Trade, Preferences and the Reversal of the Openness – Growth Connection

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Abstract

Many empirical studies argue that the positive relationship between openness and growth is a recent phenomenon and that before World War II openness was negatively associated with growth. This article presents a Ricardian model of trade that generates the reversal of the effect of free trade on growth at a more advanced stage of development, as has been widely observed empirically. The model shows that initially, when the trading countries are at a low stage of development, free trade may reduce growth. Later on, at a more advanced stage of development, the effect of free trade on growth reverses and becomes positive.

Keywords: Nonhomothetic demand, learning-by-doing, tariff-growth paradox

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1. Introduction

The openness – growth connection has long been studied in large empirical literature. The findings of this voluminous literature suggest that this relationship was not always the same. Thus, on the one hand, the large macro-econometric literature argues that free trade policies have had a positive effect on growth in the post World War II era (e.g., Dollar 1992; Ben-David 1993; Edwards 1998; Sachs and Werner 1995; Harrison 1996; Frankel and Romer 1999; Krueger 1999; Greenaway, Morgan and Wright 2002: Dollar and Kraay 2004; Warcziarg and Welsh 2008, among many others).[1]

On the other hand, it has also been widely argued that this positive relationship is a rather recent phenomenon and that before World War II openness was negatively associated with growth. First introduced by Bairock (1972), this positive correlation between tariffs and growth in the first era of globalization between 1870 and 1914 is now widely accepted in the literature (Bairock 1996; O'Rourke 2000; Clemens and Williamson 2004; Jacks 2006; Lehmann and O'Rourke 2011).[2] This positive association between high tariffs and higher economic growth before 1914, in contrast to the negative relationship observed in many studies of the post World War II period is commonly referred to in the literature as a "tariff-growth paradox".

Further on, a negative relationship between openness and growth was also observed in the interwar period as well (Vamvakidis 2002; Clemens and Williamson 2004). Similarly, it has also been argued that in the recent period, in contrast to the developed world, in many presently developing countries trade liberalization was not growth enhancing (Yanikkaya 2003).

This paper presents a Ricardian model of trade that contributes to the controversy regarding the relationship between free trade and economic growth at different levels of development. The model belongs to the large recent trade literature, such as, for example, Flam and Helpman (1987), Matsuyama (2000), Spilimbergo (2000), Mountford (2006), Stibora and de Vall (2007), Fajgelbaum, Grossman, and Helpman (2011), among others,

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[1] See, however, Rodrik, Subrananian and Trebbi (2004) for a critical view.

[2] Schularick and Solomou (2011), who recently criticized this commonly accepted view in the literature, stress that they failed to find any strong evidence for a negative tariff-growth relationship and acknowledge that in the pre-WWI era a number of high tariff countries were at the same time high growth countries.

that exploit nonhomothetic preferences.[3] Building on Spilimbergo (2000), I use nonhomothetic preferences combined with the technological progress, which is modeled as learning-by-doing, to generate the reversal of the effect of free trade on economic growth at a more advanced stage of development, as has been widely observed empirically. The model shows that initially, when the trading countries are at a low stage of development, free trade may reduce growth. Later on, at a more advanced stage of development, the effect of trade on growth reverses and becomes positive.

The intuition behind this result is as follows. Suppose the world that consists of two countries, each of which in autarky produces two sophisticated products where further technological progress is possible through the learning-by-doing and two matured products with no potential for further technological progress. The comparative advantages are such that, when trade is allowed, any country will produce and export one sophisticated good and one matured good. Except for the comparative advantages, both countries are identical.

Suppose that trade starts when the countries are at a relatively low stage of development with relatively high unit labor requirements in the production of the new sophisticated goods as compared to the production of the matured goods. Thus, for each country, the foreign matured good is cheap relative to the foreign sophisticated good, as well as to its own sophisticated good. Given the specialization pattern and as a result of the new price structure after trade, the total demand for the sophisticated products produced in each country can be lower than the initial demand for the sophisticated products in autarky. As a consequence, technological progress slows down, although if the static gains from trade are positive enough to outweigh the dynamic losses associated with a reduction in technological progress, both economies are better off with trade despite the reduction of technological progress relative to autarky.[4]

As time passes, due to the learning-by-doing, the unit labor requirement in the production of each country's sophisticated good declines, while, at the same time, the unit

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[3] Nonhomothetic preferences have been well established empirically. For example, Hunter (1991) estimates that nonhomothetic preferences may account for more than one-quarter of interindustry trade. See also Reimer and Hertel (2010) and Caron, Fally and Markusen (2012), who provide extensive literature reviews.

[4] See Young (1991) for an analysis of the dynamic effects of trade on technological progress and welfare and Redding (1999) for an analysis of a dynamic comparative advantage in the context of learning by doing. For a related infant industry protection motive, see Melitz (2005) and references therein.

labor requirement in the production of the matured good remains constant. This reduces the relative cost of the sophisticated products, thus increasing the demand for the sophisticated goods in each country. Once the unit labor requirement in the production of the sophisticated goods declines enough and therefore the foreign sophisticated good becomes attractive enough relative to the foreign matured good, the demand for the sophisticated goods in trade exceeds that in autarky. From this period on, the effect of free trade on technological progress in trading economies reverses and becomes positive.[5]

The idea that trade may have a different effect on technological progress, when the trading partners are asymmetric with respect to their levels of development, is well established in the literature. Thus, for instance, Young (1991) presents a Ricardian model of trade among countries at different levels of development. In this model with learning-by-doing, he argues that trading with less developed countries encourages growth in more developed countries and discourages growth in less developed countries. Similarly, Stockey (1991) presents a model based on learning-by-doing and human capital accumulation, in which trade magnifies initial differences between rich and poor countries. In a completely different setting, Galor and Mountford (2006) argue that international trade has an asymmetric effect on the evolution of industrial and non-industrial economies. While in the former the gains from trade were directed primarily towards investment in education and growth in per capita output, in the latter they generated an incentive to specialize in the production of unskilled labor-intensive goods, thus delaying the process of development. In contrast, Spilimbergo (2000) develops a model of trade with learning-by-doing and nonhomothetic preferences to show that trade with a less developed country can reduce growth in a more developed country, if in the less developed country the demand is biased toward the developed country's product without learning potential.

