Learning by Doing and Economic Development

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Abstract

This paper develops a tractable Ricardian model to assess the effects of trade integration on the income growth of developing of countries. Two scenarios are analyzed. Focusing first on trade integration between an advanced and a developing economy, the model concisely replicates the infant industry argument. More importantly, it helps to identify a drawback of the infant industry argument, which previous literature has overlooked: protectionism can decrease long-run growth by reducing local demand for goods with high potentials of productivity growth and thereby hinder economic growth. A second part extends the model to a three-country scenario and addresses the effects of competition among developing countries. Trade integration of large developing economies has adverse static effects on the income of small developing economies since it increases competition at the bottom of the product ladder. But under adequate conditions, the small developing economies are pushed up the production ladder and enjoy increased transitional and long-run growth, possibly leapfrogging the initial leader.

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1 Introduction

This paper addresses the effect of trade integration on the growth performance of developing countries, reevaluating the infant industry argument in a first part and analyzing in a second the effects of competition among developing nations.

The infant industry argument is about two hundred years old, extensively studied, and very well known. When certain industries, so it runs, generate knowledge by merely engaging in production, and this knowledge is appropriable by neither firms nor workers, then a temporary protection of these industries give them the room to grow competitive. The argument enjoyed greatest popularity after World War II, when it was used to justify protectionist policies in post-colonized developing countries; extensive protection was meant to foster industrialization and thereby encourage economic growth (Baldwin [2003]). Not before some decades later the advances of the endogenous growth theory provided economists with the formal techniques to careful analyze the channels between protectionism and economic growth. A most influential contribution is Young [1991], who demonstrated how protectionism can foster long-run growth in developing countries. Somewhat ironically, these theoretical achievements came at a time when a paradigm change had accomplished: the dominant view among policymakers and economists favored open trade regimes and a large part of the developing countries had liberalized their trade policy.
Its comprehensive and elegant formalization on the one hand and its downturn of political relevance on the other could have marked the end of the academic discussion of the infant industry reasoning. But recent years have seen renewed interest in the role of that argument in the context of economic development, inducing to a line of theoretical contributions (Leahy and Neary [1999], Miravete [2003], Kaneda [2003], and Melitz [2004]). At the same time, empirical studies have tried to evaluate the success of protectionism (Luzio and Greenstein [1995], Lee [1997], Das and Srinivasan [1997], Dozin and Vamvakidis [2003], Ohyama et al [2004]).
Somewhat surprisingly, the empirical studies have persistently tried to identify protectionism and its effects on sectorial productivity growth, while neglecting to look at the effect of trade liberalization between developing and industrialized economies. This is astonishing as the infant industry logic has a straight and easily testable implication concerning the effects of trade liberalization: a turn to liberal trade policies should increase international competition and thereby make high-technology industries in less developed countries contract or disappear.
I think that testing this implication has potential to systematically assess the infant industry argument. For a sketchy but illustrating example take a look at Mexico's performance in high-technology sectors after its major trade liberalization with the US and Canada, the foundation of NAFTA. As a narrow definition of high-technology sectors serves classification[2] of "Advanced Technology Prod-

[2]The ten categories are: Biotechnology, Life Science, Opto-Electronics, Information and Communications, Electronics, Flexible Manufacturing, Advanced Materials, Aerospace, Weapons, and Nuclear Technology. These categories exhibit dynamic development and dis-

ucts" (ATP) the US Census Bureau provides. Instead of production data, which are hardly available, take trade volumes of these commodities between US and Mexico. It is striking to observe that total Mexican exports in the APT category increased by roughly 400% between 1994 and 2004 (see Table 1). Even more remarkably, Mexico's exports of ATPs as a share of total bilateral trade in ATP went up from below 35% in1994 to almost 57% in 2004. This means that Mexico was a net importer of the high-technology commodities at the foundation of NAFTA but turns out to be a net exporter ten years after. Within the ATP classifications the picture is roughly the same: in all ten categories, Mexican exports surged, and for all but two of them (Biotechnology and Electronics) the Mexican exports as share of total bilateral exports increased during the ten years of NAFTA. Mexico heavily linked its economy into the production chain of these advances and dynamic industries.
These observations are alarmingly at odds with the infant industry reasoning and conventional comparative advantage considerations.

Motivated by these puzzling facts and the renewed interest in the infant industry argument the present paper aims to reexamine the infant industry logic once again. To this purpose it develops a simple and tractable model that encapsulates the infant industry argument and helps to identify one of its drawbacks previous literature has failed to address. In particular, it highlights the impact of protectionism on the demand structure of country. The model illustrates that under demand complementarities protectionism can reduce demand for industrial goods to a degree that eventually makes unprofitable the production in precisely those sectors whose promotion was originally intended. In this case protection fails to foster industrialization and on the contrary causes economic stagnation. A key precondition for this to occur is the existence of an unsophisticated (possibly imperfect) substitute to industrial production - such as a subsistence technology. In the presence of such an outside option, very inefficient domestic industries are forced to pay wages at which workers prefer to make their living with a subsistence technology. Consequently, production in these industries comes to a halt. Even worse, under demand complementarities among industrialized goods, this adversely affects demand for other high-technology commodities, and contagion thus causes a complete breakdown of large parts or the entire industrialized sector.
Conversely, trade liberalization disentangles demand complementarities on the country level and can open the way to industrialization. Within the industrial sector, a developing countries then specializes according to its comparative advantage. This mechanism offers an explanation for the amazing performance of Mexico's export performance in the "Advanced Technology Products". However, also under free trade the presence of a subsistence technology substantially impacts the industrialization of a developing country: When there is limited world demand of those industrial goods the developing country has a comparative advantage in, the entire labor force of the developing country will not

coveries and are considered to be "on the leading edge" of their fields (see Abbott et al 1989).

engage in industrial production. Instead, a dual economy establishes with part of the labor force living on a subsistence basis while the rest produces the export goods. But in a growing world economy the demand in the developing country's export sector increases, gradually drying out the labor pool occupied with the subsistence-technology. Only after this transition is accomplished, an effect sets in that generates growth in the less developed country: With foreign output, the domestic exported goods becomes relatively scarce and, by improving its terms of trade, the less developed country imports growth[3].
The implied income dynamics stand in sharp contrast to the ones the infant industry logic implies. The latter states that for developing countries static gains from trade come at the price of reduced long-run growth. The presence of a subsistence technology implies the exact opposite: during a transition period of a dual economy, income is pinned down by the subsistence-technology and growth is nil; only after the transition period the developing country's terms of trade improve and it enjoys imported growth.

