\gamma a B\eta} \frac{\alpha_T-\alpha_N}{1-(\alpha_T-\alpha_N)} \right]^{\frac{1}{1-(\alpha_T-\alpha_N)}} \]  

(32)

The physical to human capital ratio on the balanced growth path is:

\[ \bar{k} = \left[ \frac{\beta}{b(1+n)\gamma a} \left( \frac{\eta}{B \eta} \right)^{\frac{1}{1-(\alpha_T-\alpha_N)}} \right]^{1} \equiv k^A \]  

(33)

with \( \zeta = 1 + \frac{(\alpha_T-\alpha_N)(1-\mu)}{1-\alpha_T} \) and \( \eta = \frac{\alpha_N-\alpha_T}{\alpha_T} \frac{(1-\beta)(1-\mu)+\gamma a}{1+\gamma a} + 1. \)

**Proof.** See Appendix 7.2.

From (30) and (32), the BGP equilibrium is globally stable. An increase in \( P_{Nt} \) modifies the return of human capital (\( w_t \)), which affects education spending (\( e_t \)) and savings (\( s_t \)) in the same way. Nevertheless, it also makes education spending relatively more expensive than savings. Hence, from equation (28), following an increase in \( P_{Nt} \), the physical to human capital ratio goes up in the next time period. This means that physical capital endowment increases relatively more than human capital endowment. From the Rybczynski theorem, the price of the good using intensively physical capital falls. As a result, from Assumption 1, the relative price of the non-tradable good (in terms of tradable) goes up and the dynamics around the BGP is monotonous. As the growth rate is monotonically related to the relative price of goods through equation (31), we can thus claim the following:

**Proposition 1.** Under Assumption 1, the autarky growth rate exhibits monotonic behaviors.

The dynamics effect of the relative price of goods on the transitional growth rate is little discussed in the literature. Alonso-Carrera et al. (2011) is an exception and emphasizes that dynamics adjustment of the relative price alters the growth rate of consumption expenditure under particular conditions. In the infinitely lived agent model, the variation in the relative prices generates a growth effect when there are multiple consumption goods and non logarithmic preferences. In our model, the growth rate is endogenously determined and depends on the relative price through the returns to human capital and the price of education spending. The growth rate dynamics is then directly driven by relative price movements.

The following propositions contain some comparative statics results relating the long-term relative price of goods and the growth rate to preference parameters.

**Proposition 2.** Under Assumption 1, the more agents value their children’s human capital the lower the relative price of non-tradable good.

**Proof.** We check easily from equation (33) that \( P_{N}^A \) is decreasing with \( \gamma. \)

When the non-tradable sector produces a good which can be used to invest in education,
an increase in the propensity to educate, captured by an increase in \( \gamma \), has three effects on the long-term relative price of goods \( P_N \). Two effects are directly driven by the equilibrium on the non-tradable good market. On the one hand, a raise in \( \gamma \) increases the consumption of non-tradable goods, by enhancing the education spending, such that \( P_N \) increases as well. On the other hand, a raise in \( \gamma \) depresses \( P_N \) as it leads to a fall in consumption spending. The third effect of \( \gamma \) on the relative price comes from the modification of factors accumulation. An increase in \( \gamma \) favors human capital accumulation relative to physical capital accumulation. According to the Rybzinsky theorem this increase in human capital endowment leads to a decrease in the relative price of non-tradable good which is produced by the human capital intensive sector. This last effect always dominates such that a country with a higher taste for education will be characterized by a lower real exchange rate.

We examine implications of agent’s preferences on the long-term growth rate:

**Proposition 3.** The more patient individuals are, the higher the growth rate. The growth rate is first increasing and then decreasing with \( \gamma \) reaching a maximum in

\[
\tilde{\gamma} = \frac{1 - \alpha_T + \alpha_N + \sqrt{(1 - \alpha_T + \alpha_N)^2 + 4 \alpha_N (1 - \alpha_T) \left( (1 - \mu) (1 - \beta) (\alpha_N - \alpha_T) + \alpha_T \right)}}{2 \alpha_N}.
\]

Moreover, under Assumption 1, the growth rate is decreasing in \( \mu \).

**Proof.** See Appendix 7.3

The more altruistic individuals are, the higher their investment in children’s education and the lower their consumption. We obtain, as in Michel and Vidal (2000), that excessive as well as weak altruism can lead to poor growth records. The growth rate decreases with the preference for tradable goods (\( \mu \)). This is a consequence of the Stolper-Samuelson Theorem. An increase in the propensity to consume the traded good (\( \mu \)) leads to an RER depreciation. Since the non-traded good is human capital intensive, the real depreciation entails a fall in the wage. Then, the return to human capital decreases and so does the growth rate.

### 4 Economic integration and growth

We consider a two-country overlapping generations world in which countries differ in levels of patience and altruism, in taste for non-tradable goods and in sectoral-TFP. We establish the growth implications of world economic integration.

#### 4.1 International environment

In the integrated economy, as we assume no labor mobility between the two countries, the labor market clearing condition of the domestic country is given as in autarky by equation (27). Equation (25) gives the non-tradable market clearing conditions for the home country. The foreign country equations are obtained if we denote by \(^*\) foreign variables.
In a two-country integrated world, there are capital flows between countries and the equality between domestic savings and domestic investment -equation (26)- no longer holds. The equilibrium on the world capital market is given by:

\[ K_{t+1} + K_{t+1}^* = N_t s_t + N_t^* s_t^* \]

(34)

Dividing by the world population, the world capital market clearing condition is:

\[ (1 + n) \left( pk_{t+1} h_{t+1} + p^* k_{t+1}^* h_{t+1}^* \right) = ps_t + p^* s_t^* \]

(35)

With perfect capital mobility, the interest rate is the same for both countries:

\[ R_t = R_t^* \]

(36)

Using (10), we can determine the ratio between foreign and domestic relative prices:

\[ \frac{P_{Nt}^*}{P_{Nt}} = \left[ \frac{A_N}{A_N^*} \right]^{\frac{1-n_N}{1-n_{N^*}} \equiv E} \]

(37)

This ratio reflects the bilateral real exchange rate between these two countries. We denote \( \rho_t = \frac{e_t^*}{e_t} \) the ratio of foreign over home average investment in children’s human capital.