In all these models, among many others, trading partners are presented at different levels of development, which describes well the pattern of trade between the advanced economies and developing countries at present. However, this set up can be less useful to describe the historical evolution of presently developed economies, which is the major

[5] A growth enhancing effect of trading with rich, fast-growing and relatively more developed countries has been well established in the literature (e.g., Arora and Vamavakidis, 2005 and references therein).

theme of the present work. Thus, in the late 19th century technological differences between the leaders, such as, Britain, the United States and Germany, and many countries in continental Europe were not so pronounced, so as to model them as countries at different levels of development. Moreover, during the last century and a half the path of technological progress in these countries was relatively similar and at present they are at a similarly advanced level of development, as they were at a similarly less advanced level of development in the 1870s.[6] For this reason, I model the trading partners as economies at the same level of development that both undergo a similar transition from a less advanced to a more advanced stage of development.

2. The Model

In this section, I present and analyze the basic model with two countries (Home and Foreign). In both countries the population size is normalized to one. I suppose that there is no international mobility of labor, while there is perfect mobility of labor across sectors.[7] First, I introduce a nonhomothetic demand function and specify the production side. Second, I consider the equilibrium in autarky and with international trade. Finally, I show the reversal of the effect of free trade on growth at a more advanced stage of development.

2.1. Demand side

In both countries the agents share the same endowments and the same preferences. In every period each agent is endowed with one unit of labor, which is supplied to the labor market at the price of 1. The utility of an agent in country j (= Home or Foreign) at time 0 is given by:

$$W_0^j = \int_0^\infty U_t^j e^{-\rho t} dt \, , \tag{1}$$

[6] Although the Western European countries differed in the levels of income per capita, they experienced a similar growth rate of income per capita, indicating a similar rate of technological progress (e.g., Galor 2005).

[7] In Azarnert (2004) I consider the effect of the opportunities abroad for the high-skilled taxpayers on taxation and then economic growth. Cf. also Azarnert (2008).

where U_t^j is an instantaneous utility function in country j at time t, and ρ is the discount rate. The instantaneous utility function is a variation on a Stone-Geary-type utility function, and it has four arguments (the goods x, y, z, and q):[8]

$$U_t^j = \alpha \ln(x_t^j + X) + \beta \ln(y_t^j + Y) + \gamma \ln(z_t^j) + \delta \ln(q_t^j), \tag{2}$$

where j specifies the country ($j = H, F$), X and Y are nonnegative constants and $\alpha, \beta, \gamma, \delta \in (0,1)$, $\alpha + \beta + \gamma + \delta = 1$. All goods are perishable, they cannot be accumulated, and saving is not possible, so that consumers maximize their instantaneous utility each period.

Standard maximization problem (max U_t^j s. t. $P_{xt}^j x_t^j + P_{yt}^j y_t^j + P_{zt}^j z_t^j + P_{qt}^j q_t^j = 1$), where P_{it}^j is the price for a good i $(= x, y, z, q)$ in country j at time t gives the demands for x_t^j, y_t^j, z_t^j, and q_t^j:

$$x_t^j = \frac{\alpha}{P_{xt}^j}\left(1 + P_{yt}^j Y - \frac{\beta + \gamma + \delta}{\alpha} P_{xt}^j X\right), \tag{3}$$

$$y_t^j = \frac{\beta}{P_{yt}^j}\left(1 + P_{xt}^j X - \frac{\alpha + \gamma + \delta}{\beta} P_{yt}^j Y\right), \tag{4}$$

$$z_t^j = \frac{\gamma}{P_{zt}^j}\left(1 + P_{xt}^j X + P_{yt}^j Y\right), \tag{5}$$

$$q_t^j = \frac{\delta}{P_{qt}^j}\left(1 + P_{xt}^j X + P_{yt}^j Y\right). \tag{6}$$

The demand for all four goods is not homothetic. An assumption that $\frac{1-\alpha}{\alpha} P_{xt}^j X - P_{yt}^j Y < 1$ and $\frac{1-\beta}{\beta} P_{yt}^j Y - P_{xt}^j X < 1$ ensures that there are always strictly positive demands for all four goods. Given that population size in both countries is normalized to 1, equations (3) to (6) represent both individual and total demand in each country.

Finally, we obtain the indirect utility function by plugging the demand for goods $x, y, z,$ and q (equations (3) to (6)) into the instantaneous utility function (equation (2)):

$$U_t^j = \ln(1 + P_{xt}^j X + P_{yt}^j Y) - \alpha \ln P_{xt}^j - \beta \ln P_{yt}^j - \gamma \ln P_{zt}^j - \delta \ln P_{qt}^j + J, \tag{7}$$

[8] Note however that this is not a standard Stone-Geary utility function with minimum consumption requirements. A similar formulation of the demand for high income elasticity goods along with the

where $J \equiv \alpha \ln \alpha + \beta \ln \beta + \gamma \ln \gamma + \delta \ln \delta$.

