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Growth and Trade: the North can Lose

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Abstract

Models on the composition of trade and growth often assume that the technological content of trade is negatively correlated with the income of the trading partner.

First, we show that this assumption is not supported empirically. Second, we present a Ricardian model with non-homothetic preferences. The North specializes in two goods: one advanced (z) and one less advanced (y); the South specializes in a less advanced good (x). If the South's demand is biased towards good y, and if the North redirects expenditure in favor of good x after trade, the production of z diminishes and this could lower welfare in the North in the presence of learning-by-doing.

Key words: O41, F15.

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1. Introduction

The relationship between trade and growth has interested economists at least since Adam Smith. The recent formation of regional agreements among countries at different levels of economic development has posed the additional question of whether the composition of trade, more than trade itself, is relevant for growth. Hence, models were developed to analyze the relationship between trade composition and growth. Many of these models make the assumption that countries share the same homothetic demand functions; from this it follows that the more developed countries, rich in skilled labor or with superior technology, specialize in skill-intensive goods, which have more potential for technological progress. This paper makes the point that the hypothesis of homotheticity leads to the incorrect conclusion that countries will grow more, the more backward is the trading partner.

In the first part of the paper, we discuss why the homothetic demand functions have been used extensively in trade (especially in issues related to income distribution), and why using them to analyze the issues of trade and growth can lead to incorrect conclusions. Second, we provide evidence that the hypothesis of homotheticity does not explain the pattern of the technological content of U.S.

trade. Third, we develop a Ricardian model of trade with non-homothetic preferences which shows how trade with a developing country can diminish the welfare of the more advanced country.

2. Discussion of the literature and description of the model

Trade theory has stressed two channels through which trade can spur growth.[1] First, trade increases market size and promotes specialization, which increases productivity and growth; this sequence was first proposed by Adam Smith with the example of the pin factory. Second, trade can influence growth through the composition of demand: trade alters the relative prices and the demand for products, and the demand composition determines the overall rate of growth if different products have different technological progress. We focus on the second channel.

The idea that trade composition matters for growth has a long tradition starting with David Ricardo; then, in the 1970s, Lewis (1977), in painting the broad picture of the evolution of the world economy, noted how the specialization of trade among different countries had profound consequences for the growth over

[1] Grossman and Helpman (1991) have published a theoretical book on the subject. Empirical evidence shows a link between trade and growth, although until recently, it was difficult to interpret the causality of this link. Frenkel and Romer (1996), attempting to solve the problem of endogeneity, show convincingly that trade causes growth.

the long term.

But, even with this tradition, it took time before the idea that trade composition has an effect on growth was formalized. For a while, technological progress was taken as exogenous and the effects on income distribution were studied (for a review see Jones, 1979); then, the analysis was extended to include endogenous technological progress and the effects on technology adoption (for a discussion of early work in an Heckscher-Ohlin context see Jones, 1979). More recently, the issue has been analyzed in the context of monopolistic competition and endogenous growth (for a review see Grossman and Helpman, 1991).

The conclusions of the models which focus on the effect on growth of the composition of trade depend on the hypothesis about the nature of the technological progress and the structure of demand. While significant attention has been devoted to the nature of the technological progress (such as learning by doing, spill-over, learning by exporting), less attention has been paid to the demand. This is probably due to the fact that it is technically difficult to move away from standard homothetic utility functions and that some simplifications on the demand side have been perceived just as an innocuous technical assumption.

Historically, trade theory has used mainly homothetic demand functions. The hypothesis of homotheticity is a useful assumption in models explaining income distribution, because it allows us to focus on the relationship between income distribution and relative scarcity of factors of production. Later, the use of the homotheticity hypothesis was extended to the analysis of the dynamic effects of trade; but this assumption is not a minor technical simplification in this case.

For example, consider a naive model with one factor of production, two goods (computers and textiles, both produced with a constant return to scale technology), and two countries (North and South); the two countries differ because they have different comparative advantages. Under the assumption of identical and homothetic demands, the South specializes in textiles and imports computers, while the North specializes in computers and imports textiles. Both countries benefit from trade because they exploit their comparative advantages. Let us suppose that there is technological progress through learning-by-doing in the computer industry; the North, which produces computers, will experience technological progress while the South will not have any progress.[2] It follows that trading with developing countries should lead to more technological progress than trading with developed countries.

The assumption that the technological content of trade is inversely related to

[2]This argument could be used to justify selective tariffs on some goods in the developing countries (see Bardhan, 1970).

the economic development of the trading partner does not seem plausible, as we will see in the next section.

Let us extend the model sketched above, which has only two goods to a model, with non-homothetic preferences and more than two goods. For concreteness, let us suppose that there are two kinds of computers (Pentium and 486); and that while no further technological improvement is possible in the production of 486, there is plenty of room for improvement through learning-by-doing in the production of Pentium. Furthermore, let us suppose that preferences are not homothetic and that rich countries prefer Pentium to 486. The trade patterns are now slightly different: the South exports textiles and imports mostly 486, while the North produces 486 for the external market and Pentium for the internal market, and imports textiles.