The following Lemma provides a simple expression of the world capital accumulation equation, and expressions of the physical to human capital ratios:

**Lemma 3.** In an integrated world, the international capital market clearing condition is:

\[ (pk_{t+1} + p^* k_{t+1}^* \beta_{Nt}^{1-\lambda}) = \frac{1}{b(p + p^* \rho_t)^\lambda} \left( \frac{\beta p_{Nt}^*}{\gamma a(1 + n)} + \frac{p^* \rho_t}{\gamma^* a(1 + n)} \right) \]

(38)

and, the physical to human capital ratios are obtained from non-tradable market clearing conditions:

\[ k_{t+1} = P_{Nt+1}^{\alpha_N-\alpha N} B \eta + (1 - \zeta) \frac{\beta P_{Nt}}{b(p + p^* \rho_t)^\lambda \gamma a(1 + n)} \]

(39)

\[ k_{t+1}^* = P_{Nt+1}^{\alpha_T-\alpha T} B^* \eta^* + (1 - \zeta^*) \frac{p^* \beta^* P_{Nt}^*}{b(p + p^* \rho_t)^\lambda \gamma^* a(1 + n)} \]

(40)

The domestic price of the non-traded good is:

\[ \frac{1}{P_{Nt+1}^{\alpha_T-\alpha T}} = \frac{p^{\beta p_{Nt} \zeta} + \frac{p^* \rho_t}{\gamma^* a}}{B(p + p^* \rho_t)^\lambda b(1 + n)} \left( p^* + p^{1-\lambda} \frac{A_T^*}{A_T} \right)^{\frac{1}{1-\alpha_T}} \eta^* \]

(41)

With \( \zeta = 1 + \frac{(\alpha_T-\alpha N)(1-\mu)}{1-\alpha_T} \), \( \zeta^* = 1 + \frac{(\alpha_T-\alpha N)(1-\mu^*)}{1-\alpha_T} \), \( \eta = \frac{(\alpha_N-\alpha T) (1-\beta)(1-\mu) + \gamma a}{\alpha_T} + 1 \) and \( \eta^* = \frac{(\alpha_N-\alpha T) (1-\beta^*)(1-\mu^*) + \gamma^* a}{1+\gamma^* a} + 1 \).
Proof. See Appendix 7.4 ■

Introducing cross-border external effects, each country can benefit from the level of education in the other country. Using equation (20) we can compute:

\[
\rho_{t+1} = \frac{e_{t+1}^*}{e_t} = \frac{\gamma^*}{\gamma} \frac{1 + \gamma a}{1 + \gamma^* a} \frac{w_{t+1}^* h_{t+1}^*}{\bar{E}}
\]

(42)

Include equations (22) and (37), we have:

\[
\rho_{t+1} = \frac{\gamma^*}{\gamma} \frac{1 + \gamma a}{1 + \gamma^* a} \left( \frac{A_T^*}{A_T} \right)^{\frac{\alpha}{\gamma - \alpha}} \frac{A_N^*}{A_N} \rho_t^{1-\lambda}
\]

(43)

4.2 Steady state

Integration adds a dynamical dimension given by equation (43). Assuming that integration occurs at period \( t = 0 \), we consider as initial condition the state of the economy in autarky at period \(-1\), which gives \( P_{N0} \) from equation (41) with \( P_{N-1} = \bar{P}_N^A \), \( P_{N-1}^* = \bar{P}_N^A \) and \( \rho_{-1} = \frac{e_{-1}^*}{e_{-1}} \).

As a result, in the integrated world, the behavior of economies is driven by a bi-dimensional dynamical system.

\[
\begin{align*}
\rho_{t+1} &= \frac{\gamma^*}{\gamma} \frac{1 + \gamma a}{1 + \gamma^* a} \left( \frac{A_T^*}{A_T} \right)^{\frac{\alpha}{\gamma - \alpha}} \frac{A_N^*}{A_N} \rho_t^{1-\lambda} & \forall t \geq 0 \\

P_{Nt+1} &= \left( \frac{p \xi + p^* \xi^* g t}{\gamma a} \right) \left( \frac{A_T^*}{A_T} \right)^{\frac{\alpha}{\gamma - \alpha}} \left( \frac{A_N^*}{A_N} \right)^{\frac{\alpha}{\gamma - \alpha}} P_{Nt} & \forall t \geq 0 \\

P_{Nt+1}^{\alpha T - \alpha N} &= \left( \frac{p \xi + p^* \xi^* g t}{\gamma a} \right) \left( \frac{A_T^*}{A_T} \right)^{\frac{\alpha}{\gamma - \alpha}} \left( \frac{A_N^*}{A_N} \right)^{\frac{\alpha}{\gamma - \alpha}} P_{Nt} & \forall t \geq 0
\end{align*}
\]

(44)

Considering that \( \rho_{t+1} = \rho_t = \bar{\rho} \) and \( P_{Nt+1} = P_{Nt} = \bar{P}_N \) in system (44), we obtain:

Proposition 4. Under Assumption 1, there exists a unique non trivial stable steady state \( (\bar{\rho}, \bar{P}_N) \) where human capital grows at the same constant rate in the two economies.

\[
\bar{\rho} = \left( \frac{\gamma^*}{\gamma} \frac{1 + \gamma a}{1 + \gamma^* a} \left( \frac{A_T^*}{A_T} \right)^{\frac{\alpha}{\gamma - \alpha}} \frac{A_N^*}{A_N} \right)^{\frac{1}{\gamma - \alpha}}
\]

\[
\bar{P}_N = \left( \frac{p \xi + p^* \xi^* g \bar{\rho}}{\gamma a} \right) \left( \frac{A_T^*}{A_T} \right)^{\frac{\alpha}{\gamma - \alpha}} \left( \frac{A_N^*}{A_N} \right)^{\frac{\alpha}{\gamma - \alpha}} \left( \frac{A_T^*}{A_T} \right)^{\frac{\alpha}{\gamma - \alpha}} P_{Nt} \]

(45)
enhancing when comparing the growth rates before and after integration in the two countries, integration is growth enhancing or growth damaging in the long run depending on countries characteristics.

