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INTERNATIONAL TRADE AS THE SOLE ENGINE OF GROWTH FOR AN ECONOMY

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Abstract

Can international trade act as the sole engine of growth for an economy? If the answer is yes, what are the mechanisms through which trade operates in transmitting permanent growth? This paper answers these questions with two simple two-country models, in which only one country enjoys sustained growth in autarky. The models differ in the assumptions on technical change, which is either labour- or capital-augmenting. In both cases, the stagnant economy imports growth by trading. In the first model, growth is transmitted because of permanent increases in the trade volume. In the second, the stagnant economy imports sustained growth because its terms of trade permanently improve.

Key words*:* international trade; stagnant economies; growth transmission; mechanisms of transmission

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1. Introduction

The positive impact of international trade on economic growth has been widely documented from both theoretical (e.g. Grossman and Helpman, 1997) and empirical (e.g. Keller, 2002) points of view. Many studies have explored the issue from different perspectives and under the most diverse assumptions. The effects of externalities (e.g. Keller, 2004), scale economies (e.g. Grossman and Helpman, 1989), imperfect competition (e.g. Grossman et al., 1992), policy (e.g. Rodrik and Rodríguez, 1999), and a long etcetera, have been extensively analyzed in the literature.

The present paper aims to make a theoretical contribution to this debate. We ask how international trade acts in fuelling a country's economic growth in the classical framework of a Ramsey-type model when perfect competition prevails and when there are neither externalities, nor scale economies, nor government intervention. Going a step further, we ask whether a stagnant economy might "import" sustained growth simply by trading with another economy which is growing. An affirmative answer would be an argument in favor of the concept of trade as a way to escape from stagnation. If the answer is yes, we will pose a second question: what are the mechanisms through which trade can transmit sustained growth from one economy to another? To address these questions, we develop two simple two-country models of exogenous growth and trade in intermediate goods. The models are identical except in the type of technical progress, which is either labor- or capital-augmenting. Since we are concerned with the transmission of sustained growth by trading, our analysis concentrates on the long-run equilibrium.

The two countries produce one identical non-tradable final good with constant returns to scale technologies that use two intermediate goods as inputs. As in Ventura´s

model (1997), the intermediate goods are produced with linear technologies that use either labor (good 1) or capital (good 2) as factor inputs. Intermediate goods can potentially be traded in international markets, but factors cannot. The economies only differ in the existence of technological progress. More specifically, the growth rate of total factor productivity (TFP) is positive in one of the economies (country 1), and equal to zero in the other economy (country 2). Technical progress in the growing country is labor-augmenting in the first framework (model 1), and capital-augmenting in the second (model 2).

In the autarky situation the first country enjoys permanent growth, while the growth rate of the second one is nil. In model 1, countries 1 and 2 have comparative advantages in the production of intermediate goods 1 and 2 respectively, and vice versa in model 2. In both frameworks, at the equilibrium, the existence of trade leads to the transmission of sustained growth from country 1 to country 2. However, the mechanism of transmission differs substantially in the two models. In the first one, the terms of trade converge to a constant value in the long-run. The stagnant economy overcomes decreasing returns to capital accumulation because it can import (export) increasing amounts of good 1 (good 2) from country 1 (to country 1). Therefore, growth is transmitted because of permanent rises in the trade volume. In the alternative framework, country 2 does not accumulate capital in the long run, and permanent improvements in the terms of trade emerge as the mechanism of transmission of growth. Though the amount of intermediate input exported by country 2 remains constant, its imports rise over time because the terms of trade become increasingly favorable to this economy.

Notice that the behavior of international relative prices depends on the relative scarcity of intermediate inputs throughout the world. In model 1, the terms of trade of

countries approach a constant value because the world production of goods 1 and 2 tends to grow at the same positive rate. The fact that the production functions of good 1 in country 1 and good 2 in countries 1 and 2 exhibit constant returns to scale in reproducible factors is crucial for obtaining the findings. This is why country 2 overcomes decreasing returns and thus accumulates capital unboundedly. Hence, the effects of trade on growth operate via trade volume. In model 2, country 2's terms of trade permanently improve because good 1 becomes increasingly scarcer than good 2. This is due to the fact that the technology of good 1 in both economies uses a non-reproducible factor. In this case, country 2 does not need to accumulate capital to continuously raise its per capita income. Thus, trade impacts on growth via international relative prices or terms of trade.