While in models with homothetic preferences the total demand for Pentium undoubtedly goes up, it is not straightforward that this happens in this case. The total demand for Pentium is the sum of two components: the external demand from the South, and the internal demand in the North; the latter could be less than the autarchy equilibrium as a result of the new price structure after trade. If the internal demand drops enough to compensate for the new demand from the South, the total demand for Pentium diminishes, and the learning process and technological progress slow down. In this case, trade with a less developed country improves welfare through the exploitation of comparative advantages but reduces technological progress in the long run; the net effect on the welfare in the long run is ambiguous.. We formalize this model in section 4.

Finally, we take a closer look at two recent models that have interesting insights. First, Young (1992) presents a Ricardian model of trade among countries of different development. This model is interesting because it leads to the conclusion that trading with less developed countries is beneficial to growth, although the demand is non-homothetic. This is due to the assumption that the learning-by-doing and the spill-over effects are the same for all the advanced products; i.e., producing at the technological frontier or producing close to the traditional products has exactly the same consequences for the process of learning. This hypothesis is equivalent to saying that the technological progress is the same in 486 and Pentium in the language of the previous example. In this model, the composition of trade delivers the standard result because there are only two goods with respect to the learning-by-doing process, so the model really belongs to the family of models with only two goods sketched above.

Second, Grossman and Helpman (1991) sketch a model in which a country relatively more endowed with human capital can suffer a decrease in the rate of growth as a consequence of trade with a country less endowed with human capital. The reason for this slowdown comes from the supply side because the research sector, which produces technological innovation, uses the same skilled workers as the exporting sector, so that trade increases the demand for the factor used in research. In Grossman and Helpman (1991) there is an effect from the supply side, while in the present paper we analyze the demand side. The two channels are not alternative and actually reinforce each other.

3. Technological content of trade

The purpose of this section is to study the relationship between the technological content of trade and income level of the trading partner.

Hunter and Markusen (1988) rejected empirically the hypothesis of homotheticity and suggested that differences in demand play a big role in explaining trade; to show their point they used a cross-section analysis of 34 countries and 11 commodity aggregates. This analysis is very important because it provides an empirical confirmation of trade models which are based on the hypothesis of non-homothetic demands, such as Linder and Prebish-Singer. Unfortunately, this analysis is insufficient for our purposes because we need to show that the technological content of trade is not negatively correlated to the income of the trading partner. To do so we need a much more disaggregated analysis of that used by Hunter and Markusen; therefore, we focus on the U.S. trade where more precise data about technological content are available. We use data of U.S. foreign trade with 27 countries for 1989, disaggregated at 3 digit level (SIC). The data include only trade in manufactured goods, since we are not studying the effects of trade on natural resources.[3]

The first question is how to identify the high technology goods, since there is no standard classification for high tech goods. Commonly used methods are: share of researchers over the labor force, share of funds in R&D over sales, and the classification issued by the Department of Commerce. We use all these indicators to construct an index of the technological content of trade with the United States for each trading partner. The index consists in a weighted average of the technological content for each country, where the weights are given by the share of the sector in bilateral trade: $I_i = 100 * \frac{\sum_s l_s X_{is}}{\sum_s X_{is}}$, where X_{is} is the export from United States to country i in sector s, and l_s is the indicator of technological content of the sector s. We report in the Appendix five different indexes which are obtained using different measures of technological intensity.

[3]We report in the Appendix the list of countries. The countries were selected to maximize diversity in geographical coverage, income, and production structure, and to minimize missing data. They cover more than 80 percent of U.S. trade.

Table 1 shows the results of a regression of the technological content of U.S. exports according the definition of the department of commerce on the level of income of the trading partner. All variables are in logarithm. The parameter on income comes with a positive sign, even though it is only slightly significant. The significance of income in this regression increases when a variable for distance and a dummy variable for some Asian countries (Hong Kong, South Korea, Singapore, Taiwan- or the Asian "Tigers") are added. Controlling for distance is justified by the fact that in general, bulky products with high transportation costs have a low technological content (e.g., gravel), so countries with long common borders (e.g., Canada and the United States) trade a lot of low technology products. The dummy for the Asian Tigers is introduced because these countries have a peculiar pattern of trade, importing a disproportionate share of intermediate goods and not importing consumption goods (Lowe, 1991).

Table 1: Dependent variable: ln (technological content of U.S. exports in 1989)

CONSTANT	-1.55 (-1.43)	-0.80 (-0.75)	0.53 (0.74)
ln(y)	0.14 (1.99)	0.14 (1.82)	0.13 (1.63)
ln(distance)	0.23 (2.44)	0.15 (1.64)	
Tigers	-0.26 (-1.94)		
$\bar{R}^2$	0.21	0.12	.06

t-statistics are in brackets.