2.2. Supply side

In both countries all the goods are produced using labor as the only input with a constant return to scale technology:

$$x_t^j = \frac{1}{a_{xt}^j} L_{xt}^j;\ y_t^j = \frac{1}{a_{yt}^j} L_{yt}^j;\ z_t^j = \frac{1}{a_z^j} L_{zt}^j;\ q_t^j = \frac{1}{a_q^j} L_{qt}^j, \tag{8}$$

where L_{it}^j is the number of workers employed in the production of good $i\,(=x, y, z, q)$ in country j at time t and a_i^j is a coefficient that is country- and good-specific.

Suppose that the goods z and q are traditional matured goods where no further learning is possible, while the goods x and y are more sophisticated goods where learning is still possible. Thus, the unit labor requirement (a_i^j) is constant for goods z and q, whereas for goods x and y it can change over time, because in sectors x and y technological progress is possible as specified below.

The two countries have different technologies. The comparative advantages are assumed to be as follows:[9]

$$\frac{a_{xt}^H}{a_{xt}^F} > \frac{a_z^H}{a_z^F} > \frac{a_q^H}{a_q^F} > \frac{a_{yt}^H}{a_{yt}^F}. \tag{9}$$

I assume a competitive environment in both countries, so that in a closed economy $P_{xt}^j = a_{xt}^j;\ P_{yt}^j = a_{yt}^j;\ P_{zt}^j = a_z^j;\ P_{qt}^j = a_q^j$.

Technological progress, which is country specific and limited to the sophisticated goods x and y, operates through a learning-by-doing as, for example, in Krugman (1987), Lucas (1988), Redding (1999), and Spilimbergo (2000). In both advanced sectors the percentage reduction in the production cost is proportional to the number of workers employed in the production and to a constant ξ:

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underlying justification and some further references can be found, for instance, in Markusen (2010). Cf. also Caron, Fally and Markusen (2012).

[9] In line with this assumption, Jaimovich and Merella (2011) provide evidence that comparative advantages are stronger in higher-quality goods.

$$\frac{\dot{a}_{it}^{j}}{a_{it}^{j}} = -\xi L_{it}^{j}, \quad i = x, y, \tag{10}$$

where L_{xt}^{j} and L_{yt}^{j} represent the number of workers who are employed in the production of the corresponding goods x and y in country j at time t.

2.3. Equilibrium in autarky

I proceed by determining the prices faced by consumers, the relative demands, and the dynamics of the economy. Recall that except for the comparative advantages, as specified above in (9), both countries are identical.

Note that in autarky the demands for all four goods change over time because they depend on a_{xt}^{j} and a_{yt}^{j}, which decrease over time owing to technological progress. In particular, the reduction in a_{xt}^{j} and a_{yt}^{j} decreases the demand for the traditional goods z and q (equations (5) and (6)), thus reducing the share of income allocated to the products without learning. In the case of the sophisticated goods x and y, the effect of technological progress is twofold. First, it drives down the good's own price, thus increasing the demand for that good. Second, it also generates some substitution effect in favor of the other sophisticated product. But overall technological progress increases the relative demand for the products with further learning-by-doing.

The time path of a_{xt}^{j} and a_{yt}^{j} depends, through the formula for the learning-by-doing (equation (10)), on the number of workers employed in the sectors x (L_{xt}^{j}) and y (L_{yt}^{j}) and on the demand for x and y (equations (3) and (4)). Using equations (8), (3), and (4) and noting that $P_{xt}^{j} = a_{xt}^{j}$ and $P_{yt}^{j} = a_{yt}^{j}$, we can obtain the rates of growth of a_{xt}^{j} and a_{yt}^{j}:

$$\frac{\dot{a}_{xt}^{j}}{a_{xt}^{j}} = -\xi L_{xt}^{j} = -\xi(\alpha(1 + a_{yt}^{j} Y) - (\beta + \gamma + \delta) a_{xt}^{j} X), \tag{11}$$

or

$$a_{xt}^{j} = a_{x0}^{j} e^{-\xi D_{x0}^{j,a} t}, \quad \text{where} \quad D_{x0}^{j,a} \equiv \alpha(1 + a_{y0}^{j} Y) - (\beta + \gamma + \delta) a_{x0}^{j} X, \tag{12}$$

and, correspondingly,

$$\frac{\dot{a}_{yt}^{j}}{a_{yt}^{j}} = -\xi L_{yt}^{j} = -\xi(\beta(1+a_{xt}^{j}X) - (\alpha+\gamma+\delta)a_{yt}^{j}Y) , \tag{13}$$

or

$$a_{yt}^{j} = a_{y0}^{j} e^{-\xi D_{y0}^{j,a} t} , \quad \text{where} \quad D_{y0}^{j,a} \equiv \beta(1+a_{x0}^{j}X) - (\alpha+\gamma+\delta)a_{y0}^{j}Y . \tag{14}$$

Plugging $a_{xt}^{j}, a_{yt}^{j}, a_{z}^{j},$ and a_{q}^{j} for $P_{xt}^{j}, P_{yt}^{j}, P_{zt}^{j},$ and P_{qt}^{j} into equation (7), we can obtain the utility in autarky in country j at time t:

$$U_{t}^{j} = \ln(1+a_{xt}^{j}X + a_{yt}^{j}Y) - \alpha\ln a_{x0}^{j} - \beta\ln a_{y0}^{j} - \gamma\ln a_{z}^{j} - \delta\ln a_{q}^{j} + J$$
$$+ \xi(\alpha D_{x0}^{j,a} + \beta D_{y0}^{j,a})t . \tag{15}$$