The theoretical literature on this issue can be traced back to Findlay (1980), who tried to identify the conditions under which trade acts as the sole engine of growth for an economy. In his model, the aggregate income of the stagnant economy grows, but per capita income does not.[1] The study by Acemoglu and Ventura (2002) is related to our first model. They found that, even in the absence of diminishing returns and spillovers, trade can lead to a stable world income distribution. Though they were not directly interested in the transmission of sustained growth through trade, their model also has the implication that trade can act as a transmitter of permanent growth among countries. Related to our second model, the study by Diewert and Morrison (1986) aimed to develop an empirical method for properly measuring the contribution of factor inputs to output growth of open economies. Using an empirical model based on index numbers, they proved that an improvement in terms of a country's trade amounts to an increase in that country's TFP.

From the empirical point of view, Ekholm and Södersten (2002) emphasized the importance of considering income-terms of trade[2] when analyzing the relationship between trade and growth. They found that the terms of trade present a roughly constant trend, while income-terms of trade increase over time. Thus, they argued that openness relates to growth mainly through the trade volume. Several studies, such as those by Frankel and Romer (2002) and Alcalá and Ciccone (2004), have found causality going from trade volume to TFP and hence to growth. The Southeast Asian countries constitute an example of trade affecting growth through trade volume mechanisms. In this respect, the empirical study by Kohli (1997) reveals that growth of these Asian economies was mainly based on capital accumulation and, to a lesser extent, on TFP increases. The contribution of terms of trade movements was quite small. The predictions of our first model match these findings quite well.

Regarding the second mechanism of transmission (i.e. terms of trade movements), the growth regressions by Barro (1991) showed a significant positive relationship between a country's economic growth and terms of trade movements. Kohli (2004) exploited Diewert and Morrison's (1986) result to show that the omission of terms of trade movements may seriously under- and over-estimate economic growth when the terms of trade improve and deteriorate respectively. The Sri Lankan and Swiss economies constitute examples of our second mechanism of transmission. As reported by Athukorala (2000), Sri Lanka is an outward-oriented developing country which switched from exporting primary goods to exporting manufactures in the 1970s. Challenging the pessimistic view regarding the deterioration of terms of trade in developing countries (e.g. Sarkar and Singer, 1991), the terms of trade and also the

[1] In his model, the developed North is represented by Solow's (1956) framework, and the less developed South behaves like Lewis's (1954) economy.

[2] This measure is defined as the product of export volume and net barter terms of trade.

economic growth of this country have significantly improved since then. Finally, in their response to Abrahamsen et al. (2005) regarding the crisis in the Swiss economy, Kehoe and Ruhl (2005) only admitted one of the critiques made by those authors, namely the underestimation of Swiss economic growth due to the omission of terms of trade improvements. In the light of these real cases, the second mechanism for transmitting growth appears to be more than just a theoretical possibility.

The remainder of this paper is organized as follows. Section 2 describes the models. Section 3 solves the autarky equilibrium. Section 4 characterizes the trade situation. Lastly, section 5 summarizes and concludes.

2. The Models

The models that we develop build on Ventura's (1997), and differ regarding the type of technical change. Time is continuous and endless, and the world economy is composed of two countries denoted by $i = 1,2$. There is a non-tradable final good, $y^i(t)$, $i = 1,2$, which can be used for consumption or investment. There are also two tradable intermediate goods, $x^i_{zj}(t)$, $z = 1,2$, (good 1 and 2) produced in country i and used as inputs in the final good production of country j; and two factor inputs, capital $k^i(t)$ and labor $l^i(t)$, allocated to the production of intermediate goods. The notation regarding the production of intermediate inputs needs further clarification. The total production of intermediate input z in country i will be denoted by $x^i_z(t)$. The second sub-index will only appear if a part of total production is exported. In addition, we assume that international factor flows are not allowed, all markets are competitive, and foreign and domestic intermediate goods are perfect substitutes for each other.

Each country is inhabited by a continuum of identical households which is normalized to the unit. There is no population growth. Households are endowed with

one unit of time in each period that can only be allocated to work. These assumptions imply that the population is equivalent to the labor force of the economies, and that variables are expressed in per capita terms.