The second part of the paper addresses a more recent concern developing countries formulate. This is again relevant for Mexico and other developing countries who fear that the integration of the large and labor abundant nations India and China into the world market will adversely affect their national development trajectories. Recent studies confirm that China economic expansion and its extraordinary performance as a international trader crowds out exports in other East Asian and Latin American countries (see Eichengreen et al [2004] and IDB [2005]). Common knowledge based on Ricardian and Stolper-Samuelson considerations suggests that the integration of India and China countries harms other developing nations with similar factor endowments and production possibilities. Indeed, a simple plot of national income against the estimated losses due to China's trade integration for some East Asian countries (taken from Eichengreen et al [2004]) exhibit a clear negative relation (Figure 0).
Notwithstanding the threat of static losses that China's development can lay on other developing countries, this paper shows that the integration of a "big competitors" can also be a virtue for small developing countries by accelerating their economic development. Small developing countries may receive a "push up" the product ladder and start producing in sectors that generate knowledge and grant long-run growth. Thus, by freeing resources at the bottom of the product ladder, the integration of the big newcomers can set the small competitors countries on the track of fast growth, generate dynamic gains, and even make them leapfrog the initial leader. If small developing countries take advantage of cheap Chinese import and move up the product ladder, China's integration in the world economy offers them excellent growth opportunities. In fact, Eichengreen et al [2004] give hope that "the direct positive impact of China's demand for imports will soon dominate the third-market crowding-out effects of its exports for a growing number of Asian countries."

[3]Supposing, along with the standard assumptions in the infant industry context that a developing county has a comparative advantage in those goods with no learning effects, the improvement in terms of trade is in fact the only source of growth for the developing country.

Finally, the paper relates to a recent stream of literature, which empirically assesses the effect of trade liberalization on labor allocation. Imbs and Wacziarg [2003] discover that "measures of sectorial concentration follow a U-shaped pattern" when plotted against per capita income. Both, cross section and time-series data reveal that the course of economic development tends to come along with a reduction in specialization in early stages and with higher international specialization in later ones. The present paper's exhibits patterns of specialization that are consistent with these findings.

The remainder of the paper is organized as follows. Section 2 develops a model that replicates the key features of Young's [1991] argument, introduces different technological generations and discusses the implications of this change. Section 3 treats the case of competition between less developed countries under free trade. Section 4 concludes.

2 The Basic Model

This section aims to illustrate how demand complementarities can make the infant industry reasoning fail. To this purpose, it exposes a reduced-form version of Young [1991] in a first step and shows in a second that minor changes in the basic setup have dramatic consequences for the growth performance of developing countries.

The model's broad framework is the following. Individuals are of constant mass and infinitely lived. At each date $t \in \mathbb{R}_+$ they consume an amount c_t of a final good and enjoy the utility $u(c_t)$. The flow of momentaneous utilities is discounted with the time preference rate ρ, so that the individual lifetime utility at time t is

$$U_t = \int_t^\infty e^{-\rho\tau} u(c_\tau)\, d\tau \tag{1}$$

There will be no capital, no storage technology and thus no savings decision. Only "knowledge" is accumulable and grows according to a learning by doing mechanism, which, as in Krugman [1987] or Young [1991], affects productivity positively and is entirely exogenous to firms and workers. Consequently, individuals who maximize (1) simply maximize income at each point in time.
Just as in Young [1991], two different cases will be distinguished: free and costless trade in goods as opposed to autarky. Autarky is meant to capture protectionist policies. Trade in assets will be ruled out but that assumption is not crucial.

2.1 The Infant Industry Argument

This subsection develops a model that replicates the core features of the infant industry argument. It builds on the assumptions, which traditionally underlie the infant industry argument. In particular, it assumes a learning by doing process that is biased towards the goods advanced economies have a comparative advantage in. The present section illustrates the infant industry argument, replicating the key finding of Young [1991], namely the negative effect of trade on long run growth in less developed countries. It starts with the description of a closed economy that has a labor force of mass L, which is supplied inelastically. Consumers in the economy demand one final good (Y), which is produced out of two intermediates (X_i)

$$Y = (X_1^{1-1/\varepsilon} + X_2^{1-1/\varepsilon})^{\varepsilon/(\varepsilon-1)} \qquad (\varepsilon > 1) \tag{2}$$

The intermediate goods, in turn, are produced according to linear technologies, using labor as the sole factor:

$$\begin{aligned} X_1 &= L_1 \\ X_2 &= AL_2 \end{aligned} \tag{3}$$

Consider first a closed economy under these conditions. Marginal productivity of the intermediate goods determines their demand

$$p_i = (Y/X_i)^{1/\varepsilon} \tag{4}$$

while a competitive labor market implies[4] $p_1 = Ap_2$. Combining these equations leads to

$$L_1 = \frac{1}{1+A^{\varepsilon-1}}L \qquad\qquad L_2 = \frac{A^{\varepsilon-1}}{1+A^{\varepsilon-1}}L \tag{5}$$

Equations (2) and (5) together give national output

$$Y = \left(1+A^{\varepsilon-1}\right)^{1/(\varepsilon-1)} L \tag{6}$$

Suppose now that there is learning by doing, which is asymmetric in the goods and stronger in those goods, industrialized countries have a comparative advantage in - say X_2. For simplicity, assume the extreme case of no learning in production of X_1 while the productivity of X_2-production evolves according to

$$\dot{A} = \mu \cdot X_2/L \tag{7}$$

Differentiating (6) with respect to time and using (3), (5), and (7) it is straight to see that the autarky growth rate is

$$g = \dot{Y}/Y = \mu \left(\frac{A^{\varepsilon-1}}{1+A^{\varepsilon-1}}\right)^2 \tag{8}$$

[4]Note that productivity A is disembodied and atomistic individuals do not internalize their work's effect on accumulation of A such that the labor allocation (5) is not affected by intertemporal considerations.

which approaches μ as A grows large. A closed economy's long-run growth rate is therefore μ.

Now take two different closed economies of this type, called South and North (North variables denoted with *). As long as they coexist without trade, the income growth will converge in the long run[5]

$$\dot{Y}/Y - \dot{Y^*}/Y^* \to \mu - \mu = 0$$

Suppose now that these two economies, which previously lived in autarky, start to trade freely. Transport costs are negligible but labor is bound to stay within national borders.
Assume further that at the date of liberalization the countries are not identical but exhibit some technological differences. In particular, North (the advanced economy) has a comparative advantage in production of X_2. It can be shown that for any initial conditions that imply $L_2 < L/\varepsilon$, or equivalently satisfy

$$A^* L^* > A^{\varepsilon} L - (A^{\varepsilon} + A)/\varepsilon$$

South ends up completely specializing on good X_1 within finite time. Under these initial conditions, South' productivity grows too slow relatively to North' and South is gradually pushed out of X_2-production. Assume in the following that this is the case, or to keep matters simple, that full international specialization occurs on impact when countries decide to trade. This amounts to assuming $p_1 > Ap_2$ and $p_1 < A^* p_2$ or

$$\begin{aligned} A^* L^* &> A^{\varepsilon} L \\ L^* &< (A^*)^{\varepsilon - 1} L \end{aligned} \tag{9}$$

These conditions show that there is a lock-in effect in the specialization pattern: if conditions (9) hold initially, only North produces X_2 so that A^* grows but A does not. Thus, the specialization pattern carves in and consequently (9) must hold at any time after the trade integration.
Under complete international specialization world output grows according to

$$\dot{Y^w}/Y^w = \frac{(A^* L^*/L)^{1-1/\varepsilon}}{\left(1 + (A^* L^*/L)^{1-1/\varepsilon}\right)} \cdot \mu$$

and approaches μ in the long run as A^* grows large.