Therefore, the welfare in country j in autarky at time 0 is:

$$W_{0}^{j} = \int_{0}^{\infty} U_{t}^{j} e^{-\rho t} dt = \int_{0}^{\infty} S^{j,a} e^{-\rho t} dt + \xi \int_{0}^{\infty} D^{j,a} t e^{-\rho t} dt = \frac{S^{j,a}}{\rho} + \frac{\xi D^{j,a}}{\rho^{2}} , \tag{16}$$

where $S^{j,a} \equiv \ln(1+a_{x0}^{j}X + a_{y0}^{j}Y) - \alpha\ln a_{x0}^{j} - \beta\ln a_{y0}^{j} - \gamma\ln a_{z}^{j} - \delta\ln a_{q}^{j} + J$

and $D^{j,a} \equiv \alpha D_{x0}^{j,a} + \beta D_{y0}^{j,a} = \alpha^{2}(1+a_{y0}^{j}Y) + \beta^{2}(1+a_{x0}^{j}X) - \alpha(1-\alpha)a_{x0}^{j}X - \beta(1-\beta)a_{y0}^{j}Y$.

As in Spilimbergo (2000), the utility is thus decomposed into two components: a static component ($S^{j,a}/\rho$), which depends on the present state of the technology ($a_{x0}^{j}, a_{y0}^{j}, a_{z}^{j}, a_{q}^{j}$), and a dynamic component ($\xi D^{j,a}/\rho^{2}$), which depends on the accumulation rate of technological progress and on the amount of labor employed in the production of x and y.

2.4. Equilibrium with free international trade

In this section international trade is allowed. The equilibrium with trade between Home and Foreign is supposed to satisfy two conditions: first, production must be split according to comparative advantages; second, trade must be balanced. These two conditions determine the range of goods produced in the Home and in the Foreign and the relative wage between the Home and the Foreign. Using the wage in the Home as numeraire, we define ω_t as the wage in the Foreign country in terms of the wage in the Home country.

2.4.1. Comparative advantages

The first condition states that the location of the production of the goods is split according to comparative advantages. Note that the goods z and q are defined as traditional matured goods, while the goods x and y are the more sophisticated goods where further learning is possible. Note also that the Home country has a comparative advantage in the production of the matured good q and the more sophisticated good y, while the Foreign country has a comparative advantage in the production of the matured good z and the more sophisticated good x (equation (9)). Further, I suppose that when trade is allowed the Home will produce and export the goods y and q, while the Foreign will produce and export the goods x and z. Specific assumption about the parameters to ensure that the production follows this specialization pattern will be made in Section 2.4.3.

2.4.2. Balanced trade

The second condition states that trade must be balanced. To find the level of ω_t, which solves this condition, we have to determine the relative prices in both countries. Given the specialization pattern, the relative prices are:

$$\text{in the Home country} = \begin{cases} P_{xt}^H = a_{xt}^F \omega_t \\ P_{yt}^H = a_{yt}^H \\ P_{zt}^H = a_z^F \omega_t \\ P_{qt}^H = a_q^H \end{cases} \quad \text{and in the Foreign country} = \begin{cases} P_{xt}^F = a_{xt}^F \\ P_{yt}^F = a_{yt}^H / \omega_t \\ P_{zt}^F = a_z^F \\ P_{qt}^F = a_q^H / \omega_t \end{cases} \tag{17}$$

The balanced trade condition requires that the value of the import of the Home should equal the value of the import of the Foreign. Given the specialization pattern, this implies that:

$$x_t^H P_{xt}^H + z_t^H P_{zt}^H = (y_t^F P_{yt}^F + q_t^F P_{qt}^F)\omega_t . \tag{18}$$

Therefore,

$$x_t^H P_{xt}^H + z_t^H P_{zt}^H = (1 - x_t^F P_{xt}^F - z_t^F P_{zt}^F)\omega_t . \tag{19}$$

Substituting the demand for x and z in the Home and the Foreign in equation (19) yields the equilibrium level of ω_t (details are in Appendix A):

$$\omega_t = \frac{\alpha+\gamma}{1-\alpha-\gamma}\frac{1+2a_{yt}^{H}Y}{1+2a_{xt}^{F}X}. \tag{20}$$

Note that if a_{yt}^{H} and a_{xt}^{F} decline due to the learning-by-doing, whereas a_{q}^{H} and a_{z}^{F} remain constant, the relative price of the imported sophisticated good to the imported matured good – (P_{xt}^{H}/P_{zt}^{H})=(a_{xt}^{F}/a_{z}^{F}) for the Home and (P_{yt}^{F}/P_{qt}^{F})=(a_{yt}^{H}/a_{q}^{H}) for the Foreign – declines over time.

2.4.3. Welfare with free international trade

Welfare depends on the present state of the technology and on the dynamics of the prices of x and y, which, in turn, depend on the labor force producing x and y through the learning-by-doing process.