Countries possess the same Cobb-Douglas type of technology to produce the final good:

$$y^i(t) = \left(x_{1j}^i(t)\right)^{\alpha} \left(x_{2j}^i(t)\right)^{1-\alpha}, \quad 0 < \alpha < 1. \tag{1}$$

As in Ventura's (1997) model, goods 1 and 2 are produced with labor and capital, respectively, through the following linear production functions:

$$\begin{aligned} & x_1^i(t) = A^i(t) l^i(t), \quad x_2^i(t) = B^i(t) k^i(t), \\ & A^2(t) = B^2(t) = 1 \quad \forall t, \\ & \text{Model 1: } A^1(t) = e^{\gamma t}, \ \gamma > 0, \text{ and } B^1(t) = 1 \quad \forall t, \\ & \text{Model 2: } A^1(t) = 1 \quad \forall t \text{ and } B^1(t) = e^{\gamma t}, \ \gamma > 0, \end{aligned} \tag{2}$$

where $A^i(t)$ and $B^i(t)$ represent technological progress in good 1 and 2 sectors respectively. From now on, we will assume that $A^2(t) = B^2(t) = 1 \ \forall t$, which implies that country 2 will not enjoy sustained growth in autarky. The models only differ in the assumptions on $A^1(t)$ and $B^1(t)$. In the first model, technological progress in country 1 is labor-augmenting and thus $A^1(t) = e^{\gamma t}$, $\gamma > 0$ and $B^1(t) = 1 \ \forall t$. In model 2 the assumptions are $A^1(t) = 1 \ \forall t$ and $B^1(t) = e^{\gamma t}$, $\gamma > 0$ and, hence, technical change is capital-augmenting.

A general result under a Cobb-Douglas production function is that labor- and capital-augmenting technical changes are in essence the same. However, these two approaches lead to different results in our models, since they affect the mechanism through which trade operates in transmitting sustained growth. Notice that the existence of labor-

augmenting technical progress amounts to the condition that labor is a reproducible factor in country 1. Thus, in this country both intermediate goods are produced with technologies that exhibit constant returns to scale in reproducible factors. In country 2, however, labor is a non-reproducible factor, while the production function of good 2 exhibits constant returns to scale in capital. In the model with capital-augmenting technical change, the labor input is a non-reproducible factor in both economies.

Countries do not differ regarding preferences. The representative household derives utility from the consumption of the aggregate good, $c^i(t)$, and maximizes its intertemporal utility discounted at a positive rate ρ:[3]

$$U^i(0) = \int_0^\infty e^{-\rho t} \frac{\left(c^i(t)\right)^{1-\theta} - 1}{1-\theta} dt, \ \theta > 0, \tag{3}$$

Subject to the budget constraint and the initial endowment of wealth:

$$\begin{aligned} &\dot{a}^i(t) = r^i(t) a^i(t) + w^i(t) - c^i(t), \\ &a^i(0) > 0 \text{ given} \end{aligned} \tag{4}$$

where $a^i(t)$ denotes wealth, $r^i(t)$ is the interest rate and $w^i(t)$ is the wage per time unit. Since capital is the only asset in the economy, in equilibrium, household wealth will turn out to be equal to the capital stock.

3. The Autarky Situation

In autarky, countries behave in accordance with the well-known Ramsey model, but with exogenous growth in the case of country 1. The profits-maximizing behavior of firms in the final good sector implies that intermediate good prices equal marginal productivities:

[3] If $\theta = 1$, current utility becomes $ln\left|c^i(t)\right|$.

$$\left.\begin{aligned} p_1^i(t) &= \alpha\left(x_1^i(t)\right)^{\alpha-1}\left(x_2^i(t)\right)^{1-\alpha} \\ p_2^i(t) &= (1-\alpha)\left(x_1^i(t)\right)^{\alpha}\left(x_2^i(t)\right)^{-\alpha} \end{aligned}\right\} \rightarrow \frac{p_1^i(t)}{p_2^i(t)} = \frac{\alpha}{1-\alpha}\frac{x_2^i(t)}{x_1^i(t)}, \tag{5}$$

where $p_z^i(t)$, $z = 1,2$ denotes the price of good z in country i. From now on, we will refer to the price of good 1 relative to good 2 as the relative price. The price of the final good is taken as numeraire. In the intermediate good sectors, factor prices equal marginal productivities:

$$w^i(t) = p_1^i(t)A^i(t), \quad r^i(t) = p_2^i(t)B^i(t) - \delta, \tag{6}$$

where we assume that capital depreciates at the same rate $\delta > 0$ in both economies.