The other measures of technological intensity give similar results of slight but positive correlation between income of the trading partner and the technological content of exports. There could be several reasons why the technological content of trade is positively correlated with income: technology-intensive intra-industry trade is more relevant among rich countries, technologies are similar among countries with the same level of development so rich countries trade in more technologically-intensive goods, countries have non-homothetic preferences so poor countries have a relatively low demand for sophisticated goods.

Whatever the reason, the correlation between per capita income and the technological intensity of the trading partner's exports is the opposite of the assumption commonly made in the theoretical models of trade and growth. We do not need to distinguish among the possible causes of the correlation for the purpose of this paper; we simply take as fact that the technological intensity of trade is not what is supposed by a standard neoclassical model where technology is a factor of production. We construct our model starting from the assumption that less developed countries have a demand biased towards less sophisticated goods.

4. The model

In this section we develop the basic model with two countries (North and South); the population of the North is normalized to 1, while the population of the South is f. First, we introduce non-homotheticity demand function and specify our hypotheses on the production side; second, we consider the equilibrium with and without trade; and finally, we compare the welfare in autarchy and with trade.

4.1. Demand side

In this economy, the agents share the same endowments and the same preferences in both countries. Each agent is endowed with one unit of labor per period which is sold at the price of 1. The utility of an agent in country l (=North or South) at time 0 is given by $W_l \equiv \int_o^\infty U_{lt} e^{-\rho t} dt$, where U_{lt} is an instantaneous utility function in country l at time t, and ρ is the discount rate. The instantaneous utility function has three arguments (the goods x, y, and z):

$$U_{lt} = \alpha \ln(x_{lt} + X) + \beta \ln(y_{lt} - Y) + \gamma \ln z_{lt} \tag{4.1}$$

where l stands for the country ($l = n, s$), with α, β, $\gamma \in (0, 1)$, $\alpha+\beta+\gamma = 1$; X and Y are positive constants. All the goods are perishable and cannot be accumulated and saving is not possible, so consumers maximize their instantaneous utility each period.

The standard maximization problem ($\max U_{lt}$ s.t. $x_{lt}p_{xlt} + y_{lt}p_{ylt} + z_{lt}p_{zlt} = 1$, where p_{ilt} is the price for goods i $(= x, y, z)$) in country l at time t, gives the demands for x_{lt}, y_{lt}, and z_{lt}:

$$x^{dlt} = \frac{\alpha}{p_{xlt}}\left(1 - p_{ylt}Y - \left(\frac{\beta+\gamma}{\alpha}\right)p_{xlt}X\right) \tag{4.2}$$

$$y^{dlt} = \frac{\beta}{p_{ylt}}\left(1 + p_{xlt}X + \left(\frac{\alpha+\gamma}{\beta}\right)p_{ylt}Y\right) \tag{4.3}$$

$$z^{dlt} = \frac{\gamma}{p_{zlt}}\left(1 + p_{xlt}X - p_{ylt}Y\right). \tag{4.4}$$

The demand for the three goods is not homothetic; we consider z the sophisticated good that is preferred at a higher level of income, for this, reason we impose the condition that $p_{ylt}Y > p_{xlt}X$. Furthermore, we suppose that there are always positive demands for the three goods $\left(1 > p_{ylt}Y + \frac{1-\alpha}{\alpha}p_{xlt}X\right)$. Note that eqs. 4.2, 4.3, 4.4 represent both the individual and total demand in the North, given that the population of the North is normalized to 1; the total demand in the South is obtained by multiplying these equations by f.

Finally, we obtain the indirect utility function by plugging the demand for goods x, y, and z (eqs. 4.2, 4.3, and 4.4) into the instantaneous utility function:

$$U_{lt} = J + \ln\left(1 + p_{xlt}X - p_{ylt}Y\right) - \alpha\ln p_{xlt} - \beta\ln p_{ylt} - \gamma\ln p_{zlt} \tag{4.5}$$

where $J \equiv (\alpha\ln\alpha + \beta\ln\beta + \gamma\ln\gamma)$.

4.2. Supply

In this economy, all the goods are produced by using only labor with a constant return to scale technology:

$$x_{lt} = \frac{1}{a_{xl}} L_{xlt} \qquad y_{lt} = \frac{1}{a_{yl}} L_{ylt} \qquad z_{lt} = \frac{1}{a_{zlt}} L_{zlt} \tag{4.6}$$

where l stands for the country (North or South), L_{ilt} is the number of workers producing good $i\,(= x, y, z)$in country l at time t, and a_{il} is a coefficient which is country and good specific and is constant for goods x and y, a_{zlt} is not constant over time because good z has technological progress as specified below. The two countries have different technologies; we suppose that the comparative advantages are as follow:

$$\frac{a_{xn}}{a_{xs}} > \frac{a_{yn}}{a_{ys}} > \frac{a_{znt}}{a_{zst}}. \tag{4.7}$$

We assume a competitive environment in both countries, so that in a closed economy $p_{xl} = a_{xl}$, $p_{yl} = a_{yl}$, and $p_{zlt} = a_{zlt}$.