We first compute the total demand for x_t and y_t (details are in Appendix B):

$$x_t^{H,tr} + x_t^{F,tr} = \frac{1}{a_{xt}^{F}}D_{xt}^{tr}, \quad \text{where } D_{xt}^{tr} \equiv \alpha\left(\frac{1}{\alpha+\gamma}(1-\frac{2\gamma}{\alpha}a_{xt}^{F}X)\right) \tag{21}$$

and

$$y_t^{H,tr} + y_t^{F,tr} = \frac{1}{a_{yt}^{H}}D_{yt}^{tr}, \quad \text{where } D_{yt}^{tr} \equiv \beta\left(\frac{1}{1-\alpha-\gamma}(1-\frac{2\delta}{\beta}a_{yt}^{H}Y)\right). \tag{22}$$

The assumption that $1>(2\gamma/\alpha)a_{xt}^{F}X$ and $1>(2\delta/\beta)a_{yt}^{H}Y$ ensures that under free trade the demand for x and y is strictly positive and the specialization follows the pattern described above.

The total amount of labor in sector x is D_x^{tr}, and the total amount of labor in sector y is D_y^{tr}. The labor force in sectors x and y determines the temporal path of the coefficients a_{xt}^{F} and a_{yt}^{H} according to the formula for the learning-by-doing (equation (10)):

$$a_{xt}^{F} = a_{x0}^{F}e^{-\xi D_{x0}^{tr}t}, \tag{23}$$

and

$$a_{yt}^{H} = a_{y0}^{H} e^{-\xi D_{y0}^{tr} t} . \qquad (24)$$

At the same time, once trade starts, the Home stops producing x and therefore $\forall t$, $a_{xt}^{H} = a_{x0}^{H}$. Correspondingly, the Foreign stops producing y and therefore $\forall t$, $a_{yt}^{F} = a_{y0}^{F}$.

Now, once we have the temporal path followed by the prices of x and y, the utility in the Home and in the Foreign in the case of trade at time 0 can be calculated:

$$W_0^{j,tr} = \int_0^{\infty} U_t^{j,tr} e^{-\rho t} dt = \frac{S^{j,tr}}{\rho} + \frac{\xi D^{tr}}{\rho^2} \ , \qquad (25)$$

where

$$S^{F,tr} \equiv \ln(1 + a_{x0}^{F} X + (a_{y0}^{H} / \omega_0) Y) - \alpha \ln a_{x0}^{F} - \beta \ln(a_{y0}^{H} / \omega_t) - \gamma \ln a_z^{F} - \delta \ln(a_q^{H} / \omega_0) + J \ ,$$

$$S^{H,tr} \equiv \ln(1 + a_{x0}^{F} \omega_0 X + a_{y0}^{H} Y) - \alpha \ln a_{x0}^{F} \omega_0 - \beta \ln a_{y0}^{H} - \gamma \ln a_z^{F} \omega_0 - \delta \ln a_q^{H} + J \ ,$$

and $D^{tr} \equiv \alpha^2 \left(\frac{1}{\alpha + \gamma} (1 - \frac{2\gamma}{\alpha} a_{x0}^{F} X) \right) + \beta^2 \left(\frac{1}{1 - \alpha - \gamma} (1 - \frac{2\delta}{\beta} a_{y0}^{H} Y) \right)$.

As in the case of autarky, the utility is decomposed into two components: a static component ($S^{j,tr} / \rho$), which depends on the present state of the technology ($a_{x0}^{F}, a_{y0}^{H}, a_z^{F}, a_q^{H}$), and a dynamic component ($\xi D^{tr} / \rho^2$), which depends on the accumulation rate of technological progress and on the amount of labor employed in the production of x and y. Note also that with free trade the dynamic component is the same in the Home and in the Foreign, because it depends on the total demand for goods x and y worldwide.

2.5. Growth in autarky and with free trade

In this section, I consider both economies separately. I first present the Home country. Next, I proceed to the Foreign country.

For tractability, I also make the following technical assumption:

A1: $\frac{1}{2}(1-\beta-\frac{\alpha^2}{\beta})(1-\alpha-\gamma)<\delta<\gamma\left(\frac{2-\alpha-\gamma}{\alpha+\gamma}\right)+\beta\left(\frac{\beta-\alpha}{\alpha}\right).$

2.5.1. Home country

With free trade, the prices of the goods x and z in the home country are lower than in autarky ($a_{xt}^F\omega_t < a_{xt}^H$ and $a_z^F\omega_t < a_z^H$), while the prices of the goods y and q do not change. For this reason, the static component of the utility is always larger with trade than under autarky ($S^{H,tr} > S^{H,a}$):

$$S^{H,tr} - S^{H,a} = \alpha\ln\left(\frac{a_{x0}^H}{a_{x0}^F\omega_0}\right) + \gamma\ln\left(\frac{a_z^H}{a_z^F\omega_0}\right) + \ln\left(\frac{1+a_{x0}^F\omega_0 X + a_{y0}^H Y}{1+a_{x0}^H X + a_{y0}^H Y}\right). \tag{26}$$

The first two terms in the right-hand side of equation (26) represent the gains in utility due to the standard terms of trade effect, while the third term is due to the presence of nonhomotheticity. The size of the static gain depends on the relative prices of the goods x and z under autarky and with trade.