The competitive equilibrium is a set of allocations and prices which satisfy firms and household problems, and which clear all markets in both economies, including capital market, $a^i(t) = k^i(t)$, $i = 1,2$, and labor market, $l^i(t) = 1$, $i = 1,2$. Next, we characterize the autarky equilibrium under the two hypotheses for technological change.

3.1 Model 1: Labor-augmenting technical change

Given the assumptions in the previous section, country 1 will grow at the rate γ in the long run, while country 2 will not enjoy sustained growth. More specifically, looking at the interest rate of countries:

$$r^1(t) = (1-\alpha)\left(\frac{k^1(t)}{e^{\gamma t}}\right)^{-\alpha} - \delta, \quad r^2(t) = (1-\alpha)\left(k^2(t)\right)^{-\alpha} - \delta, \tag{7}$$

it follows that the long-run equilibrium of country 1 is characterized by a balanced growth path (BGP), while that of country 2 is a steady state (SS) in which the long-run growth rate is equal to zero.

The equilibrium condition for choosing consumption over time (Euler equation governing consumption) evaluated in the long-run equilibrium permits the relative prices to be obtained:

$$\begin{aligned} \frac{p_1^1(t)}{p_2^1(t)} &= \frac{\alpha}{1-\alpha}\frac{k^1(t)}{e^{\gamma t}} \quad \overset{\text{BGP}}{\rightarrow} \quad \frac{p_1^1}{p_2^1} = \alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}}\left(\frac{1}{\gamma\theta+\rho+\delta}\right)^{\frac{1}{\alpha}}; \\ \frac{p_1^2(t)}{p_2^2(t)} &= \frac{\alpha}{1-\alpha}k^2(t) \quad \overset{\text{SS}}{\rightarrow} \quad \frac{p_1^2}{p_2^2} = \alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}}\left(\frac{1}{\rho+\delta}\right)^{\frac{1}{\alpha}}. \end{aligned} \tag{8}$$

Here and throughout the paper, the omission of time will denote stationary values in the long-run equilibrium. The relative prices of countries 1 and 2 become constant as time passes. In country 1, this result is due to the assumption of constant returns to scale in reproducible factors. In country 2 the absence of technical progress is the reason why the relative price becomes stationary. The autarky prices in (8) will be useful later on for establishing the comparative advantage of countries.

3.2 Model 2: Capital-augmenting technical change

The results for country 1 depend on the assumption on technical change. Under capital-augmenting technical progress the interest rate of country 1 is equal to:

$$r^1(t) = (1-\alpha)\left(\frac{k^1(t)}{e^{\frac{1-\alpha}{\alpha}\gamma t}}\right)^{-\alpha} - \delta, \tag{9}$$

The interest rate must be constant over the BGP, which requires capital and, hence, final good output and consumption to grow at the same constant rate ϑ:

$$\vartheta = \frac{1-\alpha}{\alpha}\gamma. \tag{10}$$

The relative price is obtained by proceeding as in the previous subsection:

$$\frac{p_1^1(t)}{p_2^1(t)} = \frac{\alpha}{1-\alpha} e^{\gamma t} k^1(t) \quad \overset{\text{BGP}}{\rightarrow} \quad \frac{p_1^1(t)}{p_2^1(t)} = \alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}} \left(\frac{\alpha e^{\gamma t}}{(1-\alpha)\gamma\theta + \alpha(\rho+\delta)} \right)^{\frac{1}{\alpha}}. \quad (11)$$

In contrast to the case with labor-augmenting technological progress, country 1's relative price strictly increases through time at the rate γ/α. The reason is quite clear: good 1 is produced with a non-reproducible factor, and the production of good 2 grows at the rate γ/α.

4. The Free Trade Situation

Given that intermediates are produced with just one of the available factors in each economy, the existence of trade may imply that it is characterized by incomplete specialization in both countries. Notice that countries will always use their labor and, consequently, will always produce good 1. However, non-accumulation of physical capital may become optimal for one of the countries, since imports from the other economy can act as a substitute for capital accumulation.

Our objective in the next subsections is to determine whether international trade is able to transmit permanent growth to country 2. We start by establishing the specialization pattern of countries. Then, we show that trade acts as a transmitter of permanent growth whatever the assumption on technical change is. Nevertheless, we find that this assumption matters for how growth is transmitted.

