Trade Liberalization, Competition and Growth*

Omar Licandro (IAE)
Antonio Navas Ruiz (Universidad Autónoma de Madrid)

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Abstract

Increasing evidence support the claim that international trade enhances innovation and productivity growth through an increase in competition. This paper develops a two-country endogenous growth model, with firm specific R&D and a continuum of oligopolistic sectors under Cournot competition to provide a theoretical support to this claim. Since countries are assumed to produce the same set of varieties, trade openness makes markets more competitive, reducing prices and increasing quantities. Under Cournot competition, trade is pro-competitive. Since firms undertake cost reducing innovations, the increase in production induced by a more competitive market push firms to innovate more. Consequently, a reduction on trade barriers enhances growth by reducing domestic firm's market power.

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1 Introduction

During the last two decades the volume of international trade has increased enormously, among developed countries since the 80's and extending to developing countries since the 90s. This increase in trade volumes is contemporaneous with several attempts to create regional integration agreements, as for example the European Union, NAFTA and MERCOSUR. These two related facts have motivated researchers to reopen the old debate in international trade about the consequences of trade liberalization for productivity and growth.

Of particular relevance is the recent literature on international trade and heterogeneous firms, pioneered by Melitz (2003) and Bernard et al. (2003). It focuses on the impact of trade liberalization on industry productivity. Trade liberalization intensifies competition for rival production factors, pushing the less efficient firms out of the market and, consequently, increasing industry average productivity. Atkeson and Burstein (2010), among others,[1] have considered a similar approach to study the effects of trade liberalization on firm's decisions to innovate. They find that the selection effect generated by trade openness increases firms' R&D investments.

In this paper, we stress the positive impact on economic growth of the pro-competitive role of international trade focusing, unlike the previously mentioned literature, on firms' strategic interaction. Our paper is motivated by the recent empirical studies, at firm and industry levels, suggesting that globalization has increased both market competition, by reducing markups, and firm's R&D investments, leading to gains in aggregate productivity levels and productivity growth.[2]

The model builds on the early literature on international trade and strategic interaction developed by Brander (1981) and Brander and Krugman (1983), and the more recently general equilibrium version by Neary (2009). In a two-symmetric-country economy with Dixit-Stiglitz preferences, countries are assumed to produce the same set of varieties; each of these varieties is produced by an oligopoly under Cournot competition. As a consequence, when economies open to trade, it is not the mass of varieties that changes, but the number of firms competing within each variety. Moreover, firms are assumed to carry out cost reducing innovations. Under this assumption, innovation incentives depend positively on quantities, as cost reductions apply to the number of produced units. Differently from the standard endogenous growth literature, where competition reduces the incentives of potential entrants to undertake innovation activities, in this framework, an increase in competition may induce firms to produce more, increasing innovation and

[1] Melitz and Ottaviano (2008) is another important paper in this literature. See Ederington and McCalman (2007), Long et al. (2007) and Navas and Sala (2007) for theoretical models studying the effects of trade liberalization on firms' decisions to innovate. Impullitti and Licandro (2009) extend the current paper's framework to an environment with firm heterogeneity

[2] The empirical literature on the relation between trade and innovation, as well as the competitive role of trade for innovation and productivity growth, has been booming recently. See Bloom et al. (2008), Bugamelli et al. (2008), Bustos (2007), Chen et al. (2009), Eslava et al. (2009), Lileeva and Trefler (2009), Pavnick (2002), Topalova (2004), among others.

reducing profits simultaneously.

The paper shows a pro-competitive effect of trade; by reducing markups, trade increases output, innovation and productivity growth. When symmetric economies open to trade, both domestic and foreign markets suffer from tougher competition, which reduces markups and increases the size of the market. Local firms compensate the lost in domestic market shares by an equivalent gain in the foreign market, letting their global market shares unchanged. As a direct effect of an increase in competition, firms produce more. Since incumbent firms undertake innovation activities, returns to innovation depend crucially on firm's size. The pro-competitive effect of trade openness has consequently a positive effect on innovation and productivity growth. Trade barriers reinforce domestic firms' market power leading to low innovation and growth. Finally, since the number of firms affects innovation non-linearly, the paper shows that gains from trade are larger the less competitive countries are in autarky, since firms are more reactive in such an environment.

Early attempts to study the impact of trade liberalization on innovation and growth, as in Grossman and Helpman (1991), Rivera-Batiz and Romer (1991) and Devereux and Lapham, (1994), give little space to competition, because of the monopolistically competitive nature of markets and the assumption that innovation is carried out by potential entrants. They fail in accounting for the empirical evidence cited above since by assumption markups are constant and incumbent firms do no research activities.[3]

More recently, a new literature on competition and growth has been developed, in which incumbents are allowed to upgrade their own technologies. The seminal work by Aghion et al. (2001) points out the escape from competition effect as an incentive to innovate in highly competitive environments. Peretto (1999) extends Romer (1990) by assuming cost-reduction innovations and Bertrand instead of monopolistic competition. The latter framework has been used to study the relationship between trade openness and economic growth in two interesting papers: Peretto (2003) and Traca (2002). The first studies the case of North-North trade, showing that trade liberalization reduces both the global number of firms and R&D costs due to technological spillovers increasing the incentives to innovate. The second studies the case of trade between a small open developing economy and the developed world. Openness to trade will have a different impact on innovation and growth depending on the initial productivity gap between both economies. The developing economy will converge to the global innovation path if the initial productivity gap is lower enough. Both can be considered as complementary to this work, since they study the effects of trade liberalization on firm's incentives to innovate under Bertrand competition and product differentiation.