Now write s for South' economic size, defined as South' income relative to world income. Homothetic demand, complete specialization, and balanced trade imply $p_1(1-s)X_1 = p_2 s X_2^*$, which (together with equation (4)) gives

$$s = \frac{1}{1 + (A^* L^*/L)^{1-1/\varepsilon}}$$

So s becomes zero in the long run. The growth rate of s is

[5] There is convergence in growth rates here, but not in levels.

$$\dot{s}/s = -(1-s)(1-1/\varepsilon)\dot{A}^*/A^* = -(1-s)(1-1/\varepsilon)\mu.$$

Combining these equations, South' and North' growth rates (which are $g = (\dot{sY}^w)/(sY^w)$ and $g^* = ((1-\dot{s})Y^w)/((1-s)Y^w)$, respectively) take the following expressions

$$g = \frac{\mu}{\varepsilon}\frac{(A^*L^*/L)^{1-1/\varepsilon}}{(A^*L^*/L)^{1-1/\varepsilon}+1} \qquad g^* = \mu\left[1-\frac{1}{\varepsilon}\frac{1}{(A^*L^*/L)^{1-1/\varepsilon}+1}\right] \tag{10}$$

such that $g \to \mu/\varepsilon$ as A^* grows large. Since $\varepsilon > 1$, this means that South' long-run growth under free trade (μ/ε) is less than under autarky (μ).

$$g_{autarky} = \mu > \mu/\varepsilon = g_{trade} \tag{11}$$

Figure 1 illustrates and summarizes equations (8) and (10). The top panel shows that in autarky the growth rate of both countries converge since all countries produce and learn in the advanced sector. The bottom panel exhibits the effects of trade integration in particular for the less developed country: international trade makes it specialize in sectors with little learning effects and thereby reduces its productivity growth. Consequently, the static gains from trade come at the cost of reduced long-run growth. At the same time the productivity gap widens without bound. This illustration summarizes the main finding of Young [1991].

One underlying assumption in this model - and others relating infant industries and economic growth - is that in autarky, each country is active in sectors that generate knowledge and therefore put the countries inevitably on the track of growth. This is a somewhat liner view of economic development, which can be questioned. The next subsection does that and introduces two technological generations with only one of them creating knowledge.

2.2 A Subsistence Technology

The model developed up to here relies on the assumption that under autarky all countries keep alive their high-technology sectors, which grants learning by doing and leads to economic development. Put differently, at all production cost, domestic high-technology producers meet a positive demand. Obviously, this must not be the case. Very inefficient producers might need to sell their products at prices at which demand drops to zero. There might be some cheap substitutes, or consumers might like the goods in question, but not so dearly to pay any price for them. If that is the case, opting for autarky can hurt these sectors and protection induces a shutdown of sectors it originally intends to protect.

The present subsection describes such a scenario. It introduces a substitute for the input good X_2 (called X_2 again to save notation). This substitute can be produced with a simple, outdated, no-growth technology according to

$$X_2 = bL_{2,Old}$$

The use of that technology in the whole production process renders

$$Y = (1 + B^{\varepsilon-1})^{1/(\varepsilon-1)} L_{Old} \tag{12}$$

of the final good. In the following, this technology will be labeled the Old technology. A consistent terminology calls the previous subsection's technology the New generation
There is another way to interpret the Old technology. One can read it as an entirely unspecialized subsistence-technology with the constant return $(1 + B^{\varepsilon-1})^{1/(\varepsilon-1)}$. This interpretation has special appeal in the context of developing economies and will be adopted throughout the paper.

On one unit of labor, Old returns $(1 + B^{\varepsilon-1})^{1/(\varepsilon-1)}$ units while New delivers $(1 + A^{\varepsilon-1})^{1/(\varepsilon-1)}$ units of the final good Y. Remember that knowledge is disembodied and workers do not internalize the growth effects, so Old is used if and only if

$$B > A \tag{13}$$

Now, if (13) holds, workers optimally choose Old to work with, productivity A in the idle sector stays constant and the economy does not grow. Coordination failure prevents adoption of the New, the superior technology[6]. If initial conditions are such that (13) does not hold, the scenario is identical to the one discussed in the previous section.

Assume in the following that an unfortunate country, South, is stuck to the Old technology and consequently stagnates. What happens to this country if it engages in free trade with an advanced economy, North? As will become clear shortly, the economic integration leads South to take up production of X_1, export it while importing X_2.
In terms of the model, South being stuck to the Old technology and North being advanced means that (13) holds for South but not for North. In addition, assume that South' labor force is large. If this is the case, trade integration leads to the following international production pattern. North specializes entirely on X_2-production, while part of South' labor force (L_1) produces X_1 and the rest of South' workers ($L_{Old} = L - L_1$) works with the Old technology. Wage equalization in South requires $p_1 = B$. With $X_1 = L_1$ and $X_2 = A^* L^*$ and (4) this gives

$$L_1 = \frac{A^* L^*}{B^{\varepsilon}}$$

The condition for North to specialize on X_2 is $p_1 < A^* p_2$. This condition is satisfied since (13) was assumed to be violated for North. This shows that the

[6] Of course, there might be no coordination failure whatsoever when individuals are impatient, B is very large, or A is very small. In that case, the discounted flow of utility might be higher when working with B.

production pattern described indeed constitutes a static equilibrium allocation provided that $L > L_1$. (In precisely that sense South' labor force is assumed to be large.)

Next look at the dynamics of South and North incomes under the free trade regime. On impact of trade liberalization $L_1 = A^*L^*/B^\varepsilon$ is assumed to be less than L, but L_1 will keep growing as A^* grows. Thus, L_1 eventually hits its natural limit L, at which date South' entire labor force produces X_1. The summarizing equation is

$$L_1 = \min\left\{L, \frac{A^*L^*}{B^\varepsilon}\right\} \tag{14}$$

Thus, after trade integration, two qualitatively different periods will follow. First, the "transition period" during which the Old sector is successively drying out as a result of increasing L_1. Second, the "specialization period" which follows the transition period and during which South' labor force is fully allocated to the X_1-sector.
The income dynamics of South are very much different in the two periods. Note first that North produced X_2 only while South does not engage in X_2-production at all. This means that growth of productivities in the two countries are (remember (7))

$$\dot{A^*}/A^* = \mu \qquad \text{while} \qquad \dot{A}/A = 0$$

The wages are $w = p_1$ and $w^* = A^*p_2$. With (14) one calculates the world prices and the growth rates of South and North income during the transition period

$$g^* = \mu \qquad \text{and} \qquad g = 0$$

After the transition period, the respective growth rates are just like in (10) and South and North income grow at different rates in the long run:

$$g \to \mu/\varepsilon \qquad g^* \to \mu$$

Figure 2 illustrates these dynamics and contrasts them to the growth performance of the closed economies. The top panel shows that in autarky North grows while South sticks to the Old technology and stagnates. The bottom panel exhibits the growth rates of the two economies in the two different periods that follow a trade liberalization. The first period lasts the amount of time it takes for the growing world market to absorb South' labor supply. During this transition, South' growth is zero since national income equals labor income and its wages are pinned down by the Old technology: $w = (1 + B^{\varepsilon-1})^{1/(\varepsilon-1)}$. Only after the transition period is completed, South' wages start to rise. Growth, however, does not come from productivity growth but from an improvement in the terms of trade as goods produced in North become cheaper.