The change in the dynamic component depends on the strength of the substitution and the nonhomotheticity effects vis-à-vis the income effect. The income, the substitution and the nonhomotheticity effects can be separated in the equation for the difference between the dynamic components of welfare with and without trade:

$$\begin{aligned} D_t^{H,tr} - D_t^{H,a} &= \left(\alpha^2\frac{1-\alpha-\gamma}{\alpha+\gamma} + \beta^2\frac{\alpha+\gamma}{1-\alpha-\gamma}\right) + \left(\beta(1-\beta)-\alpha^2-\frac{2\beta\delta}{1-\alpha-\gamma}\right)a_{yt}^H Y \\ &\quad + \left((\alpha(1-\alpha)-\beta^2)a_{xt}^H - \frac{2\alpha\gamma}{\alpha+\gamma}a_{xt}^F\right)X\ . \end{aligned} \tag{27}$$

With homotheticity, X and Y are equal to 0 and the difference between $D_t^{H,tr}$ and $D_t^{H,a}$ is simply $\alpha^2\frac{1-\alpha-\gamma}{\alpha+\gamma} + \beta^2\frac{\alpha+\gamma}{1-\alpha-\gamma}$, which represents the sum of the income and substitution effects. The income and substitution effects are always positive.

The second and third terms in the right-hand side of equation (27) represent the nonhomothetic effect, which can be either positive or negative. Thus, under assumption A1, $\delta > (1/2)(1-\beta-(\alpha^2/\beta))(1-\alpha-\gamma)$, which implies that the second term is always negative. The third term in the equation is negative as long as $\frac{a_{xt}^{H}}{a_{xt}^{F}} < \frac{2\gamma}{(\alpha+\gamma)((1-\alpha)-(\beta^{2}/\alpha))}$, while if the inequality changes its sign, it becomes positive.

In sum, the difference between the dynamic component with and without trade in the Home country is negative if:

$$\frac{2\alpha\gamma}{\alpha+\gamma}a_{xt}^{F}X+\left(\frac{2\beta\delta}{1-\alpha-\gamma}+\alpha^{2}-\beta(1-\beta)\right)a_{yt}^{H}Y$$
$$>\alpha^{2}\frac{1-\alpha-\gamma}{\alpha+\gamma}+\beta^{2}\frac{\alpha+\gamma}{1-\alpha-\gamma}+(\alpha(1-\alpha)-\beta^{2})a_{xt}^{H}X\ . \qquad (28)$$

Note that if the difference between the dynamic component with and without trade is negative, free trade reduces technological progress in the Home country relative to autarky.

The net effect of trade on welfare is ambiguous. But, if the static gains due to the exploitation of comparative advantages are positive enough to outweigh the dynamic losses, the Home country is better off with trade, even if free trade reduces technological progress in the Home country relative to autarky. The formal condition for the Home country not to lose from trade is relegated to Appendix C.

Inequality (28) is central in the present story. Recall that once free trade starts, the Home country stops producing the good x, which implies that the learning process in the production of x in the Home ceases and, therefore, $\forall\, t$, $a_{xt}^{H}=a_{x0}^{H}$. At the same time, under free trade the Home and the Foreign specialize in the production of y and x, correspondingly. Therefore, unit labor requirements in the production of the goods y in the Home (a_{yt}^{H}) and x in the Foreign (a_{xt}^{F}) decrease over time due to the learning-by-doing. Thus, the LHS of inequality (28) decreases over time with a_{yt}^{H} and a_{xt}^{F}, while the RHS of this inequality remains constant, because $\forall\, t$, $a_{xt}^{H}=a_{x0}^{H}$. Therefore, even if initially when trade starts the LHS of (28) is larger than the RHS, the LHS will eventually decline enough to intersect with the constant RHS:

$$\alpha^{2}\frac{1-\alpha-\gamma}{\alpha+\gamma}+\beta^{2}\frac{\alpha+\gamma}{1-\alpha-\gamma}+(\alpha(1-\alpha)-\beta^{2})a_{x0}^{H}X\ .$$

This intersection point is crucial in the story. When the LHS of inequality (28) declines enough to fall below the RHS, the effect of trade on economic growth changes. From this intersection point on, the difference between the dynamic component with and without trade (equation 27) becomes positive. This implies that from this period on, the effect of trade on technological progress is no longer negative, but instead free trade starts to increase technological progress in the Home country.

2.5.2. Foreign country

As in the Home country, in the Foreign country, I also separate the effect of trade on static and dynamic components. The difference in the static component is

$$S^{F,tr} - S^{F,a} = \beta \ln\left(\frac{a_{y0}^{F}\omega_0}{a_{y0}^{H}} \right) + \delta \ln\left(\frac{a_{q}^{F}\omega_0}{a_{q}^{H}} \right) + \ln\left(\frac{1 + a_{x0}^{F}X + (a_{y0}^{H}/\omega_0)Y}{1 + a_{x0}^{F}X + a_{y0}^{F}Y} \right). \tag{29}$$

Because the prices of the goods y and q are always lower with trade than in autarky ($((a_{yt}^{H}/\omega_t) < a_{yt}^{F}$ and $((a_{q}^{H}/\omega_t) < a_{q}^{F}$), while the prices of the goods x and z do not change, the static component is always larger with trade than in autarky ($S^{F,tr} > S^{F,a}$).

The difference in the dynamic component is

$$D_t^{F,tr} - D_t^{F,a} = \left(\alpha^2 \frac{1-\alpha-\gamma}{\alpha+\gamma} + \beta^2 \frac{\alpha+\gamma}{1-\alpha-\gamma} \right) + \left(\alpha(1-\alpha) - \beta^2 - \frac{2\alpha\gamma}{\alpha+\gamma} \right) a_{xt}^{F} X$$
$$+ \left((\beta(1-\beta) - \alpha^2) a_{yt}^{F} - \frac{2\beta\delta}{1-\alpha-\gamma} a_{yt}^{H} \right) Y . \tag{30}$$

As in the Home country, the combined income and substitution effect of trade in the Foreign country (the first term in the right-hand side of equation (30)) is always positive. Moreover, given that the size of population in both countries is supposed to be the same (and normalized to 1), the combined income and substitution effect is the same across the countries.