### 4.3 Long-term integration benefits

We examine in this section the impact of integration on the long-term growth rates. By comparing the growth rates before and after integration in the two countries, integration is growth enhancing when $\bar{g}^w/\bar{g}^A > 1$. Using equations (31) to (33) and (45), we can write $1 + \bar{g}^w/1 + \bar{g}^A$ as a function of the foreign over domestic autarky physical to human capital ratio, in line with Michel and Vidal (2000):

$$G \equiv \frac{1 + \bar{g}^w}{1 + \bar{g}^A} = \frac{\eta^* (\frac{A^T}{A_T})^{1-\alpha_T} (\frac{A^N}{A_T})^{1-\alpha_N}}{p_0 + (\frac{A^*}{A_T})^{1-\alpha_T} \eta^* \rho \hat{\rho}^{1 - \lambda}} \left( \frac{p (\frac{A^T}{A_T})^{1-\alpha_T} (\frac{A^N}{A_T})^{1-\alpha_N}}{p_0 + (\frac{A^*}{A_T})^{1-\alpha_T} \eta^* \rho \hat{\rho}^{1 - \lambda}} \right)^{\frac{\alpha_N}{1 - \alpha_T + \alpha_N}} \left( p + p^* \hat{\rho} \right)^{\frac{\lambda}{1 - \alpha_T + \alpha_N}} \lambda \zeta_1^{1 - \alpha_T - \alpha_N}$$

$$G^* \equiv \frac{1 + \bar{g}^w}{1 + \bar{g}^A} = \eta^* (\frac{A^T}{A_T})^{1-\alpha_T} (\frac{A^N}{A_T})^{1-\alpha_N} \left( \frac{p (\frac{A^T}{A_T})^{1-\alpha_T} (\frac{A^N}{A_T})^{1-\alpha_N}}{p_0 + (\frac{A^*}{A_T})^{1-\alpha_T} \eta^* \rho \hat{\rho}^{1 - \lambda}} \right)^{\frac{\alpha_N}{1 - \alpha_T + \alpha_N}} \left( p + p^* \hat{\rho} \right)^{\frac{\lambda}{1 - \alpha_T + \alpha_N}} \lambda \zeta_1^{1 - \alpha_T - \alpha_N}$$

We define $k^{A^*}/k^A \equiv \tilde{K}$, thus $G \equiv G(\tilde{K})$ and $G^* \equiv G^*(\tilde{K})$. When $\tilde{K} < 1$, the foreign economy is physical capital-scarce. Let us denote $A_1 = (\xi^{1 - \alpha_T})^{1 - \alpha_T}$ and $A_2 = (\frac{\lambda \zeta_1}{\lambda \zeta_1 + 1 - \alpha_T} \frac{\gamma}{\eta} (\frac{1 + \gamma}{\gamma \eta})^{1 - \alpha_T})^{1 - \alpha_T} \frac{\gamma}{\eta} (\frac{1 + \gamma}{\gamma \eta})^{1 - \alpha_T}$ . The benefits from integration are then appraised in the following statements:

**Proposition 5.** Under Assumption 1, when the home and foreign economies are characterized by: $\frac{A^T}{A_T} \in (\min (A_1, A_2) , \max (A_1, A_2))$, there exists a critical thresholds $\tilde{K}$, such that, when $\tilde{K} > \tilde{K}$, integration is growth enhancing in the domestic country. Similarly, there exists a critical thresholds $\tilde{K}^*$ such that, when $\tilde{K} < \tilde{K}^*$, integration is growth enhancing in the foreign country. The two thresholds are higher than one when $A_1 < A_2$ and lower than one if $A_1 > A_2$.

**Proof.** See Appendix 7.5. □
Economic integration affects growth through two channels: the cross-border externality and the relative price changes. The relative price shapes the growth rate through the cost of education spending and the wage. In this two-sector two-factor model, under Assumption 1, the wage is an increasing function of the relative price of the non-traded good. This result differs crucially from the Michel and Vidal's one-sector setting in which the wage increases with the capital intensity. This difference between the one-sector and the two-sector structures drives differences between the benefits of integration. Let us consider the case where, in the long run, education spending is higher in the domestic country than in the foreign one (i.e \( \bar{\rho} < 1 \) which is equivalent to the condition \( \frac{A^*_T}{A^*_T} < A_2 \)). Integration is always growth enhancing for the foreign country as long as the domestic country is physical capital abundant (\( K < 1 \)) and has a relatively high relative price of the non-traded good in autarky. In this case, integration will increase the relative price of the non-traded good in the foreign country, so does the foreign wage and foreign education. This means that when \( \frac{A^*_T}{A^*_T} \in (A_1, A_2) \) (\( A_1 < A_2 \)), integration is growth improving for the foreign country (relatively poor, with a low taste for services). A symmetric result emerges when \( \frac{A^*_T}{A^*_T} \in (A_2, A_1) \) (\( A_2 < A_1 \)), with \( K > 1 \). For other intermediary cases, all scenarios may be observed: Integration can be growth enhancing or reducing for the two countries, or favors one country at the expense of the other. The different results are summarized in the following array:

<table>
<thead>
<tr>
<th>( \bar{\rho} &lt; 1 )</th>
<th>( \bar{\rho} &gt; 1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{A^<em>_T}{A^</em>_T} &gt; A_1 )</td>
<td>( \frac{A^<em>_T}{A^</em>_T} &lt; A_1 )</td>
</tr>
<tr>
<td>( K &gt; 1 )</td>
<td>( K &lt; 1 )</td>
</tr>
<tr>
<td>( g^{A*} &lt; g^w &lt; g^A )</td>
<td>( g^A &lt; g^w &lt; g^{A*} )</td>
</tr>
</tbody>
</table>

Table 1: Long-term growth impact of integration

Economic integration can be favorable for the two countries when particular conditions are satisfied:

**Corollary 1.** Under Assumptions 1, and denoting \( A_3 = (\frac{K}{N})^{1-\alpha_T} \), when the economies are such that \( \frac{A^*_T}{A^*_T} \in (\text{Min}(A_2, A_3), \text{Max}(A_2, A_3)) \), and \( \lambda > \alpha_N/(1-\alpha_T+\alpha_N) \), the two critical thresholds satisfy \( \bar{K} < \bar{K}^* \). When \( K \in (\bar{K} ; \bar{K}^*) \) integration is growth enhancing for the two countries.