From North' point of view, the effect of trade integration is quite different: in the transition period the constant inflow of South workers in X_1-sector prevents the relative price p_1/p_2 from rising, so North' terms of trade is constant. Thus, although growing in only one sector, North does not experience decreasing returns. During this time growth of world output goes entirely to the pockets of North workers whose incomes grow at rate $g^* = \mu$. After the transition period, output of X_2 keeps growing and North runs into decreasing returns as the price of X_1 appreciates. The favorable conditions in which North' terms of trade stays constant comes to an end. Consequently, the growth rate drops back to moderate levels.

Note that under trade integration, the incomes in South and North diverge just as in the previous section because in the limit South grows strictly less than North:

$$\dot{(Y^*/Y)}/(Y^*/Y) \to \mu(1 - 1/\varepsilon)$$

South' autarky alternative, however, is no growth at all, which implies divergence at a much higher rate μ.

A comparison the model's two versions presented up to here reveals that the presence of the Old technology puts upside down the growth effects of trade integration for South. In the model of subsection 2.1 South' static gains from trade came at the cost of reduced long-run growth just like in Young [1991]. In the present subsection, however, the introduction the Old or subsistence technology implied that initial benefits of a trade integration were zero but South' growth take-off came after a transition period.
Yet also in the presence of the Old technology, South' long-run growth rates are less than North' and the respective incomes diverge. It seems that South' dilemma is to choose between bad and worse and it is unable to participate in high growth. Once again, this must not be the case. The next subsection illustrates how trade can induce developing countries to start production in advanced, high-growth sectors that were idle in autarky.

2.3 Differentiation in the Advanced Sector

Suppose that technologies are like in subsection 2.2 except that the production is subdivided into further steps. In particular, the intermediate X_2 good is produced out of two input goods z_i and according to the following production function[7]

$$X_2 = \left(z_1^{1-1/\varepsilon} + z_2^{1-1/\varepsilon}\right)^{\varepsilon/(\varepsilon-1)} \tag{15}$$

[7]The assuption that the elasticity of substitution of the intermediate and input-level is identical is convenient but not essential.

The input goods are produced with the input technologies

$$z_i = a_1 L_{2i} \qquad\qquad i = 1, 2$$

Following the parallel calculations that led to equations (5) one derives that within the X_2-sector, labor allocates to the sub-sectors according to

$$L_{2i} = \frac{a_i^{\varepsilon-1}}{a_1^{\varepsilon-1} + a_2^{\varepsilon-1}} L_2 \qquad\qquad i = 1, 2 \tag{16}$$

Thus, output of X_2 is

$$X_2 = \left(a_1^{\varepsilon-1} + a_2^{\varepsilon-1}\right)^{1/(\varepsilon-1)} L_2 \tag{17}$$

Writing

$$A = \left(a_1^{\varepsilon-1} + a_2^{\varepsilon-1}\right)^{1/(\varepsilon-1)} \tag{18}$$

for the composite productivity in the X_2-sector, one recovers exactly the setup of the previous section. Note that L_2 is still determined by equation (5) and the static equilibrium for a closed economy is determined with equations (2), (5), (17), and (16).
Assume that learning by doing now affects productivity of X_2-production through the two sub-sectors according to

$$\dot{a}_i = \mu \cdot z_i / L \qquad\qquad i = 1, 2 \tag{19}$$

In the case where the input goods z_i cannot be traded the scenario collapses to the one of the previous section with (19) replacing (7). The condition for South to be stuck to the Old technology in autarky (condition (13)) is now modified to be

$$B > \left(a_1^{\varepsilon-1} + a_2^{\varepsilon-1}\right)^{1/(\varepsilon-1)} \tag{20}$$

Now suppose that intermediate and input goods can be traded freely across borders. All results of the previous section go through unchanged under these assumptions but for one major qualification: South can be set on the track of fast economic growth through trade integration. To see this, set South' productivities in the z_i-sectors to $a_1 = a$ and $a_2 = 0$. As throughout the whole section, assume that in autarky South is trapped to B ((20) holds) and that L is large. When trade is liberalized, South workers will start to produce X_1. But now they will also enter the z_i-sector, provided that it pays high enough wages. The according condition is that South' wages in the z_1-sector exceed those of the X_1-sector: $p_1 < aq_1$. Using (14), (16), (18), and (4) this condition is equivalent to

$$\frac{B}{\left((a_2^*/a_1^*)^{\varepsilon-1} + 1\right)^{1/(\varepsilon-1)}} < a \tag{21}$$

At the same time, North exits z_1-production if North wages in the z_2-sector exceed those of the z_2-sector: $a_1^* q_1 < a_2^* q_2$ or

$$\frac{q_1}{q_2} = \left(\frac{a_2^* L^*}{a_2 L_2}\right)^{1/\varepsilon} < \frac{a_2^*}{a_1^*}$$

With $X_1^* = 0$ and $z_1^* = 0$, and performing parallel calculations that lead to (14), one derives that

$$L_{21} = a^{\varepsilon-1} L_1 \qquad \text{and} \qquad L_1 = \frac{a_2^* L^*}{(B^{\varepsilon-1} - a^{\varepsilon-1})^{\varepsilon/(\varepsilon-1)}} \tag{22}$$

Combining both equations leads to

$$\tfrac{1}{a}\left(B^{\varepsilon-1} - a^{\varepsilon-1}\right)^{1/(\varepsilon-1)} < a_2^*/a_1^*$$

which exactly coincides with condition (21). For an intuition for this concurrence assume that South engages in X_1- and z_1-production. Since South' wages equal the return on the Old technology, the price q_1 is fixed to be $q_1 = (1/a)(B^{\varepsilon-1} + 1)^{1/(\varepsilon-1)}$ and North' wages in the z_1-sector must be constant and equal to $w^* = (a_1^*/a)w$. At the same time, South keeps up with any increase in z_2-output by supplying more of X_1- and z_1- goods, reallocating its labor force from the Old to the New technology. This fixes relative prices and implies that North meets constant returns to labor in the z_2-sector, too. Thus, both z_i-sectors offer wages which are independent of North' labor allocation. Only in a knife-edge case, which is ruled out here the wages in both sectors coincide. (Technically speaking, under North' diversification, one has $w^* = a_1^* q_1 = a_2^* q_2$ and $w = p_1 = aq_1 = (B^{\varepsilon-1}+1)^{1/(\varepsilon-1)}$, which together with the fixed relative prices constitutes an over-identified system.)