4.1 Model 1: Labor-augmenting technical change

From the relative prices in expression (8) it is clear that country 1 and 2 eventually have comparative advantage in the production of intermediate good 1 and 2 respectively. The structure of the model implies that investment in country 1 might hit a corner. In this case, country 1 would only produce good 1 in the long-run. Our main

results are unaffected by this issue, so we assume the existence of an interior solution. Also notice that, by construction, the trade situation in the model leads to interest rate equalization between countries in all time periods.

Given the comparative advantage of countries, the productions of final good can be written as:

$$y^1(t)=\left(x_{11}^1(t)\right)^{\alpha}\left(x_2^1(t)+x_{21}^2(t)\right)^{1-\alpha},\quad y^2(t)=\left(x_1^2(t)+x_{12}^1(t)\right)^{\alpha}\left(x_{22}^2(t)\right)^{1-\alpha}. \quad (12)$$

Remember that the second sub-index does not appear when the input is produced and entirely used within the country. From the profit maximization problem of firms in the final good sector of both economies, and the equilibrium in the trade balance $p_1(t)x_{12}^1(t)=p_2(t)x_{21}^2(t)$, we obtain the following equilibrium conditions:

$$\frac{p_1(t)}{p_2(t)}=\frac{\alpha}{1-\alpha}\frac{x_2^1(t)+x_{21}^2(t)}{x_{11}^1(t)}=\frac{\alpha}{1-\alpha}\frac{x_{22}^2(t)}{x_1^2(t)+x_{12}^1(t)}=\frac{x_{21}^2(t)}{x_{12}^1(t)}. \quad (13)$$

Straightforward manipulations of the conditions in expression (13) yield the exported-imported proportions of intermediate goods:

$$\begin{aligned} v^1(t)&\equiv\frac{x_{11}^1(t)}{x_1^1(t)}=\frac{(1-\alpha)x_2^1(t)x_1^2(t)}{x_1^1(t)\left(x_2^1(t)+x_2^2(t)\right)}+\frac{x_2^1(t)+\alpha x_2^2(t)}{x_2^1(t)+x_2^2(t)},\\ v^2(t)&\equiv\frac{x_{21}^2(t)}{x_2^2(t)}=\frac{\alpha\left(x_1^1(t)x_2^2(t)-x_2^1(t)x_1^2(t)\right)}{x_2^2(t)\left(x_2^1(t)+x_2^2(t)\right)}. \end{aligned} \quad (14)$$

Taking into account (13) and (14), we find that international relative prices depend on the ratio of world production of good 2 to world production of good 1:

$$\frac{p_1(t)}{p_2(t)}=\frac{\alpha}{1-\alpha}\frac{x_2^1(t)+x_2^2(t)}{x_1^1(t)+x_1^2(t)}\ \rightarrow\ \frac{p_1(t)}{p_2(t)}=\frac{\alpha}{1-\alpha}\frac{k^1(t)+k^2(t)}{e^{\gamma t}+1}. \quad (15)$$

A necessary condition for the transmission of sustained growth is that benefits from free trade do not extinguish as time passes. In other words, the trade situation must last

forever. Trade will be mutually beneficial for countries if relative prices in (8) and (15) fulfill:

$$\begin{aligned} &\frac{p_1^1(t)}{p_2^1(t)} \leq \frac{p_1(t)}{p_2(t)} \quad \rightarrow \quad \frac{k^1(t)}{k^1(t)+k^2(t)} \leq \frac{e^{\gamma t}}{e^{\gamma t}+1}, \\ &\frac{p_1^2(t)}{p_2^2(t)} > \frac{p_1(t)}{p_2(t)} \quad \rightarrow \quad \frac{k^1(t)+k^2(t)}{k^2(t)} < e^{\gamma t}+1, \text{ for } t \geq \tilde{t}, \end{aligned} \tag{16}$$

where $\tilde{t}$ is the period in which countries entered the trade situation.

Next, we concentrate on the long-run equilibrium of the world economy. As is clear from the Euler equation, the interest rate equalization implies that consumption in both countries grows at exactly the same rate in every period. The expression for the interest rate in equilibrium:

$$r(t) = (1-\alpha)\left(\frac{k^1(t)+k^2(t)}{e^{\gamma t}+1}\right)^{-\alpha} - \delta, \tag{17}$$

reveals that the world economy converges to a quasi-balanced growth path (QBGP). A QBGP in the model is a competitive equilibrium in which the growth rates of capital and consumption asymptotically converge to γ. Imposing a growth rate of γ for consumption, we obtain that the relative price $p_1(t)/p_2(t)$ asymptotically approaches the long-run autarky price of country 1 in expression (8). Moreover, the conditions in (16) hold in the long run and thus trade is always beneficial for countries.