**Proof.** See Appendix 7.6.

Corollary 1 has shown that both foreign and home countries may benefit from integration in special situations. For example, let us consider that the foreign country is more educated than the home country (\( \bar{\rho} > 1 \) meaning that \( \frac{A^*_T}{A^*_T} < A_2 \)). Integration improves growth in the home economy through the externality in education, if \( \lambda \) is high enough. The integration will also improve growth in the foreign country if it leads to a rise in the wage compared to the previous

---

\( ^6 \) A high relative price is the brand of a strong taste for services (\( A_1 \) low), or a traded sector highly productive (\( A_T/A^*_T \) large)
autarky’s situation. This rise in the foreign wage happens only when the foreign relative price of the non-traded good increases - due to Assumption 1. This corresponds to the case where the foreign traded productivity is low enough ($A_T^* < A_T A_T^*$). To recap, both countries may benefit from integration if the home country integrates with a foreign country highly educated but with a technological lag in the traded sector in the case where the cross-border externality is large enough.

4.4 Short-term implications

In the previous section, we have highlighted the long-term consequences of economic integration when two sectors of production are considered. The present section completes the analysis by evaluating the impact of economic integration for both countries at the time of integration. We consider that economies are in the steady state in autarky. It follows that, immediately after economic integration, the growth rate jumps in each economy by a factor that depends on countries characteristics and initial conditions. To evaluate the costs or benefits of such adjustment, we compare the growth rates in autarky, given by equation (31), and the growth rates after the jump, obtained with equation (23) at $t = 0$ and equation (44). We define the ratio $G_0 \equiv \frac{1 + g_0}{1 + \bar{g}_0}$ and $G_0^* \equiv \frac{1 + g_0^*}{1 + \bar{g}_0^*}$, with:

$$G_0 = \left( \frac{p + p^* \rho_{-1} \left( \frac{A_T}{A_T^*} \right)^{1 - \alpha_T - \alpha_N \frac{A_T}{A_T^*} A_T^* A_T^*} \left( \frac{A_N}{A_N^*} \right)^{1 - \alpha_T - \alpha_N}}{p^* \rho_{-1} \left( \frac{A_T}{A_T^*} \right)^{1 - \alpha_T - \alpha_N} \left( \frac{A_N}{A_N^*} \right)^{1 - \alpha_T - \alpha_N}} \right)^{\alpha_N} (p + p^* \rho_{-1})^{\lambda(1 - \alpha_N)}$$ (48)

$$G_0^* = \left( \frac{p \left( \frac{A_T}{A_T^*} \right)^{1 - \alpha_T - \alpha_N} \left( \frac{A_N}{A_N^*} \right)^{1 - \alpha_T - \alpha_N} + p^* \rho_{-1}}{p^* \rho_{-1} \left( \frac{A_T}{A_T^*} \right)^{1 - \alpha_T - \alpha_N} + p^* \rho_{-1}} \right)^{\alpha_N} (p + p^* \rho_{-1})^{\lambda(1 - \alpha_N)}$$ (49)

As in the long run, we show that sectoral TFPs differences across countries explain the growth effects of economic integration. Our analysis allows to identify two reasons for this. The first comes from the relation between the relative price and factor accumulation. Cross country disparities in sectoral TFPs generate differences in the relative price of non-traded to traded goods, which in turn leads to differences in human and physical investment across countries. When productivity is high in the non-tradable sector relative to the tradable one, the price of education is low relative to savings meaning that the country invests relatively more in human than in physical capital. As economic integration results from a perfect mobility of physical capital, it is beneficial for the low-traded TFP country (physical capital scarce) while damageable for the high-traded TFP country (physical capital abundant). Using expressions (48) and (49), we observe that TFPs differences in the tradable sector play a second role. This result comes from the fact that the accumulation of physical capital, which is perfectly mobile across countries, requires the use of tradable good. 

\footnote{Using the dynamical system (44), we can provide a complete dynamical analysis in the integrated world. Such analysis describes the evolution of the relative price and of the ratio of foreign over home education spending along the convergence path. Nonetheless, it does not allow to analytically examine the growth consequences of economic integration on the growth rates, and hence is relegated in Appendix 7.8.}
From this second effect, when the world economy opens to capital mobility, capital flows from the low traded-TFP country to the high traded-TFP country, characterized by a higher return to physical capital. Thus, this effect plays in reversed compared to the previous one as economic integration favors the growth rate in the high traded-TFP country, which receives capital.

The combination of this two opposite effects makes the impact of the traded-TFP gap between countries ambiguous when we examine the growth implications of international capital movements. We determine the conditions on this variable under which foreign or domestic economy benefits from economic integration at the time of integration. Let us assume, without loss of generality, that domestic country invests initially more in education, we can claim the following:

**Proposition 6** Under Assumption 1 and the condition $\rho_{-1} < 1$:

- i) There exist two thresholds $A^*$ and $\bar{A}$ such that when $A < \frac{A^*}{A_T} < \bar{A}$ (resp. $\frac{A^*}{A_T} < A$ or $\frac{A^*}{A_T} > \bar{A}$), economic integration enhances (resp. reduces) the growth rate of the domestic economy.

- ii) There exists a threshold $\tilde{A}$ such that when $\frac{A^*}{A_T} > \tilde{A}$ (resp. $\frac{A^*}{A_T} < \tilde{A}$), economic integration enhances (resp. reduces) the growth rate of the foreign economy.

**Proof.** See Appendix 7.7.

We observe a growth improvement in the low-educated (foreign) country when it is characterized by a high traded-TFP relative to the highly educated country. For the less advanced economy in education, the second effect associated to the traded-TFP gap between countries always undertakes the first one. For the highly-educated (domestic) country a growth improvement requires an intermediary traded-TFP gap. This is because the low level of education spending in the foreign economy generates a negative externality such that economic integration discourages the accumulation of human capital accumulation when traded-TFP is infinitely high in the domestic country relative to the foreign country.

The analytical study does not allow to determine if both countries can experience growth improvement at the time of integration. To provide more insights about the short and the long-term effects of economic integration, we perform in the next section a numerical analysis of the model.