The world economy gives now the following picture: there is complete international specialization in the New technology, with North only producing z_2 and South providing world output of X_1 and z_1, while still keeping alive the Old technology. This means that after trade liberalization the productivities a and a_2^* grow according to (19). A quick look at condition (21) confirms that here again the pattern of comparative advantage deepens and international specialization is preserved: the condition will hold after trade liberalization as long as some of South' labor force still uses the Old technology. When finally South' transition period is over, the conditions for North to stay out of the z_1 and X_1-sectors are, respectively, $q_1/q_2 < (a_2^*/a_1^*)^{1/\varepsilon}$ and $p_1/q_2 < (a_2^*/1)^{1/\varepsilon}$, or

$$\left(\frac{L^*}{L} \cdot \frac{1 + a^{\varepsilon-1}}{a^{\varepsilon}}\right)^{1/\varepsilon} < \frac{(a_2^*)^{1-1/\varepsilon}}{a_1^*} \qquad \text{and} \qquad \left(\frac{L^*}{L}(1 + a^{\varepsilon-1})\right)^{1/\varepsilon} < (a_2^*)^{1-1/\varepsilon}$$

which, too, exhibit a carve-in effect as a and a_2^* grow. Finally, notice that after South' transition period, its labor allocates to the two active sectors according

to[8]

$$L_1 = \frac{1}{1+a^{\varepsilon-1}}L \qquad\qquad L_{21} = \frac{a^{\varepsilon-1}}{1+a^{\varepsilon-1}}L \tag{23}$$

such that South productivity and income growth converge to μ.

The relevant conditions (20) and (21) describe the range for intermediate values of productivity a

$$\frac{B}{\left((a_2^*/a_1^*)^{\varepsilon-1}+1\right)^{1/(\varepsilon-1)}} < a < B$$

When these conditions hold, the following episode can be told about the economic development of South:
During an initial period the two economies coexist without trading. One of them - North - grows since it uses the New technology that consists of production including low-technology intermediate goods (X_1) and high-technology input goods (z_i). The other economy - South - stagnates because it works with the Old technology. At some point in time, these economies decide to open up to trade and North specializes on one of the high-technology goods, while South picks up production in the low-technology and one of the high-technology goods. It supplies these goods cheaply to North since its wages are pinned down by the Old technology. In that period, South does not grow. At the date when South completely abandons the Old technology, its income starts to grow and it enjoys a long-run growth rate equal to the advanced trading partner.
By the forces of trade, South thus becomes a successful but lagged success story of economic growth.

Before closing this section, it is worth taking a look at the labor allocation in this model. It turns out that it offers an explanation for the relation between economic development and specialization Imbs and Wacziarg [2003] discover. In their empirical work the authors find that "measures of sectorial concentration follow an U-shaped pattern" when plotted against per capita income. The present model exhibits precisely this characteristic. Consider the labor allocation in the New technology[9]: While poor countries with very low productivities a_i only engage in X_1-production, medium-income countries produce in both, the X_1- and z_1-sector, and finally high-income countries completely concentrate on z_2-production. But not only a cross section analysis, also the time paths of a developing country exhibits this feature: at early stages, a developing country allocates very little of its labor to the z_1-sector when a is smaller than unity ($L_{21}/L = a^{\varepsilon-1}$ compare (23)). As productivity a grows, more and more of its labor force shifts towards the z_1-sector, first decreasing the degree of specialization and later increasing it up to complete specialization on z_1-production

[8] By $a = 0$, South never enters the z_2-sector.
[9] Imbs and Wacziarg [2003] analyze the manufacturing sector.

$(L_{21}/L_1 \to \infty)$. Thus, the country diversifies during early stages of development just to reach later periods of high specialization.

This section has illustrated the adverse effects protectionism can have on economic development. While in a closed economy the advanced X_2-production lay idle, trade integration made the developing country participate in the high-technology production and enjoy economic growth. Subsection 2.3 has highlighted that the presence of relatively weak demand complementarities ($\varepsilon > 1$) is enough to cause contagion in the industrialized sector, in the sense that a very inefficient subsector (z_2) reduces demand for otherwise competitive subsectors (z_1) such that the entire industrialized production comes to a halt[10]. Trade integration, on the other hand, disentangles the demand complementarity between the z_i, makes production of at least a subset of high-technology goods profitable and spurs economic growth[11]. One consequence of this mechanism is that trade liberalization is followed by a stimulation of high-technology production in developing countries. The example of NAFTA and the following surge in Mexican production of "Advanced Technology Products" (ATPs) nicely illustrates this effect: in the decade after the treaty, Mexico's exports of the ATPs increased by roughly 400%. Looking at the bilateral trade balance with the US reveals an even more striking fact: Mexico, being a net importer of ATPs in 1994, turned to be a net exporter ten years later. This episode is consistent with the explanation offered in this paper: after abolishing trade barriers, Mexico was able to extensively integrate in the production process of the dynamic and advanced goods production.

The effect of trade integration on the demand structure described here constitutes one of the two main points of the paper. It is illustrated with the help of a very simple and tractable model and sheds doubt on the claim that, when climbing up the product-ladder, competition "from above" is harmful. Another and more recent concern deals with competition "from below", i.e. the competition among developing countries for world markets. Developing countries on the track to industrialization observe with concern that large and labor-abundant nations India and China integrate into the world market. Increased competition in labor-intensive sectors is believed to harm countries in Latin America and the developing nations of East Asia.
But this competition "from below" can also have beneficial effects for the poor countries. The next section shows this second main point of this paper. The tractable model of the present section is used to analyze a three country model and give some insights on the effect of competition among developing countries.

[10] Precondition is a relatively complex and diversified production in the industrialized production process and a rather plain and simple one in the self-subsistence technology - not a too unreasonable assumption after all.

[11] It is worth noting here that the demand functionin this model is assumed to be homothetic. Non-homothetic demand like in Matsuyama [2000] with more demand for high-technology goods at higher income levels obviously strengthen this effect.

3 Competition Among Developing Countries

This section focuses on the effect of competition for market shares among less developed countries in a globalized economy. Common knowledge suggests that small developing countries and transition economies should fear the large pool of cheap labor the big nations China and India supply to the world market. This cheap labor, the argument runs, drives other economies out of prospering industries and undermines their development trajectory. The present section looks at this claim and develops some intuition on it.

3.1 A Push Up

Suppose that technologies are like in subsection 2.3. Unfortunately for the developing country South, trade integration will not automatically lead to activity in a high-technology sector. When South does not enter the z_1-sector, it seems to be doomed to low growth rates as in subsection 2.2. Quite surprisingly, competition from another developing country can set South on the road of fast long-run growth.
To see this, suppose that while trading with North only, South does not produce any of the z_i. The general conditions for South not producing z_i are $a_i q_i < p_i$ or

$$a_i < \frac{a_i^*}{\left(a_1^{*(\varepsilon-1)} + a_2^{*(\varepsilon-1)}\right)^{1/\varepsilon}} \cdot (L^*/L)^{1/\varepsilon} \qquad i = 1, 2 \tag{24}$$

Assume now that South and North were trading for a while, South exporting X_1 and importing the z_i.
Suddenly, there appears a new potential trading partner: an economy called East (whose variables are characterized by a twiggle). East is initially in autarky, has a huge population $\tilde{L}$, possesses the Old technology, is capable to produce X_1 just like the rest of the world, but is inefficient in z_i- production.