As the time variable tends to infinity, the proportions in (14) asymptotically converge to:

$$\begin{aligned} &\lim_{t\to\infty} \nu^1(t) = \alpha + \phi(1-\alpha), \quad \lim_{t\to\infty} \nu^2(t) = \alpha, \\ &\phi \equiv \frac{k^1(t)}{k^1(t)+k^2(t)}. \end{aligned} \tag{18}$$

Notice that the limit of $\nu^1(t)$ in (18) also corresponds to country 1's share of gross world income, which is composed of world labor share plus the portion of world capital share that corresponds to its capital. Country 2's income comes increasingly from capital because its labor productivity is constant. Thus, its share of gross world income is the proportion of world capital that corresponds to its capital. The value of ϕ depends on the capital stocks that countries had in the first period of trade.

We conclude, then, that country 2 imports sustained growth from country 1 by trading in intermediate goods. The mechanism of transmission is related to the trade volume. Indeed, rewriting the physical capital accumulation of country 2 as:

$$\dot{k}^2(t) = \left(1 + \overbrace{\left(1-\nu^1(t)\right)e^{\gamma t}}^{x_{12}^1(t)}\right)\left(\frac{1-\alpha}{\alpha}\frac{p_1(t)}{p_2(t)}\right)^{1-\alpha} - c^2(t) - \delta k^2(t), \qquad (19)$$

one can see that imports of good 1 (exports of good 2) rise over time due to productivity gains in sector 1 of country 1, while both $\nu^1(t)$ and the relative price tend towards constant values as time passes.

4.2 Model 2: Capital-augmenting technical change

The relative prices in (8) and (11) indicate that countries 1 and 2 eventually have comparative advantage in good 2 and 1 respectively. As in the previous case, we start by obtaining some results that will be useful for analyzing the long-run equilibrium. The final good productions of countries can be written as:

$$y^1(t) = \left(x_1^1(t) + x_{11}^2(t)\right)^{\alpha}\left(x_{21}^1(t)\right)^{1-\alpha}, \; y^2(t) = \left(x_{12}^2(t)\right)^{\alpha}\left(x_2^2(t) + x_{22}^1(t)\right)^{1-\alpha}. \qquad (20)$$

The competitive behavior of firms in the final good sector, and the equilibrium in the trade balance, $p_2(t)x_{22}^1(t) = p_1(t)x_{11}^2(t)$, permit three expressions for the relative price to be obtained:

$$\frac{p_1(t)}{p_2(t)} = \frac{\alpha}{1-\alpha}\frac{x_{21}^1(t)}{x_1^1(t)+x_{11}^2(t)} = \frac{\alpha}{1-\alpha}\frac{x_2^2(t)+x_{22}^1(t)}{x_{12}^2(t)} = \frac{x_{22}^1(t)}{x_{11}^2(t)}. \tag{21}$$

The imported-exported proportions of intermediates can be calculated from (21):

$$\begin{aligned} v^1(t) &\equiv \frac{x_{21}^1(t)}{x_2^1(t)} = \frac{(1-\alpha)x_1^2(t)}{x_1^1(t)+x_1^2(t)} + \frac{x_1^1(t)\left(x_2^1(t)+\alpha x_2^2(t)\right)}{x_2^1(t)\left(x_2^1(t)+x_2^2(t)\right)}; \\ v^2(t) &\equiv \frac{x_{11}^2(t)}{x_1^2(t)} = \frac{(1-\alpha)\left(x_1^2(t)x_2^1(t)-x_2^2(t)x_1^1(t)\right)}{x_1^2(t)\left(x_2^1(t)+x_2^2(t)\right)}. \end{aligned} \tag{22}$$

Substituting the proportions from (22) in (21), the relative price becomes:

$$\frac{p_1(t)}{p_2(t)} = \frac{\alpha}{1-\alpha}\frac{e^{\gamma t}k^1(t)+k^2(t)}{2}. \tag{23}$$

In this case, the condition for the benefits from free trade to hold over time is:

$$\left.\begin{aligned} \frac{p_1^1(t)}{p_2^1(t)} &\geq \frac{p_1(t)}{p_2(t)} \\ \frac{p_1^2(t)}{p_2^2(t)} &< \frac{p_1(t)}{p_2(t)} \end{aligned}\right\} \rightarrow \frac{k^2(t)}{k^1(t)} \leq e^{\gamma t} \quad \text{for} \quad t \geq \tilde{t}, \tag{24}$$

Now, we are ready to analyze the long-run equilibrium of the world economy.