Technological progress, which is limited to the sophisticated goods z, operates through a learning-by-doing process and is country specific. The percentage reduction in the production cost is proportional to the number of workers devoted to it and to a constant δ:

$$\frac{\dot{a}_{zlt}}{a_{zlt}} = -\delta L_{zlt} \tag{4.8}$$

where L_{znt} is the number of workers who are producing z in country l at time t.

In the terminology of the example given in the introduction, good x is a mature product such as textiles where developing countries have the biggest comparative advantages, good y is a more sophisticated product such as computer 486 where the North has a bigger comparative advantage but no further learning is possible, and good z is the most sophisticated good such as Pentium where learning is still possible. As real income grows, consumers buy relatively more Pentium and spend relatively less for 486.

4.3. Equilibrium in autarchy

We consider the equilibrium in the North. We proceed by determining the relative prices faced by consumers, the relative demands, and the dynamics of the economy. We take nominal wages as a numeraire so that $p_{int} = a_{int}$. The total demands for goods x, y, and z is obtained from eqs. 4.2, 4.3, and 4.4.

Note that the demands for x and y are constant over time, but the demand for z changes over time because it depends on a_{znt}, which decreases over time due to technological progress. The time path of a_{znt} depends on the amount of workers employed in sector z, L_{znt}. We can determine the temporal path of the price a_{znt} from time 0 on by plugging L_{znt} into the formula for the learning-by-doing process $\left(\frac{\dot{a}_{znt}}{a_{znt}} = -\delta L_{znt} = -\delta\gamma\left(1 + p_{xn}X - p_{yn}Y\right)\right)$:

$$a_{znt} = a_{zn0}e^{-\delta D_a t} \tag{4.9}$$

where $D_a \equiv \gamma\left(1 + a_{xn}X - a_{yn}Y\right)$. We can obtain the instant utility in autarchy at time t by plugging the expression for a_{znt} into 4.5:

$$U_{nt}^a = J + \ln\left(1 + a_{xn}X - a_{yn}Y\right) - \alpha \ln a_{xn} - \beta \ln a_{yn} - \gamma \ln a_{zn0} + \delta D_a t. \tag{4.10}$$

The utility at time 0 is:[4]

$$W^a = \int_o^\infty U_{nt}^a e^{-\rho t} dt \tag{4.11}$$

$$= \frac{S_a}{\rho} + \frac{\delta D_a}{\rho^2} \tag{4.12}$$

where $S_a \equiv \left(J + \ln\left(1 + a_{xn}X - a_{yn}Y\right) - \alpha \ln a_{xn} - \beta \ln a_{yn} - \gamma \ln a_{zn0}\right)$. The utility can be decomposed into two components: a static component $\left(\frac{S_a}{\rho}\right)$, which de-

[4] The complete derivation is in the Appendix.

pends on the present state of the technology (a_{xn}, a_{yn}, and a_{zn0}), and a dynamic component $\left(\frac{\delta D_a}{\rho^2}\right)$, which depends on the dynamic of the rate of accumulation of technological progress.

4.4. Equilibrium with trade

In this section, we allow trade between North and South. We remind the reader that the two countries share the same preferences but have different comparative advantages. We also allow for the two countries to have different populations: the population of the North is normalized to 1 , while the population of the South is f.

The equilibrium with trade between North and South must satisfy two conditions: first, production must be split according to comparative advantages; second, trade must balanced. These two conditions determine the range of goods produced in the North and in the South, and the relative wages between North and South. We define ω as the wage of the South in terms of the wage in the North.

Comparative advantages

The first condition states that the location of the production of the goods is split according to comparative advantages. Following our interpretation that y

and z are computers where the North definitely has large comparative advantages, we make the hypothesis that the North produces and exports the goods y and z, while the South produces and exports goods x. We will make specific assumptions about the parameters so that the production follows this specialization pattern.

Balanced trade

The second condition states that trade must be balanced. To find the level of ω which solves this condition we have to determine the relative prices and the relative demands. The relative prices are:

$$\text{in the North} = \begin{cases} p_{xn} = a_{xs}\omega \\ p_{yn} = a_{yn} \\ p_{znt} = a_{znt} \end{cases} \text{ and in the South} = \begin{cases} p_{xs} = a_{xs} \\ p_{ys} = \frac{a_{yn}}{\omega} \\ p_{zst} = \frac{a_{znt}}{\omega}. \end{cases} \tag{4.13}$$

We obtain the total demand for imports from the South by multiplying the individual demand by f, the number of individuals.[5] The balanced trade condition is:

$$\underbrace{p_{xn}x^{dn}}_{\text{import of North}} = \underbrace{\left[p_{zst}z^{dst} + p_{ys}y^{ds}\right] f\omega}_{\text{import of South}} \tag{4.14}$$

[5]We do not to multiply the individual demand in the North because we normalized the population by 1.