## 5 A numerical example

In this section, we derive a numerical solution for the model to illustrate the short- and the long-term effect of economic integration. We construct an artificial European Union. To this aim, we calibrate the parameters of domestic country to match the characteristics of the average of ten “old” European countries for which we have data (Austria, Belgium, Finland, France, Germany, Greece, Italy, Netherlands, Portugal, Spain) while the foreign country corresponds to the average
of Eastern European countries that joined the EU in 2004 (Czech Republic, Estonia, Poland). The model is calibrated using the Eurostat database, the Penn World tables and estimations or computations provided in the literature. A summary of calibrations and targets is provided in Table 2 and details by countries are provided in Appendix 7.9.

We assume that each period has a length of 30 years. Using equation (20), we choose education preferences $\gamma a$ to match data on education spendings (public and private). From equation (19), the discount factor $\beta$ is set to target the share of savings in GDP. Sectoral capital shares ($\alpha_T$, $\alpha_N$) and the share of tradable goods in consumption ($\mu$) are set following Lombardo and Ravenna (2014). In line with macroeconomic evidences for OECD countries, $\alpha_T = 0.67$ and $\alpha_N = 0.33$. We use input-output table data provided by these authors to calibrate $\mu$. These data emphasize that countries jointed the EU in 2004 are characterized by a high preferences for tradable good compared with most other member states. As regards sectoral TFPs, we follow Chinn (2000) by considering that average labor productivity is a proxy for sectoral TFPs. Thus, we use data on sector labor productivity provided by Inklaar and Timmer (2012).\footnote{They use the World Input-Output Table (WIOT) of 2005 and data from the food and agricultural organization of the United Nations (FOAstat), and labor productivity is defined as value added per hour worked.} We identify the non-tradable sector by non-market and market services and tradable sector by manufacturing and other goods. Calibrations are in line with Hsieh and Klenow (2007) and Herrendorf and Valentinyi (2012), who emphasize that TFP gap between developed and developing countries is not the same between sectors and developing countries are particularly unproductive in tradable and investment goods. We have that TFP gap in the tradable sector is more than twice as high as TFP gap in the non-tradable sector. We abstract from population growth and from the difference in population size, fixing $n = 0$ and $p = 0.5$. We compute the model for two different values of the magnitude of the cross-border external effect $\lambda$: 0.02 and 0.2. Finally, for the short-term analysis, we use data on education spendings and we calibrate the initial condition to match $\rho_{-1} = 0.87$.\footnote{We consider countries for which data are available i.e: Czech Republic, Estonia, Poland.}
We compute the critical thresholds provide in Section 4.3 and 4.4 to identify the growth gains or losses of economic integration in our calibrated economy. \( A_1 \) and \( A_2 \) are directly obtained with the calibration of the parameters while \( \bar{A}_1 \), \( \bar{A}_2 \) and \( \hat{A} \) are computed using equations (48) and (49):

\[
\begin{align*}
\text{Long-term analysis} \\
A_1 & = 0.96 \\
A_2 & = 1.54 \\
\text{Short term analysis} & \quad \lambda = 0.02, \lambda = 0.2 \\
\bar{A} & = 0.02, 0.07 \\
\bar{A} & = 1.47, 1.41 \\
\hat{A} & = 1.46, 1.36
\end{align*}
\]

**Table 3: Critical Thresholds**

First, we focus on the long-term effects. Using the values of \( A_1 \) and \( A_2 \) presented in Table 3 and theoretical results given in Table 1, we cannot determine if economic integration is growth benefit for foreign or domestic economy. Thus, we directly compute \( G \) and \( G^* \), given by equations (46) and (47), to determine the growth consequences of economic integration in the long run:

\[
\begin{align*}
G & = \frac{1+\bar{g}^w}{1+\bar{g}^x} \\
G^* & = \frac{1+\hat{g}^w}{1+\hat{g}^x} \\
\lambda=0.02 & \quad 0.99, 2.22 \\
\lambda=0.2 & \quad 0.93, 2.08
\end{align*}
\]

**Table 4: Long-term impact of integration on growth**

The foreign economy formed by Eastern European countries that joined the EU in 2004
always benefits from integration while the long-term growth rate of the Euro zone decreases slightly. Two reasons explain this result. First, the foreign economy benefits from the higher level of education spending in domestic economy. Second, the foreign economy is characterized by a high preference for tradable good (μ∗ high) and is relatively more productive in the non-tradable sector (AT∗/AN < 1) while the reverse is observed in the domestic economy. It entails that, in the long run, the relative price of education and hence the wage goes up for the foreign economy and goes down for the domestic one. We note that the long-term growth gains are higher when λ is low. Nevertheless, λ being the converging factor, this situation illustrates an extremely slow convergence of countries growth rates across time.

In a second step, we determine the numerical solution for the transitional dynamics using system (44). From Table 3 and Proposition 6, we conclude that at the time following integration, the growth rate falls in the foreign country while it increases in the domestic one. This is because the foreign economy is particularly unproductive in the tradable sector, that produces the good uses to accumulate physical capital, relative to the domestic economy. At the time of economic integration, the two economies converge to a common world return on physical capital and even if the foreign country is physical capital scarce, it suffers from capital outflows that reduce its growth rate. The positive externality in education for the foreign economy works in the opposite direction but is not sufficient to compensate this effect.11 Considering the long-term results and examining the evolution of growth rates along the transitional dynamics we see that this situation is temporary as the pattern of winners and losers is reversed in the long run.

6 Conclusion

The disaggregation of the standard one-sector setting into a two-sector model with production of traded and non-traded goods helps to account for effects of economic integration. Unlike to Michel and Vidal (2000), we identify the short-term effect of economic integration by analyzing the behavior of non-tradable good price. We obtain that the sectoral traded-TFP is a crucial determinant of the growth effect of integration. From a policy perspective, we reveal that providing funds to increase the transboundary externalities in education is favorable to reduce cross country disparity. However, less advanced country being particularly unproductive in the tradable sector, we show that in the short run economic integration can exacerbates this disparity by improving the growth rate in the more advanced country and reducing it in the less advanced one. As a result, the interpretation of observations of short-term growth variations must be done with care: an increase or decrease in the growth rate in the years following the integration does not mean that integration will be favorable / unfavorable in the long run.