An advantage of our framework relies on the fact that an increase in competition is

[3]In Rivera-Batiz and Romer, for example, openness to trade increases market size and the number of firms in the same proportion, leaving innovation rents unchanged. It is only under the existence of technological spillovers that innovation is fostered.

modeled by an increase in the number of competitors offering the same product.[4] Notice that in this framework, other measures of competition like markups, market shares or market concentration reduce when the number of firms increases. Moreover, it is important to say that this paper studies the case of economic integration among similar economies where openness to trade intensifies competition within existing industries rather than opening opportunities to profit from comparative advantages, giving access to different goods produced abroad, something more frequent in the case of North-South trade.

Finally, Cournot competition is particularly suitable for the study of bilateral trade in industries whose firms supply homogeneous products, which, as pointed out by Bernhofen (1999), turns out to be a main characteristic of R&D intensive industries like petrochemicals and airlines. Griffith et al. (2006) found that in the European Union the chemical industry was one of the most affected by the Single Market Program, which according to Bernhofen (1999) also offers quite homogenous products. Other industries as machinery, medical and surgical equipment, telecommunications equipment are not characterized by high product differentiation. When goods are highly homogeneous, the alternative assumption of Bertrand competition, is unsuitable since iceberg transportation costs prevents trade to take place acting as a barrier to the entry of foreign firms. In contrast, our model is able to explain bilateral trade in this environment.[5]

The paper is structured as follows. Section 2 presents the basic model in autarky and analyzes the main forces driving growth. Section 3 studies costly trade in the case of two identical economies. Section 4 concludes

2 Autarky

Consider an economy populated by a continuum of consumers of measure L, with instantaneous logarithmic preferences defined over two final consumption goods X and Y,

$$\int_0^\infty e^{-\rho t}(\ln C_t^x + \ln C_t^y)dt,$$

[4] In Aghion et al. (2001), competition is measured by the elasticity of substitution between different varieties. However, as Koeninger and Licandro (2005) point out, the elasticity of substitution is an element of the environment reflecting preferences or technology. They claim that changes in the elasticity of substitution results on different efficient allocations, which may be confounded with the associated change in competition.

[5] Another important difference is the general equilibrium perspective adopted in this paper. Peretto (2003) and Traca (2002) consider strategic interaction within a monopolistic competition structure assuming that the number of firms is small enough to have some market power. However, this implies that firms should take into account income effects derived from their strategies. Also these firms have market power in the labor market. These effects are completely ignored in the previous works. Our model avoids that by assuming a continuum of varieties and n firms producing each variety. Then firms have market-power on their single market but they are small enough to have any effect on aggregate outcomes.

where C_t^x, C_t^y represent consumption levels. Good Y is an homogeneous good.[6] Good X is a Dixit-Stiglitz composite good defined in a continuum of industries of measure N:

$$C_t^x = \left(\int_0^N x_{jt}^{\alpha} dj \right)^{\frac{1}{\alpha}}, \ \alpha \in (0,1),$$

where x_{jt} represents consumption of good j. Each individual is endowed with one unit of labour at each point in time. In order to finance R&D activities, firms issue shares, A_t, which pay a rate of return r_t. Let us take the homogeneous good as the numeraire (*i.e.* $p_t^y = 1$). The representative consumer budget constraint is given by:

$$\dot{A}_t = w_t + r_t A_t - \int_0^N p_{jt} x_{jt} dj - C_t^y, \ A_0 > 0,$$

where w_t is the wage rate, and p_{jt} is the price of good j.

Good Y is produced by a continuum of firms of measure one with technology:

$$C_t^y = L_t^y, \tag{1}$$

where L_t^y represents labour allocated to this sector. Sector Y is competitive implying that $w_t = 1$.

Each good j in X is produced by n firms in an oligopolistic environment. A firm i in j produces using technology (let us omit the subscript j for simplicity)

$$q_{it} = z_{it} L_{it}^x, \tag{2}$$

where z_{it} is the stock of knowledge, which is assumed to be firm-specific. Firms in X can also invest in R&D activities leading to a reduction in marginal production costs. The R&D technology is

$$\dot{z}_{it} = \left(L_{it}^z\right)^{\gamma} z_{it}, \ \gamma \in (0,1), \tag{3}$$

where L_{it}^z represents labor allocated to R&D.[7]

At any point in time firms in j decide the quantity to supply and the optimal allocation of workers to both activities, physical production and R&D, taking into consideration other firms' strategies. This game belongs to the family of differential games, or repeated games defined in continuous time, in which past actions affect current payoffs. Two different concepts of Markov Perfect Nash equilibrium have been proposed in the literature, open-loop and closed-loop Nash equilibria. In an open-loop Nash equilibrium firms decide at time $t = 0$ the optimal path of strategies taking other firms' path strategies as given.