$$p_{xn}x^{dn} = \left[1 - p_{xs}x^{ds}\right] f\omega. \tag{4.15}$$

Substituting in equation 4.14 the demands for x in the North and the South yields the equilibrium level of ω:[6]

$$\omega = \frac{1-(1+f)\,a_{yn}Y}{f+(f+1)\,a_{xs}X}\left(\frac{\alpha}{1-\alpha}\right) \equiv B\left(\bar{f}, \bar{a_{xs}}, \bar{a_{yn}}, \overset{+}{\alpha}, \bar{X}, \bar{Y}\right). \tag{4.16}$$

Note that ω is constant over time because it depends only on parameters which are constant over time. We make the hypothesis that $1 > (1+f)\,a_{yn}Y$ to ensure that ω is positive and the specialization follows the pattern described above.

Welfare

Welfare depends on the present state of the technology and on the dynamics of the price of z, which, in turn, depends on the labor force producing z through the learning-by-doing process. So, we first compute the total demand for z^{dt}:[7]

$$z^{dt} = z^{dnt} + fz^{dst} = \frac{1}{a_{znt}}D_{tr} \tag{4.17}$$

where $D_{tr} \equiv \gamma\left[\frac{1+(1+f)(1-2\alpha)a_{yn}Y}{1-\alpha}\right]$. The total amount of labor in sector z is D_{tr},

[6] The derivation of equation 4.16 is in the Appendix.
[7] The complete derivation is in the Appendix.

and is constant over time. The labor force in sector z determines the temporal path of the coefficient a_{znt} according the formula for the learning-by-doing process $\left(\frac{\dot{a}_{znt}}{a_{znt}} = -\delta L_{znt} = -\delta D_{tr}\right)$:

$$a_{znt} = a_{zn0}e^{-\delta D_{tr}t}. \tag{4.18}$$

Now that we have the temporal path followed by the price of z, we can calculate the utility in the North in the case of trade at time 0:

$$W^{tr} = \int_{o}^{\infty} U_{nt}^{tr} e^{-\rho t} dt \tag{4.19}$$

$$= \frac{S_{tr}}{\rho} + \frac{\delta D_{tr}}{\rho^2} \tag{4.20}$$

where $S_{tr} \equiv (J + \ln(1 + a_{xs}\omega X - a_{yn}Y) - \alpha \ln a_{xs}\omega - \beta \ln a_{yn} - \gamma \ln a_{zn0})$. The utility can be decomposed into two components, as in the case of autarchy: a static component $\left(\frac{S_{tr}}{\rho}\right)$, which depends on the present state of the technology in both countries (a_{xs}, a_{yn}, and a_{zn0}), and a dynamic component $\left(\frac{\delta D_{tr}}{\rho^2}\right)$, which depends on accumulation of technological progress and on the amount of labor which is employed in the production of good z.

4.5. Comparison between autarchy and free trade

We study under which condition trade is detrimental to the welfare of the North. The condition for welfare in the North to be higher in autarchy than under free trade is:

$$W^a > W^{tr} \tag{4.21}$$

$$\frac{\delta}{\rho}(D_a - D_{tr}) > S_{tr} - S_a. \tag{4.22}$$

The interpretation of inequality of eq. 4.22 is quite simple: autarchy leads to a higher utility than free trade only if the dynamic advantages are big enough to compensate for the increase in the level of utility due to comparative advantage.

The price of the good x is always lower with trade than with autarchy $(a_{xs}\omega < a_{xn})$. For this reason, the static component of the utility is always bigger with trade than with autarchy $S_{tr} - S_a > 0$; the size of the gain will depend, on first approximation, on the relative prices of good x in autarchy and in trade:

$$S_{tr} - S_a = \alpha \ln \frac{a_{xn}}{a_{xs}\omega} - \ln\left(\frac{1 + a_{xn}X - a_{yn}Y}{1 + a_{xs}\omega X - a_{yn}Y}\right) > 0. \tag{4.23}$$

The difference between the dynamic components of the welfare is:

$$D_a - D_{tr} = \gamma \left(a_{xn} X + \frac{f+\alpha}{1-\alpha} a_{yn} Y - \frac{\alpha}{1-\alpha} \right). \tag{4.24}$$

A necessary condition to have a negative effect of trade on welfare is that $D_a > D_{tr}$, or that Y and X are more than 0, which means that a necessary condition for $D_a > D_{tr}$ is that the utility function be non-homothetic. Moreover, the condition $D_a > D_{tr}$ is satisfied if α is sufficiently low; α measures the preference toward x, the goods produced in the South; if α is big a higher share of income is spent on the goods x.