11In Table 3, we see that when externality is high, the interval to observe growth benefit is lower for the domestic economy and higher for the foreign one. Nevertheless, a sensitivity analysis allows to conclude that the effect going through capital outflows prevails for λ ∈ [0, 1 − a].
7 Appendix

7.1 Non-tradable market equilibrium: Proof of Lemma 1

Substituting equations (2) and (18) in equation (24), and dividing by $N_t$, we obtain:

$$(1 - \mu)\pi_t\left(c_t + \frac{d_t}{1+n}\right) + P_N t = P_N A_N k_N N_t \alpha N h_t h_{N_t}$$

Integrating the budget constraints (14), (15) and the optimal level for $s_t$ and $e_t$ from equations (19) and (20) gives:

$$\frac{1 - \mu}{1 + \gamma a} \left((1 - \beta) w_t h_t + \frac{\beta R_t w_{t-1} h_{t-1}}{1+n}\right) + \frac{\gamma a}{1 + \gamma a} w_t = P_N A_N k_N N_t \alpha N h_t h_{N_t}$$

Moreover, from the optimal choice of investment in children’s education (20) we know:

$$h_{t-1} = \frac{1 + \gamma a}{\gamma ab w_{t-1} b_{t-1}} P_{N_t-1}$$

And thus using equation (22) and dividing (50) by $h_t$ we get:

$$1 - \mu \left((1 - \beta) w_t h_t + \frac{\beta R_t (1 + \gamma a) P_{N_t-1}}{1+n \gamma ab (p + p^* \rho_{t-1})}\right) + \frac{\gamma a}{1 + \gamma a} w_t = P_N A_N k_N N_t h_t h_{N_t}$$

As from equation (4), $h_N = \frac{k - k_t}{k_N - k_T}$, the non-tradable market clearing condition is:

$$\frac{1 - \mu}{1 + \gamma a} \left((1 - \beta) w_t + \frac{\beta R_t (1 + \gamma a) P_{N_t-1}}{1+n \gamma ab (p + p^* \rho_{t-1})}\right) + \frac{\gamma a}{1 + \gamma a} w_t = P_N A_N k_N \alpha N N_t h_t h_{N_t}$$

From equations (9), we finally get the condition of the Lemma.

7.2 Proof of Lemma 2

Considering autarky, and thus $\lambda = 0$ and $k_t = k_A$, the non tradable market clearing condition (25) is:

$$\frac{1 - \mu}{1 + \gamma a} \left((1 - \beta) w_t + k_A R_t (1 + \gamma a)\right) + \frac{\gamma a}{1 + \gamma a} w_t = P_N A_N Dk_T k_N^{-1} k_t - k_T$$

Substituting $P_{N_t}$ from equations (9):

$$\frac{1 - \mu}{1 + \gamma a} \left((1 - \beta) w_t + k_A R_t (1 + \gamma a)\right) + \frac{\gamma a}{1 + \gamma a} w_t = \frac{\alpha T (1 - \alpha T)}{\alpha N - \alpha T} k_T k_T^{-1} (k_A - k_T)$$
With factor prices from equations (7) and (8), we get:

\[
\frac{1-\mu}{1+\gamma a} (1-\beta)(1-\alpha T)A_T k T_t^{\alpha T} + k_A (1+\gamma a) \alpha T A_T k T_t^{\alpha T-1} + \frac{\gamma a}{1+\gamma a} (1-\alpha T) A_T k T_t^{\alpha T-1} = A_T \frac{\alpha T}{\alpha N-\alpha T} k T_t^{\alpha T-1} (k_A - k_T)
\]

Dividing by \( k T_t^{\alpha T-1} \):

\[
\frac{(1-\alpha T) k T_t}{1+\gamma a} ((1-\mu)(1-\beta) + \gamma a) + (1-\mu) k_A \alpha T A_T = A_T \frac{\alpha T}{\alpha N-\alpha T} (k_A - k_T)
\]

From straightforward computations, we finally obtain equation (29). The last task is to compute the equilibrium growth rate \( g_A \). Using equation (23), we readily obtain equation (31).

\[
7.3 \text{ Proof of Proposition 3}
\]

As \( \bar{P}_N^A = \left[ \left( \frac{\beta}{\beta(1+n)|aB|} \right) \left( \frac{\alpha T}{1-\alpha T} \frac{1-\alpha T-(1-\mu)(\alpha N-\alpha T)}{2(1+\gamma a)(1-\beta)+(1-\mu)(1+\gamma a)} \right) \right]^{\frac{\alpha T-\alpha N}{1-\alpha T-\alpha N}} \), we can define the growth factor as a function of \( \beta, \gamma, \) and \( \mu \):

\[
1+g_A = \frac{\gamma a b}{1+\gamma a} (1-\alpha T) A_T B^{\alpha T} \bar{P}_N^{\alpha A} \equiv G^A(\beta,\gamma,\mu)
\]

The logarithmic derivative of \( G^A \) with respect to \( \beta \) is:

\[
\frac{\partial \ln G_A(\beta,\gamma,\mu)}{\partial \beta} = \alpha T \left( \frac{1}{\beta} + \frac{(1-\mu)(1-\beta)+\gamma a(\alpha N-\alpha T)+\alpha T(1+\gamma a)}{((1-\mu)(1-\beta)+\gamma a)(\alpha N-\alpha T)+\alpha T(1+\gamma a)} \right)
\]

Which is positive if and only if

\[
\frac{(1+\gamma a-\mu)(\alpha N-\alpha T)+\alpha T\gamma a}{((1-\mu)(1-\beta)+\gamma a)(\alpha N-\alpha T)+\alpha T(1+\gamma a)} \geq 0
\]

The numerator is always positive. Since \((1-\mu)(1-\beta) < 1\), the denominator is positive for \( \alpha N \leq \alpha T \) or \( \alpha N \geq \alpha T \). The growth factor is always increasing with \( \beta \).