Akin to the Home country, the nonhomothetic effect, as represented by the second and third terms in the right-hand size of equation (30), can be either positive or negative.

Thus, under assumption A1, $\delta < \gamma\left(\frac{2-\alpha-\gamma}{\alpha+\gamma}\right)+\beta\left(\frac{\beta-\alpha}{\alpha}\right)$, which implies that the second term is always negative, while if $\frac{a_{yt}^{F}}{a_{yt}^{H}} < \frac{2\delta}{(1-\beta-(\alpha^2/\beta))(1-\alpha-\gamma)}$, the third term is negative as well.

In sum, the difference in the dynamic component in the Foreign country is negative if

$$\left(\frac{2\alpha\gamma}{\alpha+\gamma}+\beta^2-\alpha(1-\alpha)\right)a_{xt}^{F}X+\frac{2\beta\delta}{1-\alpha-\gamma}a_{yt}^{H}Y$$
$$>\alpha^2\frac{1-\alpha-\gamma}{\alpha+\gamma}+\beta^2\frac{\alpha+\gamma}{1-\alpha-\gamma}+(\beta(1-\beta)-\alpha^2)a_{yt}^{F})Y \qquad (31)$$

As long as the above inequality holds, free trade reduces technological progress in the Foreign country relative to autarky.

However, as in the case of the Home, if the static gains due to the exploitation of comparative advantages are positive enough to outweigh the dynamic losses, the Foreign can be better off with trade, despite the initial negative effect of free trade on technological progress in the Foreign country relative to autarky. The formal condition for the Foreign country not to lose from trade is relegated in Appendix C.

With the same intuition as in the case of the Home country, inequality (31) demonstrates the reversal of the effect of free trade on economic growth. Thus, if initially the LHS of (31) is larger than the RHS, the difference between the dynamic components with and without trade (equation 30) is negative, and free trade reduces technological progress in the Foreign country. However, exactly as in the Home, in the course of time unit labor requirements a_{xt}^{F} and a_{yt}^{H} decline, while $\forall\, t$, $a_{yt}^{F}=a_{y0}^{F}$. This guarantees that the LHS of (31) will eventually fall below the constant RHS of (31):

$$\alpha^2\frac{1-\alpha-\gamma}{\alpha+\gamma}+\beta^2\frac{\alpha+\gamma}{1-\alpha-\gamma}+(\beta(1-\beta)-\alpha^2)a_{y0}^{F})Y\,.$$

Akin to the Home country, from this intersection point on, the effect of free trade on technological progress in the Foreign country reverses and becomes positive.

This allows us to conclude that initially, when the trading countries are at a low stage of development with relatively high unit labor requirements in the production of the sophisticated products x and y (a_{xt}^{F} and a_{yt}^{H}), free trade reduces economic growth. In contrast, when the trading countries are at a more advanced stage of development with relatively low unit labor requirements, free trade enhances economic growth.

3. Conclusion

Many empirical studies argue that the positive relationship between openness and growth is a recent phenomenon and that before World War II openness was negatively associated with growth. This article presents a Ricardian model of trade that generates the reversal of the effect of trade on growth at a more advanced stage of development, as has been widely argued empirically. To generate this reversal, I combine technological progress, which is modeled as learning-by-doing, with nonhomothetic preferences. The model shows that initially, when the trading economies are at a low stage of development, free trade may reduce growth. Later on, at a more advanced stage of development, the effect of trade reverses and becomes positive.

Appendix A: Computation of ω_t

The steps to compute ω_t are:

$$\alpha\left(1+P_{yt}^{H}Y-\frac{\beta+\gamma+\delta}{\alpha}P_{xt}^{H}X\right)+\gamma\left(1+P_{xt}^{H}X+P_{yt}^{H}Y\right)$$

$$=\left[1-\alpha\left(1+P_{yt}^{F}Y-\frac{\beta+\gamma+\delta}{\alpha}P_{xt}^{F}X\right)-\gamma\left(1+P_{xt}^{F}X+P_{yt}^{F}Y\right)\right]\omega_t\,,$$

$$\alpha\left(1+a_{yt}^{H}Y-\frac{\beta+\gamma+\delta}{\alpha}a_{xt}^{F}\omega_t X\right)+\gamma\left(1+a_{xt}^{F}\omega_t X+a_{yt}^{H}Y\right)$$

$$=\left[1-\alpha\left(1+\frac{a_{yt}^{X}}{\omega_t}Y-\frac{\beta+\gamma+\delta}{\alpha}a_{xt}^{F}X\right)-\gamma\left(1+a_{xt}^{F}X+\frac{a_{yt}^{H}}{\omega_t}Y\right)\right]\omega_t\,.$$

Solving this equality for ω_t gives equation (20).

Alternatively, the solution for ω_t can be obtained using equality: $[1-(P_{yt}^H y_t^H + P_{qt}^H q_t^H)]/\omega_t = P_{yt}^F y_t^F + P_{qt}^F q_t^F$.