The trade situation does not lead to interest rate equalization between countries:

$$\begin{aligned} r^1(t) &= (1-\alpha)\left(\frac{e^{\gamma t}k^1(t)+k^2(t)}{2}\right)^{-\alpha} e^{\gamma t} - \delta, \\ r^2(t) &= (1-\alpha)\left(\frac{e^{\gamma t}k^1(t)+k^2(t)}{2}\right)^{-\alpha} - \delta. \end{aligned} \tag{25}$$

A constant interest rate in country 2 implies that the interest rate in country 1, and hence the growth rate of consumption, tends to infinity. This is incompatible with the existence of a long-run equilibrium. Conversely, the interest rate of country 2 tends to zero if country 1's interest rate is constant. Therefore, a BGP exists in which physical capital of country 2 is equal to zero and its terms of trade strictly increase over time.

These results show that country 1's capital and consumption grow at the same rate ϑ as in autarky. In addition, the proportions in (22) become:

$$v^1 = 1 - \frac{\alpha}{2}; \quad v^2 = \frac{\alpha}{2}. \tag{26}$$

International trade allows country 1 to increase its production of intermediate good 1 (its labor) in the proportion α. Thus, country 1 owns all the capital income and half of world labor income, while the rest of labor income is owned by country 2.

Again, the conclusion is that trade acts as an engine of growth for country 2. The capital-augmenting technological progress in country 1 makes good 2 relatively more abundant than good 1, which results in a continuous improvement of country 2's terms of trade:

$$\left.\begin{aligned} p_1(t) &= \alpha\left(\frac{1-\alpha}{\alpha}\frac{p_1(t)}{p_2(t)}\right)^{1-\alpha} \\ c^2(t) &= p_1(t) \end{aligned}\right\} \rightarrow \quad \frac{\dot{c}^2(t)}{c^2(t)} = \frac{\dot{p}_1(t)}{p_1(t)} \quad \overset{\text{BGP}}{\rightarrow} \quad \frac{\dot{c}^2(t)}{c^2(t)} = \vartheta. \tag{27}$$

The amount of good 1 exported by country 2 holds constant over time, but its imports permanently increase because the terms of trade become progressively more favorable to this economy. Hence, the role of trade volume is substituted by the role of terms of trade movements. Country 2 does not need to accumulate physical capital in order to continuously raise its consumption level. The existence of a non-reproducible

factor in country 1 is crucial for achieving this result, since it permits a strictly decreasing time path for the autarky relative price of this economy.

5. Conclusion

The role of international trade in promoting economic growth has been extensively studied in the literature from different perspectives and under a wide range of assumptions. Nonetheless, little attention has been paid to identifying the explicit mechanisms through which trade impacts on economic growth in the classical framework of a Ramsey model. This paper makes a contribution in this direction. More specifically, we have posed two related questions: can trade act as the sole engine of growth for an economy? If the answer is affirmative, how does trade operate in transmitting permanent growth? To our knowledge, the rather scarce theoretical literature on this issue has analyzed the first question, but no attempt has been made to answer the second one.

In this paper, we have answered both questions with two simple models of exogenous growth and trade of intermediate inputs. The models only differ in the type of technical progress, which is labor-augmenting in first framework, and capital-augmenting in the second one. The world economy consists of two countries whose economies behave in accordance with Ramsey's model, but just one of them enjoys sustained growth in autarky. In both models, the stagnant economy imports growth by trading. However, the kind of technical progress matters for how growth is transmitted. In the first model, the mechanism of transmission is associated to permanent increases in the trade volume, while it relies on continuous improvements of the terms of trade in the second.

These simple models are able to determine the conditions under which trade emerges as the sole engine of growth for an otherwise stagnant economy. They also allow us to

identify the two mechanisms through which trade transmits sustained growth. In this respect, there exists empirical evidence showing that these mechanisms do in fact operate in real economies.

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