The main interest will be the consequences of East's trade integration on South' economy. In order to simplify the setup, assume that $a_1^* = a_2^* = a^*$ for North' input productivities and $a_1 = a$ and $a_2 = 0$ for South'. Finally, let South' and North' labor force satisfy: $a^* L^* > aL$. With these simplification, the relevant conditions from (24) comes down to be

$$a < (a^* L^*/2L)^{1/\varepsilon} \tag{25}$$

Now, suppose that all trade barriers between East and South and North fall and East integrates to the world economy. Since East's labor force is very large, it does not fully allocate to the X_1-sector and consequently pins down the price of good X_1 to $p_1 = (B^{\varepsilon-1} + 1)^{1/(\varepsilon-1)}$. How does this affect the income of South citizens?
The first and obvious effect is that East competes with South in production of X_1. As East is assumed to be very large it will flood the world market with X_1

goods, pushing down the price and therefore this sector's wages all the way to the lowest possible level $(B^{\varepsilon-1}+1)^{1/(\varepsilon-1)}$. This effect clearly harms South' workers and causes a depression in South. Beneficiary is North by an appreciation of its terms of trade. The situation appears to create clear-cut losers and winners.

But the entrance of the newcomer can have beneficial effects for South, too. In particular, the big newcomer can push South into production of z_1. As production input good z_1 exhibits potentials of productivity growth, this means that the "push up" by the large competitor sets the small country on a track toward increased rates growth.
Under the adequate condition, the production pattern of the world economy right after integration of East is

$$\begin{array}{lll} \tilde{X}_1 = \tilde{L}_1 & X_1 = 0 & X_1^* = 0 \\ \tilde{z}_1 = 0 & z_1 = a & z_1^* = (a^*L^* - aL)/2 \\ \tilde{z}_2 = 0 & z_2 = 0 & z_2^* = (a^*L^* + aL)/2 \end{array} \tag{26}$$

For these production patterns to be an equilibrium, in neither country none of the idle sectors can pay higher wages that the prevailing domestic wage. This translates to[12]

$$p_1 > \tilde{a}_i \quad \text{for East} \qquad p_1 < aq_1 \quad \text{for South} \qquad p_1 < a^*q_i \quad \text{for North}$$

where q_i are the respective prices for the inputs z_i.
To rewrite these conditions in terms of productivities, start by considering the labor market of East. With the $\tilde{a}_i$ small enough, the condition for East holds always. Now, as East's labor force is assumed to be very large, $\tilde{L}_1$ is determined by the condition $p_1 = (\bar{Y}/\bar{X}_1)^{1/\varepsilon} = (B^{\varepsilon-1}+1)^{1/(\varepsilon-1)}$ (where variables with an upper bar indicate world aggregates). These conditions give

$$\tilde{L}_1 = (aL + a^*L^*)2^{1/(\varepsilon-1)}/B^{\varepsilon} \tag{27}$$

The condition for South to specialize on z_1 becomes with (26), (27) and $p_1/q_1 = (\bar{X}_1/\bar{z}_1)^{1/\varepsilon}$

$$B/2^{1/(\varepsilon-1)} < a \tag{28}$$

Finally, note that North exits the z_1-sector if only if $q_1 < q_2$ or equivalently $\bar{z}_1 > \bar{z}_2$ for the aggregate output levels $\bar{z}_i$. But this is not possible since $a^*L^* > aL$ was assumed and the newcomer East does not produce the z_i at all. So $q_1 = q_2$ and $\bar{z}_1 = \bar{z}_2$ must hold.
This proves that the allocation pattern of (26) together with the according prices constitute an equilibrium, provided condition (28) holds.

Combining conditions (25) and (28) - and adding the condition that South does not engage in z_1-production under autarky - one summarizes the relevant range for a as

$$B/2^{1/(\varepsilon-1)} < a < \min\{(a^*L^*/2L)^{1/\varepsilon}, B\} \tag{29}$$

[12] I disregard knife-edge cases here.

If these conditions hold at the date of East's integration in the world economy, the production patter (26) establishes. The first inequality implies that East's trade integration gives South a "push up" the production ladder and makes South specialize on z_1. The second inequality tells that South did not produce z_1 before East's integration and grew only moderately under bilaterally free trade with North nor did it engage in z_1-production under autarky.
All conditions together imply that in order for South to specialize in a high-growth good, trade with both partners, North and East is necessary.

Thus, for intermediate ranges of a (defined by (29)), the consequences of East's economic integration on South' income are twofold. First, there is an adverse and immediate level effect and second, there is a positive growth effect. Consider first the level effect, which appears on impact of East's accession. With (4) one quickly checks that South' and North' wages before the integration of East are

$$\begin{aligned} w_o &= \left(1+2(a^*L^*/2L)^{1-1/\varepsilon}\right)^{1/(\varepsilon-1)} \\ w_o^* &= a^*\left((2L/a^*L^*)^{1-1/\varepsilon}+2\right)^{1/(\varepsilon-1)} \end{aligned}$$

while immediately after it they are

$$\begin{aligned} w_1 &= a\left(2(1+B^{1-\varepsilon})\right)^{1/(\varepsilon-1)} \\ w_1^* &= a^*\left(2(1+B^{1-\varepsilon})\right)^{1/(\varepsilon-1)} \end{aligned} \tag{30}$$

With the inequalities (29) it is quick to see that $w_o > w_1$, i.e. that wage drops in South as a consequence of the accession of large newcomer, while North wage rises unambiguously: $w_o^* < w_1^*$. This constitutes the level effect.
The second effect is a growth effect. Notice that on impact of East's accession, South experiences a complete structural change, stops producing X_1, and fully specializes on z_1 instead. So South' productivity in the z_1-sector starts to grow at the rate μ (remember (19)). At the same time, North diversifies, producing z_1 and z_2. Consequently, by (19) and (26), North' productivity growth is biased towards the z_2-sector and North gradually shifts labor from the z_1-sector to the z_2-sector until it completely specializes on z_2.

Use (4) and conditions $q_1/q_2 = a_2^*/a_1^*$ and $p_1 = (B^{\varepsilon-1}+1)^{1/(\varepsilon-1)}$ to find that[13]

$$q_1 = \left(\frac{(1+(a_2^*/a_1^*)^{\varepsilon-1})}{(1+1/B^{\varepsilon-1})}\right)^{1/(\varepsilon-1)}$$

Then $w = a_1 q_1$ and $w^* = a_2^* q_2 = a_2^*(q_1 a_1^*/a_2^*)$ imply the growth rates of incomes

$$\begin{aligned} g &= \dot{a}/a + \tfrac{1}{\varepsilon-1}\tfrac{d}{dt}\ln(1+(a_2^*/a_1^*)^{\varepsilon-1}) > \mu \\ g^* &= \dot{a}_2^*/a_2^* + \tfrac{1}{\varepsilon-1}\tfrac{d}{dt}\ln\left(1+(a_1^*/a_2^*)^{\varepsilon-1}\right) < \mu \end{aligned} \tag{31}$$

[13] One needs to reintroduce the indices for North' productivities a_i^* again, since unequal growth makes them cease to be identical.

After North' structural change is completed, the wages in both countries grow at the same rates $g = g^* = \mu$.