Concerning the variation of the growth rate with \( \gamma \). The logarithmic derivative of \( G^A \) with respect to \( \gamma \) is:

\[
\frac{\partial \ln G_A(\beta,\gamma,\mu)}{\partial \gamma} = \frac{1-\alpha T}{\gamma(1-\alpha T+\alpha N)} - \frac{a(1-\alpha T)}{(1+\gamma a)(1-\alpha T+\alpha N)} - \frac{1}{(1-\alpha T+\alpha N)(1-\mu)(1-\beta)(\alpha N-\alpha T)+\alpha T+\alpha N\gamma a}
\]

\[
= \frac{(1-\alpha T)((1-\mu)(1-\beta)(\alpha N-\alpha T)+\alpha N\gamma a)-\alpha N^2 a(1+\gamma a)}{\gamma(1+\gamma a)(1-\mu)(1-\beta)(\alpha N-\alpha T)+\alpha T+\alpha N\gamma a}
\]

Which is zero for a unique positive value of \( \gamma \):

\[
\gamma = \frac{1-\alpha_T-\alpha_N+\sqrt{(1-\alpha_T-\alpha_N)^2+4\alpha_N(1-\alpha_T)((1-\mu)(1-\beta)(\alpha_N-\alpha_T)+\alpha_T)}}{2\alpha_N}
\]

Concerning the variations of the growth rate with \( \mu \). As

\[
\frac{\partial \ln G_A(\beta,\gamma,\mu)}{\partial \mu} = \alpha_T (\alpha_N - \alpha_T) \left\{ \frac{(1-\beta)(1-\alpha_T)+\alpha N\gamma a+\alpha_T}{((1-\mu)(1-\beta)+\gamma a)(\alpha N-\alpha T)+\alpha T(1+\gamma a)(1-\mu T-(1-\mu)\alpha N)} \right\}
\]
The denominator is positive from the previous analyses and the positivity of \(k_T\). Thus this derivative is of the sign of \(\alpha_N - \alpha_T\).

### 7.4 Proof of Lemma 3

From equations (19) and (20), we obtain \(s_t = \frac{\beta P_N t_e}{\gamma a}\) and \(s^*_t = \frac{\beta^* P^*_N t^*_e}{\gamma^* a}\). Thus, the world capital market clearing condition (35) can be written:

\[
(1 + n) (pk_{t+1} h_{t+1} + p^* k^*_t h^*_{t+1}) = p \frac{\beta P_N t_e}{\gamma a} + p^* \frac{\beta^* P^*_N t^*_e}{\gamma^* a}
\]

Substituting the individual level of human capital for equation (22):

\[
(1 + n) \left( pk_{t+1} e_t (1 - \lambda) + p^* k^*_t e^*_t (1 - \lambda) \right) (pe_t + p^* e^*_t) = p \frac{\beta P_N t_e}{\gamma a} + p^* \frac{\beta^* P^*_N t^*_e}{\gamma^* a}
\]

dividing by \(e_t\) to write the equation as a function of \(\rho_t = \frac{e^*_t}{e_t}\), we obtain:

\[
(1 + n) b (pk_{t+1} e_t (1 - \lambda) + p^* k^*_t e^*_t (1 - \lambda)) (pe_t + p^* e^*_t) = p \frac{\beta P_N t_e}{\gamma a} + p^* \frac{\beta^* P^*_N t^*_e}{\gamma^* a}
\]

In the integrated world, the non-traded goods market clearing condition for the home country is obtain from equation (25):

\[
k_t = \frac{w_t}{1 + \gamma a} \left( (1 - \mu)(1 - \beta) + \gamma a \right) + \frac{R_t (1 - \mu) \beta P_N t_{e-1}}{(1 + n) \gamma a (p + p^* \rho_{t-1})^\lambda} - k_T t
\]

Substituting the expression of \(k_T\) from equation (9), the factor prices \(w_t\) and \(R_t\) from equations (10), and simplifying by \(P^*_N t_{e-1}^{\alpha - \alpha N}\), we obtain the expressions for \(k_t\) given by equation (39). The foreign ratio \(k^*\) is deduced similarly and given by equation (40). Finally, the domestic price of non-tradable goods given by equation (41) is obtained by substituting equations (39) and (40) in (38).

### 7.5 Proof of Proposition 5

Using equations (46) and (47) we have the following properties: \(G(K)\) is a increasing function of \(K\) with \(G(0) > 0\) and \(G(\infty) = \infty\) and \(G^*(K)\) is a decreasing function of \(K\) with \(G^*(0) = \infty\) and \(G^*(\infty) > 0\). Moreover, we have:

- \(G(1) < 1\) and \(G^*(1) > 1\) when \(\bar{\rho} < 1\) and \(\zeta \eta^* \left( \frac{A_T^*}{\bar{A}_T} \right)^{\frac{1}{1 - \alpha_T}} > \zeta^* \eta^*\). In this case there exists \(\bar{K} > 1\) over which integration favors the domestic country and \(\bar{K}^* > 1\) under which integration favors the foreign country.
7.7 Proof of Proposition 6

We define \( A_T^* / A_T \equiv \mathcal{X} \), thus \( G_0 \equiv G_0(\mathcal{X}) \) and \( G_0^* \equiv G_0^*(\mathcal{X}) \). Under Assumption 1 and the condition \( \rho_{-1} < 1 \), from (48), we have \( G_0(0) < 1 \) and \( \lim_{\mathcal{X} \to \infty} G_0(\mathcal{X}) < 1 \). Moreover, \( \partial G_0(\mathcal{X}) / \partial \mathcal{X} \) is decreasing with \( \partial G_0(0) / \partial \mathcal{X} > 0 \), \( \lim_{\mathcal{X} \to \infty} \partial G_0(\mathcal{X}) / \partial \mathcal{X} < 0 \) and \( \partial G_0(\mathcal{X}^{\text{max}}) / \partial \mathcal{X} = 0 \). As
\( G_0(\lambda^{\text{max}}) > 1 \) the first item of Proposition 6 follows. From (49), we have \( G_0^*(0) < 1 \) and \( \lim_{\lambda \to \infty} G_0^*(\lambda) > 1 \). Moreover, \( \partial G_0^*(\lambda) / \partial \lambda > 0 \), thus we deduce the second item of Proposition 6.

### 7.8 Transitional Dynamics in the integrated economy

Using the dynamical system (44), we can analyze the local behavior of the balanced growth path equilibrium around the steady state \((\bar{P}_N, \bar{\rho})\). We have the following properties:

\[
\frac{\partial P_{Nt+1}}{\partial P_{Nt}} (\bar{\rho}, \bar{P}_N) = \alpha_T - \alpha_N; \quad \frac{\partial P_{Nt+1}}{\partial \rho_t} (\bar{\rho}, \bar{P}_N) = c; \quad \frac{\partial \rho_{t+1}}{\partial P_{Nt}} (\bar{\rho}, \bar{P}_N) = 0; \quad \frac{\partial \rho_{t+1}}{\partial \rho_t} (\bar{\rho}, \bar{P}_N) = 1 - \lambda
\]

The eigenvalues are between 0 and 1, thus, we conclude that the converging paths around the steady state are always monotonous.