Different parameters have different effects on the static and dynamic gains. Table 2 illustrates how different parameters influence the static and dynamic gains:

Table 2: effects of change in parameters on static and dynamic gains

parameters	$S_{tr} - S_a$	$\frac{\delta}{\rho}(D_a - D_{tr})$
f	$+$	$+$
X	$+$	$+$
Y	$+$	$+$
α	$+/-$	$-$
a_{xs}	$-$	$=$
a_{xn}	$+$	$+$
a_{yn}	$-$	$+$
γ	$=$	$+$
ρ	$=$	$-$
δ	$=$	$+$

Note that the static gains are no influenced by γ, ρ, and δ, while these parameters magnify the effect of the dynamic gains. An increase in the population of the South relatively to the population of the North increases both the static and dynamic gains; an increase of X or Y has the same effect. An increase in the cost of production in the South a_{xs} decreases the static gains but does not have any effect on the dynamic gains, this is due to the fact that the total demand for z does not depend on a_{xs}. This result indicates that there is little scope for a tax on imports from a less developed country; imposing a tax simply decreases the static gains deriving from trade, while it does not have any effect on the dynamics.

An increase in the price of the non-sophisticated good produced in the North (a_{yn}) leads to a decrease in the static gains and to an increase in the dynamic gains because a higher price of y will lead to an increased expenditure for z. This result indicates that the scope for a tax on the production of the least sophisticated product in the North is mixed. While such a tax would increase the dynamic gains, it would decrease the static gains; the net gain depends on the parameters of the economy.

5. Conclusions

This paper studied the effect of the composition of trade on growth. Several recent papers on this issue have reached the conclusion that a more developed country would have an increase in technological progress when trading with a less developed country. According to this reasoning, the North should specialize in sophisticated products, which have plenty of potential for technological progress; the less sophisticated the trading partner, the higher technological content trade should have. This view is not empirically supported.

We found that the technological content of trade is inversely proportional to the income of the trading partners; this is consistent both with non-homothetic preferences and with country-specific technology. For whatever reason this is true, we need to reconsider the relationship between composition of goods and trade in the light of this empirical fact. Starting from this observation, we showed how the composition of trade can, in effect, slow down technological progress in the more developed country.

We presented a Ricardian model in which the North specializes in the production of a sophisticated good (z) and a less sophisticated good (y); the South specializes only in a less sophisticated good (x). The exploitation of comparative advantages produces a permanent jump in the utility indicated in the paper by $(S_{ft} - S_a)$. This gain is proportional to the difference in the technology used in the different countries. The compositional effect of trade depends on the preference toward sophisticated goods of the trading partner. We showed that the bias toward less sophisticated goods can lead to a technological slowdown in the North.

We ignored many realistic features concerning the supply side, such as economies of scale and the existence of several factors of production. Economies of scale reinforce the basic mechanism because if there is a shift in the demand toward the intermediate good y, production will rise and so the costs and the price will diminish, and this will induce a further increase in demand for y. Note that if we stick to our interpretation that z is the frontier good while y is a good with more consolidated technology, good y is more likely to benefit from economies of scale than the more advanced product z.

Introducing more than a factor of production can reinforce the bias toward less sophisticated goods if there is non-homotheticity in demand. For instance, if there are two factors of production (skilled labor and unskilled labor) and the goods z is more skilled-labor intensive than the goods y or x, the fact that good x is produced abroad will make the unskilled labor cheaper in the North and so will decrease the price of y relatively to z.

The purpose of this paper was to show the important consequences that non-homothetic demand functions have on the relationship between trade and growth; further research should integrate non-homothetic demand functions with a more elaborated supply side, including more than one factor of production, economies of scale, externalities, and departures from perfect market competition.

A. Appendix

A.1. Technological contents of U.S. trade

The index of technological contents of export is a weighted average of the technological content for each country where the weights are given by the share of the sector in bilateral trade: $I_i = 100 * \frac{\sum_s l_s X_{is}}{\sum_s X_{is}}$, where X_{is} is the export from United States to country i in sector s, and l_s is the indicator of technological content of the sector s. The variables l_s used in the computation are:

- *Discrete* follows the Department of Commerce classification;
- *Researchers* is the number of researchers over 100 workers;
- *Tot. funds* is the share of revenues in research (private and public) in the last year available (it differs from sector to sector);
- *Tot. funds 80* is the share of revenues in research (private and public) in 1980;
- *Private funds* is the share of revenues in research (only private research).

Country	discrete	researchers	tot funds	tot funds 80	private funds
Argentina	4.4	5.976	5.96	5.26	4.82
Australia	5.0	6.044	6.62	6.03	4.73
Austria	5.4	6.385	6.74	6.20	5.27
Belgium	3.7	4.668	4.58	3.91	3.73
Brasil	6.0	6.755	7.52	6.62	5.03
Canada	2.6	4.514	4.41	4.36	3.70
Colombia	2.9	4.661	4.44	3.88	3.76
Denmark	6.0	6.417	7.58	7.01	4.62
France	6.2	6.993	8.27	7.54	5.08
Germany	6.1	6.592	7.40	6.85	5.30
Hong Kong	4.3	4.935	5.13	4.45	3.94
Ireland	7.0	7.940	8.28	7.38	7.18
Italy	4.9	5.708	6.00	5.47	4.73
Japan	4.1	4.767	4.92	4.42	3.94
S. Korea	4.0	5.090	5.49	4.81	3.86
Mexico	2.7	3.941	3.77	3.62	3.22
Netherland	5.4	6.177	6.66	6.09	5.07
New Zealand	5.6	6.296	7.04	6.35	4.68
Norway	5.7	6.260	7.23	6.76	4.65
Philippines	5.4	6.021	6.27	5.25	4.82
Singapore	6.0	6.877	7.63	6.90	5.52
Spain	5.6	6.344	7.73	6.96	4.13
Sweden	6.0	6.770	8.10	7.56	4.75
Switzerland	3.9	5.310	5.56	4.99	4.11
Taiwan	3.7	5.006	4.92	4.43	4.03
U.K.	6.0	6.731	7.69	7.06	5.28
Venezuela	2.6	4.109	3.89	3.45	3.49