Figure 3 illustrates these dynamics. It shows that for South the initial drop in income is followed by extraordinarily high growth ($g > \mu$), which sets back to lower levels after North' structural change is completed. The fact that South' income growth is temporarily extremely high stems from forces. First, complete specialization renders maximal productivity growth in South ($\dot{a}/a = \mu$); and since North is gradually retreating from z_1-production and East increases its supply of X_1, this maximal productivity growth does not lead to decreasing returns but translates into pure income growth. This explains the first term of South' growth rate in (31). But a second effect comes on top, which is due to the endogenous change of North' comparative advantage. As North partly retreats from z_1-production, its productivity growth is biased towards the z_2-sector. In fact, North not only moves out of z_1-production because its comparative advantage moves against the z_1-sector but conversely its comparative advantage moves against the z_1-sector precisely because North is moving out of it. This makes North retreating from z_1-production at an even faster pace. The additional force makes South' terms of trade appreciate and translates into even higher growth in South and explains the second term in (31). (The same mechanism affects North' growth rate adversely.) In sum, while South can increase the productivity of its export good faster than any other country, it does not run into decreasing return to scale but experiences even an appreciation of its terms of trade.
Finally, note that when East's structural change is complete, South and North experience the same setback in growth rates, which was already discussed in section 2.

Before going on, take a closer look at the two effects that drive the growth rate in South to exceptionally high levels during the period of North' structural change. The first effect is well known. Quite generally, a country benefits the more from international trade the better it can avoid decreasing returns to output of the sectors it has a comparative advantage in. In a Heckscher-Ohlin framework with constant total factor productivity and capital accumulation Ventura [1997] shows that growth miracles can occur when countries avoid decreasing returns to capital accumulation by shifting production to goods of higher capital intensity. In the present model, South essentially avoids decreasing returns to knowledge accumulation by East's willingness to increase supply X_1 along with South' productivity growth.
Yet the second effect is unique to the Ricardian model. When the endogenous change of a country's productivities accelerates its exit from a certain sector, the one trading partner that actually takes over this sector enjoys an appreciation of its terms of trade. This gives the latter an extra boost for its growth rates.[14]

[14]It is interesting to observe that in the Heckscher-Ohlin world, structural changes are a natural result of capital accumulation and are therefore associated with economic growth. In

Finally, a complete discussion of the "competition among developing countries" in this three-country model needs to assess the effects of South' presence on East's growth. The dynamics of East's income is essentially the same as South' in the subsection 2.2[15]. But South' membership in this free trade area does affect East in two ways. First, with South producing the input good z_1, the demand of East's exports, $\tilde{X}_1$, is higher. Thus, the transition period East experiences is shorter and it's period of growth sets in earlier. The second reason is a growth effect. By assumption (19), there are increasing returns to specialization. Since South completely specializes in the z_1-production and thereby makes North specialize completely on z_2 within finite time, it enhances output growth in the z_i-sectors, and growth of East's terms of trade. By each of these effects, the newcomer's economic growth and welfare is unambiguously higher when its "low-wage competitor" takes part in the free trade area. The key assumption is here again that South is moving up the production ladder at the entrance on East and therefore essentially stops being a competitor of East but is rather an attractive trade partner.

In sum, the competition among developing countries is beneficial for each of them - given that (29) holds and provided that South discounts only mildly its future gains. In a setting that describes firms as perfectly competitive the positive impact of increased competition among less developed countries on the on their respective income is remarkable.

3.2 Leapfrogging

Not enough that the less developed country benefits in terms of long run growth from the accession of the newcomer, this subsection shall show that South can in fact take over the leading position is this three-country world economy and leapfrog the initial leader, North.

Figure 4 illustrates such a case. As explained in the previous subsection, South grows faster than North during the period in which North diversifies and produces both of the z_i goods. This is because first, South completely specializes and second, its terms of trade appreciates as North gradually retreats from production of South' export good. After that period, both countries grow at the same pace. Thus, the longer North' transition period, the more South can catch up with North. If the period is long enough, South eventually overcomes North.

Precondition for South leapfrogging North is that the ratio of their labor forces L/L^* is relatively small. The reason for the size to play a crucial role is the following. The smaller South' labor force L, the larger must be South' productivity

contrast, in the present Ricardian model, where the accumulable factor, knowledge, is sector-specific specialization is associated with high growth rates and structural changes tend to induce losses in income growth.

[15]One could also extend the model to an equivalent of sebsection 2.3 without major difficulties by further differentiating the high-tech sector z_i with $i = 1, 2, 3,$. In such a setting all countries eventually grow at the rate μ.

a in order to be able to satisfy world demand of z_1 alone - and thus the longer is the period during which North still engages in z_1-production and South' growth exceeds North'. In short, the smaller South' labor force L, the longer is its period of excess growth over North and the more likely occurs leapfrogging.

To analyze these dynamics formally, suppose that all assumptions of the previous section still hold ($a_1 = a$, $a_2 = 0$ and $a_1^* = a_2^*$ and $a_1^* L^* > aL$ at the date of East's trade integration).
Define now the fraction of North' workforce employed in input sector z_2 as λ^*. It was mentioned above that this fraction is constantly increasing and finally hits one when North' structural change is complete. This can be seen in the following way. Use $a_1^* L^* > aL$ and (26) to see that $\lambda^* \in (\frac{1}{2}, 1)$ at the date of East's trade integration. Further employ $q_1/q_2 = (\bar{z}_2/\bar{z}_1)^{1/\varepsilon}$ to derive North' labor allocation during the period of its diversification:

$$\begin{aligned} L_{21}^* &= L^* \frac{a_2^*/a_1^*}{(a_2^*/a_1^*)^\varepsilon + a_2^*/a_1^*} - L \frac{a}{a_1^*} \frac{(a_2^*/a_1^*)^\varepsilon}{(a_2^*/a_1^*)^\varepsilon + a_2^*/a_1^*} \\ L_{22}^* &= \left(\tfrac{a}{a_1^*} L + L^*\right) \frac{(a_2^*/a_1^*)^\varepsilon}{(a_2^*/a_1^*)^\varepsilon + a_2^*/a_1^*} \end{aligned} \tag{32}$$

Together with (19), this leads to

$$\dot{\lambda^*}/\lambda^* = \tfrac{d}{dt} \ln(L_{22}) = \mu \lambda^* \frac{aL}{aL + a_1^* L^*} + (\varepsilon - 1)\mu(2\lambda^* - 1) \frac{(a_1^*)^{\varepsilon-1}}{(a_1^*)^{\varepsilon-1} + (a_2^*)^{\varepsilon-1}}$$

This differential equation tells that, if $\lambda^* > 1/2$, the fraction λ^* grows ($\dot{\lambda^*} > 0$). Since at the date of East's integration $\lambda^* > 1/2$ held, this means that λ^* grows and finally reaches 1: North completely specializes on z_2.