To give intuitions about the effect of integration on relative prices and growth for the periods following integration, we conduct a global stability analysis. We build a phase diagram to describe the global dynamics of economy. We define the two loci

\[
EE \equiv \{(\rho_t) : \rho_{t+1} = \rho_t\}
\]

and

\[
PP(\rho_t) \equiv \{(\rho_t, P_{Nt}) : P_{Nt+1} = P_{Nt}\}.
\]

From (44), we obtain:

\[
\rho_t = \left( \frac{\gamma^*}{\gamma} \right)^{1+\gamma a} \left( \frac{A_T^*}{A_T} \right)^{\frac{\alpha_N}{1-\alpha_T}} \equiv EE
\]

And

\[
P_{Nt} = \left[ \frac{\frac{\mu \beta}{\gamma a} + \frac{P^* \gamma^* a}{\gamma^* a} \frac{\epsilon \rho_t}{\gamma a}}{B(p + p^* \rho_t)^\lambda b(1 + n)} \left( p\eta + \left( \frac{A_T^*}{A_T} \right)^{\frac{1}{1-\alpha_T}} p^* \rho_t^{1-\lambda} \eta^* \right) \right]^{\frac{\alpha_T - \alpha_N}{1-\alpha_T - \alpha_N}} \equiv PP(\rho_t)
\]

The EE Locus is a vertical line whereas the PP locus is a curve in plane \((\rho_t, P_{Nt})\).

From the PP locus: \( \lim_{\rho_t \to 0} PP(\rho_t) = \left[ \frac{\frac{\mu \beta}{\gamma a}}{Bp^\lambda b(1+n)\eta} \right]^{\frac{\alpha_T - \alpha_N}{1-\alpha_T - \alpha_N}} \equiv L_0 > 0 \)

and \( \lim_{\rho_t \to \infty} PP(\rho_t) = \left[ \frac{\frac{\mu \beta}{\gamma a}}{\left( \frac{A_T^*}{A_T} \right)^{\frac{1}{1-\alpha_T}} Bp^\lambda b(1+n)\eta} \right]^{\frac{\alpha_T - \alpha_N}{1-\alpha_T - \alpha_N}} \equiv L_\infty > 0 \). Moreover we have:

\[
\text{Sign} \left( \frac{\partial PP}{\partial \rho_t} \right) = \text{Sign}(D_1(\rho_t))
\]

with

\[
D_1(\rho_t) \equiv \epsilon (\gamma a^\beta \xi) \left( p^* \rho_t \eta (1 - \lambda) + p^* \rho_t^{1-\lambda} \left( \frac{A_T^*}{A_T} \right)^{\frac{1}{1-\alpha_T}} \eta^* \lambda + p\eta \right) - \zeta \lambda \rho_t \eta \gamma^* a - \zeta \left( \frac{A_T^*}{A_T} \right)^{\frac{1}{1-\alpha_T}} \eta^* \gamma^* a^\beta \rho_t^{(1 - \lambda)p + p^* \rho_t})
\]

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We can rewrite this equation:

\[
D_1(\rho_t) = \left( \frac{A_T^T}{A_T} \right)^{\frac{1}{\alpha_T}} \eta^* p^* \rho_t^{1-\lambda} (\zeta^* \gamma a \beta^* \lambda \varepsilon - \zeta^* a \beta) + \eta p (\zeta^* \beta^* \gamma a \varepsilon - \lambda \zeta \gamma^* a)
\]

\[
+ \varepsilon \zeta^* \gamma a \beta^* p^* \rho_t (1-\lambda) - \zeta^* \gamma a \beta \frac{\rho_t (1-\lambda)}{\rho_t^{1-\lambda}} \left( \frac{A_T^T}{A_T} \right)^{\frac{1}{\alpha_T}}
\]

Since \( \lim_{\rho_t \to 0} D_1 = -\infty \) and \( \lim_{\rho_t \to +\infty} D_1 = +\infty \), the PP locus is not monotonous. Deriving \( D_1 \) with respect to \( \rho_t \), we obtain:

\[
\text{Sign} \left( \frac{\partial D_1}{\partial \rho_t} \right) = \frac{p^* \eta^*}{\rho_t^\lambda} \left( \frac{A_T^T}{A_T} \right)^{\frac{1}{\alpha_T}} (\zeta^* \gamma a \beta^* \lambda - \zeta^* a \beta) + \zeta^* \gamma a \beta^* p^* \eta + \zeta p \eta^* \gamma a \beta \left( \frac{A_T^T}{A_T} \right)^{\frac{1}{\alpha_T}} \frac{\lambda}{\rho_t^{1+\lambda}}
\]

Under the following sufficient condition \( \zeta^* \gamma a \beta^* \lambda > \zeta^* a \beta \), \( D_1 \) is strictly increasing in \( \rho_t \). Consequently, PP is decreasing and then increasing in \( \rho_t \) and achieves a minimum in \( \hat{\rho} \). The threshold \( \hat{\rho} \) is lower than \( \bar{\rho} \) when \( D_1(\bar{\rho}) > 0 \). As \( D_1(\bar{\rho}) \) is decreasing in \( \beta \) and positive when \( \beta = 0 \), there exists a \( \tilde{\beta} \) under which \( \hat{\rho} < \bar{\rho} \).

Thus, under Assumption 1, if

\[
1 - a > \lambda > \frac{\zeta^* \gamma \beta}{\zeta \gamma \beta^*} \equiv \lambda
\]

then the PP locus is first decreasing and then increasing with \( \rho_t \), reaching a minimum in \( \hat{\rho} \), denoted \( P_N^{\min} = PP(\hat{\rho}) \). Moreover, \( \hat{\rho} < \bar{\rho} \) if and only if \( \beta < \tilde{\beta} \).

Figure 1 gives the corresponding phase diagrams that depict the overall dynamic of the model when cross border externalities are sufficiently important, i.e \( \lambda > \Delta \):

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{Global Dynamics when \( 1 - a > \lambda > \Delta \)}
\end{figure}
7.9 Calibration

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References