A.2. Derivation of the demands for x, y, and z

The maximization problem is:

$$\max\left(\alpha\ln\left(x_{lt}+X\right)+\beta\ln\left(y_{lt}-Y\right)+\gamma\ln z_{lt}\right)\ \text{s.t.}\ x_{lt}p_{xl}+y_{lt}p_{yl}+z_{lt}p_{zlt}=1. \tag{A.1}$$

The first order conditions are:

$$\begin{cases} \frac{\alpha}{x_{tt}+X}=\lambda p_{xl} \\ \frac{\alpha}{y_{tt}-Y}=\lambda p_{yl} \\ \frac{\alpha}{z_{tt}}=\lambda p_{zlt}. \end{cases}$$

Substituting for λ and using the budget constraint, we obtain the demands:

$$x^{dlt} = \frac{\alpha}{p_{lx}}\left(1-p_{ly}Y-\left(\frac{\beta+\gamma}{\alpha}\right)p_{lx}X\right) \tag{A.2}$$

$$y^{dlt} = \frac{\beta}{p_{ly}}\left(1+p_{lx}X+\left(\frac{\alpha+\gamma}{\beta}\right)p_{ly}Y\right) \tag{A.3}$$

$$z^{dlt} = \frac{\gamma}{p_{lzt}}\left(1+p_{lx}X-p_{ly}Y\right). \tag{A.4}$$

A.3. Utility in autarchy

The indirect instantaneous utility function is:

$$\begin{aligned} U_{lt}^{a} &= \alpha\ln\left(x_{lt}+X\right)+\beta\ln\left(y_{lt}-Y\right)+\gamma\ln\left(z_{lt}\right) \\ &= \alpha\ln\left(\frac{\alpha}{p_{xl}}\left(1-p_{yl}Y-\left(\frac{\beta+\gamma}{\alpha}\right)p_{xl}X\right)+X\right)+\beta\ln\left(\frac{\beta}{p_{yl}}\left(1+p_{xl}X+\left(\frac{\alpha+\gamma}{\beta}\right)p_{yl}Y\right)-\right. \\ &\quad \left.+\gamma\ln\left(\frac{\gamma}{p_{zlt}}\left(1+p_{xl}X-p_{yl}Y\right)\right)\right. \\ &= J+\ln\left(1-p_{yl}Y+p_{xl}X\right)+\alpha\ln\frac{1}{p_{xl}}+\beta\ln\frac{1}{p_{yl}}+\gamma\ln\frac{1}{p_{zlt}}. \end{aligned} \tag{A}$$

where $J\equiv(\alpha\ln\alpha+\beta\ln\beta+\gamma\ln\gamma)$. The utility can be decomposed into two parts:

$$W^{a} = \int_{o}^{\infty}U_{nt}^{a}e^{-\rho t}dt$$

$$= \int_o^{\infty} (J + \ln(1 + a_{xn}X - a_{yn}Y) - \alpha \ln a_{xn} - \beta \ln a_{yn} - \gamma \ln a_{zn0} + \delta D_a t)\, e^{-\rho t} dt$$
$$= \int_o^{\infty} S_a e^{-\rho t} dt + \delta D_a \int_o^{\infty} t e^{-\rho t} dt \tag{A.6}$$

Where $S_a \equiv (J + \ln(1 + a_{xn}X - a_{yn}Y) - \alpha \ln a_{xn} - \beta \ln a_{yn} - \gamma \ln a_{zn0})$. And, integrating by parts the second integral:

$$= \frac{S_a}{\rho} + \frac{\delta D_a}{\rho^2}. \tag{A.7}$$

A.4. Derivation of ω

From balanced trade equation:

$$\begin{aligned}
\alpha\left(1 - p_{yn}Y - \left(\frac{\beta+\gamma}{\alpha}\right) p_{xn}X\right) &= \left[1 - \alpha\left(1 - p_{ys}Y - \left(\frac{\beta+\gamma}{\alpha}\right) p_{xs}X\right)\right] f\omega \\
\alpha\left(1 - a_{yn}Y - \left(\frac{\beta+\gamma}{\alpha}\right) a_{xs}\omega X\right) &= \left[1 - \alpha\left(1 - \frac{a_{yn}}{\omega}Y - \left(\frac{\beta+\gamma}{\alpha}\right) a_{xs}X\right)\right] f\omega \\
1 - a_{yn}Y - \left(\frac{\beta+\gamma}{\alpha}\right) a_{xs}\omega X &= \left(\frac{f}{\alpha} - f + f\left(\frac{\beta+\gamma}{\alpha}\right) a_{xs}X\right)\omega + a_{yn}fY \\
1 - (1+f)\, a_{yn}Y &= \left(\frac{f}{\alpha} - f + (f+1)\left(\frac{1-\alpha}{\alpha}\right) a_{xs}X\right)\omega \\
\omega &= \frac{1 - (1+f)\, a_{yn}Y}{f\left(1 + \left(1 + \frac{1}{f}\right) a_{xs}X\right)} \frac{\alpha}{(1-\alpha)}.
\end{aligned} \tag{A.8}$$

A.5. The demand of z in equilibrium with trade

The total demand for z is the sum of demand in the North and in the South. We multiply the individual demand in the South by f to obtain the total demand in the South:

$$\begin{aligned}
z^{dnt} + f z^{dst} &= \frac{\gamma}{p_{znt}}(1 + p_{xn}X - p_{yn}Y) + \frac{\gamma f}{p_{zs}}(1 + p_{xs}X - p_{ys}Y) \\
&= \frac{\gamma}{a_{znt}}(1 + a_{xs}\omega X - a_{yn}Y) + \frac{\omega\gamma f}{a_{zn}}\left(1 + a_{xs}X - \frac{a_{yn}}{\omega}Y\right) \\
&= \frac{\gamma}{a_{znt}}\left[1 + (a_{xs}\omega X - a_{yn}Y) + f\omega + f\,(\omega a_{xs}X - a_{yn}Y)\right]
\end{aligned}$$

$$= \frac{\gamma}{a_{znt}} \left[1 + f\omega + (1+f)\left(a_{xs}\omega X - a_{yn}Y\right)\right]. \tag{A.9}$$

Plugging in the equation for ω:

$$\begin{aligned}
z^{dnt} + f z^{dst} &= \frac{\gamma}{a_{znt}} \left[1 + f\omega + (1+f)\left(a_{xs}\omega X - a_{yn}Y\right)\right] \\
&= \frac{\gamma}{a_{znt}} \left[1 + \left(f + (1+f)\, a_{xs}X\right)\omega - (1+f)\, a_{yn}Y\right] \\
&= \frac{\gamma}{a_{znt}} \left[1 + \left(f + (1+f)\, a_{xs}X\right) \frac{1 - (1+f)\, a_{yn}Y}{f + (f+1)\, a_{xs}X} \frac{\alpha}{(1-\alpha)} + (1+f)\, a_{yn}Y\right] \\
&= \frac{\gamma}{a_{znt}} \left[1 + \frac{\alpha}{1-\alpha} + \left(1 - \frac{\alpha}{1-\alpha}\right)(1+f)\, a_{yn}Y\right] \\
&= \frac{\gamma}{a_{znt}} \left[\frac{1 + (1+f)(1-2\alpha)\, a_{yn}Y}{1-\alpha}\right].
\end{aligned} \tag{A.10}$$

A.6. Comparison between the welfare in trade and in autarchy

The difference between S_{tr} and S_a is:

$$S_{tr} - S_a = \ln\left(\frac{1 + a_{xs}\omega X - a_{yn}Y}{1 + a_{xn}X - a_{yn}Y}\right) + \alpha \ln \frac{a_{xn}}{a_{xs}\omega}. \tag{A.11}$$

We can approximate the expression above with a Taylor expansion:

$$\begin{aligned}
S_{tr} - S_a &\approx a_{xs}\omega X - a_{xn}X + \alpha a_{xn} - \alpha a_{xs}\omega \\
&\approx (\alpha - X)\left(a_{xn} - a_{xs}\omega\right).
\end{aligned} \tag{A.12}$$

The difference between $D_a - D_{tr}$ is:

$$\begin{aligned}
D_a - D_{tr} &= \gamma\left[\left(1 + a_{xn}X - a_{yn}Y\right) - \left(1 + \left(f + (1+f)\, a_{xs}X\right)\omega - (1+f)\, a_{yn}Y\right)\right] \\
&= \gamma\left[a_{xn}X - a_{yn}Y - \left(f + (1+f)\, a_{xs}X\right)\omega + (1+f)\, a_{yn}Y\right] \\
&= \gamma\left[f a_{yn}Y + a_{xn}X - \left(1 - (1+f)\, a_{yn}Y\right)\frac{\alpha}{1-\alpha}\right] \\
&= \gamma\left[a_{xn}X + \frac{f+\alpha}{1-\alpha} a_{yn}Y - \frac{\alpha}{1-\alpha}\right].
\end{aligned} \tag{A.13}$$

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