Now note that during the transition period, wages in South and North are $w = aq_1$ and $w^* = a^* q_1$. With (19), this means that relative incomes evolve like

$$\tfrac{d}{dt} \ln(w/w^*) = \mu \lambda^* \tag{33}$$

The goal is now to give a lower estimate on the ratio w/w^* at the date when North completely leaves the z_1-sector. When this date is T, and the date of East's trade integration is set to be $t = 0$, the inequality $\lambda^* > 1/2$ and equations (30) and (33) imply that at T relative incomes are

$$\frac{w(T)}{w^*(T)} = \frac{w(0)}{w^*(0)} \cdot e^{\mu \int_o^T \lambda^* dt} > a(0)/a_1^*(0) \cdot e^{\mu T/2} \tag{34}$$

In order to calculate the lower estimate on w/w^*, one can therefore give a lower estimate of T and plug it in the RHS. By (32) the transition period is characterized by

$$L^*/L \leq a(a_2^*)^{\varepsilon-1}(a_1^*)^{-\varepsilon} \tag{35}$$

with equality at date T. A lower bound for T is established by equalizing an upper bound of the RHS to the LHS. Since $a(t) = a(0)e^{\mu t}$, an upper bound of the RHS can be found by giving an upper bound for a_2^* and an lower bound for a_1^*. But a_2^* grows at the rate $\mu\lambda^*$, and a_1^* at the rate $\mu(1-\lambda^*)$. Some generous lower and upper bounds are therefore, respectively

$$a_1^*(t) < a_1^*(0) \cdot e^{\mu t} \qquad \text{and} \qquad a_1^*(t) > a_1^*(0)$$

Thus, the RHS of (35) is bounded from above by the expression

$$a(0)e^{\mu t} \cdot (a_2^*(0)e^{\mu t})^{\varepsilon-1}/(a_1^*(0))^{\varepsilon},$$

or

$$a(a_2^*)^{\varepsilon-1}(a_1^*)^{-\varepsilon} < \frac{a(0)}{a_1^*(0)}e^{\mu\varepsilon t} \tag{36}$$

The lower bound for date T is calculated by equating the LHS of (35) with the RHS of (36)

$$\bar{T} = \frac{1}{\varepsilon\mu}\ln\left(\frac{a_1^*(0)L^*}{a(0)L}\right)$$

This together with (34) and $\lambda^* > 1/2$ gives the estimate

$$w(T) > w^*(T) \cdot e^{1/2\varepsilon}L^*/L$$

These last steps lead to the following surprising finding: given that conditions (29) hold, trade integration with East makes South specialize in z_1-production and South *always* leapfrogs North when its labor force is relatively small compared with North', i.e. if the sufficient condition $L < e^{1/2\varepsilon}L^*$ is satisfied. Note that once North' structural change is complete, both countries' productivities grow according to (19) at the same rate and so does either national income. South can conserve its newly acquired leading position.

This subsection has generated a growth miracles with the help of two different effects. The first comes from avoiding decreasing returns. When a country is able to escape decreasing returns in the sector of its comparative advantage, productivity growth translates into pure income growth. The second effect comes from the dynamic change in comparative advantage due to learning by doing. When a developing country enters production of one specific sector, its incumbent producer partially shifts labor out of that sector. For the latter, this adjustment means a reduction in this sector's productivity growth and he not only retreats from the sector because the comparative advantage is moving against him, but the comparative advantage moves against him precisely because he is moving out of the sector. This amplification leads to an even faster appreciation of the developing country's terms of trade and increases its growth rate up to the point where it induces leapfrogging.

For developing countries the lesson to draw from this exercise is the following. Capturing parts of a sector with high growth potentials not necessarily makes a growth miracle. It can well be that higher productivity growth in competing countries eventually drives the developing country out of the newly entered sectors (as in section 2.1). Unless there exist other attractive production opportunities for the incumbent producers to shift their production to (as in sections 2.3, 3.1, and 3.2) a race for market shares sets in between competing countries with uncertain result. A further beneficial condition for a growth miracle to occur is the outsourcing of (low-technology) goods whose production does not exhibit learning by doing (as in section 3). In fact, this constitutes a pure infant industry argument from the winner's point of view. Finally, for a growth miracle to occur, the newly entered sector should meet a demand large enough to offer expansion in the medium run (reflected in the condition $L < e^{1/2\varepsilon}L^*$ of the present section)

This present section emphasized the beneficial effect that trade integration of a large developing economy can have on the growth performance of smaller developing countries. By freeing resources at the bottom of the product ladder these latter can enter industries with higher learning effects and growth potential. However, the immediate static level effect on the small developing countries is always negative. Whether the static welfare loss can be compensated by higher future growth then depends on the patience of the developing countries' citizens.

4 Conclusion

This paper has contributed to the discussion on the channels between international trade and economic growth. It has focused on the growth performance of developing countries in the race for market shares in advanced and dynamic sectors. It thereby distinguished between first, the effects of international trade with industrialized countries, evaluating the infant industry reasoning and second, an increased competition among developing nations in a three-country setting.

The first part of the paper developed a simple model that puts Young's [1991] version of the infant industry argument of into a very handy form, illustrating that for developing countries the static gains from trade may come at the cost of reduced long-run growth. In such a case trade integration hinders economic development. Yet, a small modification of the model turns around that picture and helps to identify a drawback of the infant industry argument that previous literature had overlooked. It was shown that the presence of a subsistence-technology, barriers to trade can reduce the demand for high-technology goods such that production drops precisely in those sectors, which protectionism originally intended to promote. In that scenario, protectionism undermines industrialization and long-run growth. The underlying assumptions conversely imply that trade liberalization spurs the production of higher-technology goods in developing countries. The surge of Mexico's exports of "Advanced Technology

Products" in the first decade of NAFTA up to the fivefold of their 1994 level can be understood as support for this view.

The second part of the paper extended the model to a three-country setting to address the impact of competition among developing countries on their growth performance. Some small developing countries observe with concern that large labor abundant nations like India and China integrate in the world economy. But the analysis showed that trade integration of a large developing nation can push small developing economies up the product ladder into production with higher growth potential. Thus, the increased competition sets small developing countries on the track of faster economic development. While a static level effect of the increased competition is always adverse, the following boost in income growth makes small developing countries outperform industrialized economies and can even bring them to leapfrog the initial leaders. In the period of exceptionally high growth of the developing country two beneficial effects are identified. First, as competitors are moving out of production in the sector of its comparative advantage, the developing country meets constant returns while growing in one sector only. Second, this effect is amplifies by the endogenous change in comparative advantage.

Appendix

In the two-country model of section 2.1, when $L_2 < L/\varepsilon$ holds, then L_2 goes to zero in finite time. Assume that $L_2 > 0$, i.e. South diversifies, implying $p_1/p_2 = A$ The world aggregates are then $\bar{X}_1 = L - L_2$ and $\bar{X}_2 = A^* L^* + AL_2$ and (4) gives

$$L_2 = \frac{A^\varepsilon L - A^* L^*}{A^\varepsilon + A} \tag{A1}$$

This expression has the upper bound $L_2 < L_M := L - A^* L^*/A^\varepsilon$. By (A1), L is increasing in A and by (7) $\dot{A}$ is increasing in L_2. Thus, the solution to (7) with initial values (A1) has an upper bound by the solution to (7) when replacing L_2 by L_M Using $\dot{A}^*/A^* = e^{\mu t}$, the system (7) and $L_2 = L_M$ has a stationary solution at

$$\tfrac{d}{dt} L_M = A^* L^*/A^\varepsilon \left(\mu - \mu\varepsilon L_M/L\right) = 0$$

or $L_M = L/\varepsilon$. For initial values $L_M < L/\varepsilon$ the upper bound L_M decreases at an accelerating pace and hits zero in finite time. Thus, so does L_2.

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