Appendix B: Computation of the total demand for x_t and y_t

The total demand for x_t and y_t is the sum of the demand in the Home and in the Foreign. The total demand for x_t is:

$$x_t^{H,tr} + x_t^{F,tr} = \frac{\alpha}{P_{xt}^H}\left(1 + P_{yt}^H Y - \frac{\beta+\gamma+\delta}{\alpha} P_{xt}^H X\right) + \frac{\alpha}{P_{xt}^F}\left(1 + P_{yt}^F Y - \frac{\beta+\gamma+\delta}{\alpha} P_{xt}^F X\right)$$

$$= \frac{\alpha}{a_{xt}^F \omega_t}\left(1 + a_{yt}^H Y - \frac{\beta+\gamma+\delta}{\alpha} a_{xt}^F \omega_t X\right) + \frac{\alpha}{a_{xt}^F}\left(1 + \frac{a_{yt}^H}{\omega_t} Y - \frac{\beta+\gamma+\delta}{\alpha} a_{xt}^F X\right)$$

$$= \frac{\alpha}{a_{xt}^F}\left(1 + \frac{1+2a_{yt}^H Y}{\omega_t} - 2\frac{\beta+\gamma+\delta}{\alpha} a_{xt}^F X\right).$$

Plugging in the equation for ω_t (20) and simplifying gives equation (21).

Similarly, the total demand for y_t is:

$$y_t^{F,tr} + y_t^{H,tr} = \frac{\beta}{P_{yt}^F}\left(1 + P_{xt}^F X - \frac{\alpha+\gamma+\delta}{\beta} P_{yt}^F Y\right) + \frac{\beta}{P_{yt}^H}\left(1 + P_{xt}^H X - \frac{\alpha+\gamma+\delta}{\beta} P_{yt}^H Y\right)$$

$$= \frac{\beta\omega_t}{a_{yt}^H}\left(1 + a_{xt}^F X - \frac{\alpha+\gamma+\delta}{\beta}\frac{a_{yt}^H}{\omega_t} Y\right) + \frac{\beta}{a_{yt}^H}\left(1 + a_{xt}^F \omega_t X - \frac{\alpha+\gamma+\delta}{\beta} a_{yt}^H Y\right)$$

$$= \frac{\beta}{a_{yt}^H}\left(1 + (1+2a_{xt}^F X)\omega_t - 2\frac{\alpha+\gamma+\delta}{\beta} a_{yt}^H Y\right).$$

Plugging in the equation for ω_t (20) and simplifying gives equation (22).

Appendix C: Free trade or autarky?

The condition for the welfare in either country to be higher under free trade than in autarky is

$$W_0^{j,tr} > W_0^{j,a} \quad \Rightarrow \quad S^{j,tr} - S^{j,a} > \frac{\xi}{\rho}(D^{j,a} - D^{j,tr}).$$

Using equations (26) and (27) and substitution ω_t from (20), the Home country gains from free trade if in the period of trade liberalization ($t = 0$):

$$\alpha \ln\left(\frac{1-\alpha-\gamma}{\alpha+\gamma}\frac{1+2a_{x0}^F X}{1+2a_{y0}^H}\frac{a_{x0}^H}{a_{x0}^F}\right) + \gamma \ln\left(\frac{1-\alpha-\gamma}{\alpha+\gamma}\frac{1+2a_{x0}^F X}{1+2a_{y0}^H Y}\frac{a_z^H}{a_z^F}\right)$$

$$+ \ln\left(\frac{1+a_{y0}^H Y - \dfrac{\alpha+\gamma}{1-\alpha-\gamma}\dfrac{1+2a_{y0}^H Y}{1+2a_{x0}^F Y}a_{x0}^F X}{1+a_{x0}^H X + a_{y0}^H Y}\right)$$

$$> \frac{\xi}{\rho}\left[\frac{2\alpha\gamma}{\alpha+\gamma}a_{x0}^F X + \left(\frac{2\beta\delta}{1-\alpha-\gamma} + \alpha^2 - \beta(1-\beta)\right)a_{y0}^H Y\right.$$

$$\left. - \alpha^2\frac{1-\alpha-\gamma}{\alpha+\gamma} + \beta^2\frac{\alpha+\gamma}{1-\alpha-\gamma} + (\alpha(1-\alpha) - \beta^2)a_{x0}^H X\right].$$

Otherwise, if the above inequality changes its sign, the Home country can lose with trade relative to autarky.

Likewise, using equations (29) and (30) and substitution ω_t from (20), the Foreign country gains from the free trade if in the period of trade liberalization ($t = 0$):

$$\beta \ln\left(\frac{\alpha+\gamma}{1-\alpha-\gamma}\frac{1+2a_{y0}^Y Y}{1+2a_{x0}^F X}\frac{a_{y0}^F}{a_{y0}^H}\right) + \delta \ln\left(\frac{\alpha+\gamma}{1-\alpha-\gamma}\frac{1+2a_{y0}^H Y}{1+2a_{x0}^F X}\frac{a_q^F}{a_q^H}\right)$$

$$+ \ln\left(\frac{1+a_{x0}^F X + \dfrac{1-\alpha-\gamma}{\alpha+\gamma}\dfrac{1+2a_{x0}^F X}{1+2a_{y0}^H Y}a_{y0}^H Y}{1+a_{x0}^F X + a_{y0}^F Y}\right)$$

$$> \frac{\xi}{\rho}\left[\left(\frac{2\alpha\gamma}{\alpha+\gamma} + \beta^2 - \alpha(1-\alpha)\right)a_{x0}^F X + \frac{2\beta\delta}{1-\alpha-\gamma}a_{y0}^H Y\right.$$

$$\left. - \alpha^2\frac{1-\alpha-\gamma}{\alpha+\gamma} + \beta^2\frac{\alpha+\gamma}{1-\alpha-\gamma} + ((\beta(1-\beta) - \alpha^2)a_{y0}^F)Y\right].$$

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