[6] The existence of a traditional good allows for the reallocation of labor to the R&D sector without necessarily reducing labor assigned to composite good production. A similar result would arrive under the assumption of an elastic labor supply as in Aghion el al (2001) but this alternative simplifies the model. Although important, the effect of trade openness on employment is not an issue in this paper.

[7] Since we are focusing on the effects on growth of a pure increase in competition, no technological spillovers are assumed.

Instead, in a closed loop Nash equilibrium firms decide at every period the optimal strategy taking as given the strategy of their opponents. Since our model fulfill the conditions for both type of equilibrium to coincide, we focus on open loop equilibria allowing us to apply standard optimal control theory techniques.[8]

Let $a_i = [q_{iT,} L^z_{iT}]$, $\forall\ T \geq t$ be firm's i strategy, where $[q_{iT,} L^z_{iT}]$ are the time-paths of output and R&D workers, and let us call Ω_i, the set of strategies of firm i. Let V_i be the value of firm i when the v firms in the market, $n \geq 2$, play strategies $A_n = [a_{1,} a_{2,} ...., a_n]$.

Definition 1 *At time t, $A_n = [a_i, a_{-i}]$ is an open loop Nash equilibrium if*

$$V_i\left[A_n\right] \geq V_i\left[A'_n\right] \geq 0,$$

where $A'_n = [a'_i, a_{-i}]$, $\forall\ a'_i \in \Omega_i$.

This condition implies that the optimal time path of strategies a_i maximizes the value of firm i taking as given other firms' strategies, (a_{-i}), and that the firm value has to be non-negative.

2.1 Solving for the autarkic equilibrium

Consumers solve the standard optimal control problem defined above. The optimal conditions are

$$\begin{aligned} E^x_t &= E^y_t = E_t, && (4) \\ \frac{\dot{E}_t}{E_t} &= r_t - \rho, && (5) \\ p_{jt} &= \left(\frac{LE_t}{P_t N x_{jt}}\right)^{1-\alpha} P_t, && (6) \end{aligned}$$

where E^x_t, E^y_t are individual expenditures in goods X, Y, respectively, i.e.,

$$E^x_t = \int_0^N p_{jt} x_{jt} dj$$

and $E^y_t = C^y_t$. In the following, we use the notation E_t to refer to both. The price index of the composite good X is given by

$$P_t = \left(\int_0^N p_{jt}^{\frac{\alpha}{\alpha-1}} dj\right)^{\frac{\alpha-1}{\alpha}}$$

Firm i producing good j solves the problem:

$$V_{is} = \max \int_s^\infty R_{s,t}\left((p_{jt} - z^{-1}_{it}) q_{it} - L^z_{it}\right) dt, \qquad \text{s.t.} \tag{7}$$

[8] See Fershtman and Muller (1982), Fershtman (1987) and Reinganum (1982). A non technical summary can be found in Cellini and Lambertini (2004).

$$
\begin{aligned}
p_{jt} &= \left(\frac{LE_t}{P_t N x_{jt}}\right)^{(1-\alpha)} P_t \\
x_{jt} &= \sum_{i=1}^{n} q_{it} \\
\dot{z}_{it} &= (L_{it}^{z})^{\gamma} z_{it},
\end{aligned}
$$

where $\gamma \in (0,1)$, $z_{i0} > 0$ and $R_{s,t} = e^{-\int_s^t r_\tau d\tau}$ is the usual market discount factor. Deriving first order conditions, rearranging terms and applying symmetry, we get:

$$
\begin{aligned}
q_t &= \theta l z_t E_t, && (8)\\
1 &= \gamma v_t (L_t^z)^{\gamma-1} z_t, && (9)\\
\frac{z_t^{-2} q_t}{v_t} + (L_t^z)^{\gamma} &= \frac{-\dot{v}}{v} + r_t, && (10)
\end{aligned}
$$

where v_t is the costate associated with variable z_t and $\theta \equiv \frac{n-1+\alpha}{n}$ is the inverse of the markup rate. We restrict the analysis to symmetric equilibria. In particular, we assume the initial stock of knowledge is equal for all firms in all sectors, i.e. $z_{i0} = z_0 \forall i$ in all j. As it can be seen in the last term of equation (8), the relevant scale is the number of workers per firm, $l \equiv \frac{L}{nN}$.

The left hand side of condition (10) is the marginal gain of accumulating one more unit of knowledge, and it can be decomposed in two parts: the first consisting on the reduction in marginal production costs, which are proportional to the quantity supplied, and the second representing learning by doing in research. Notice that the benefit of a cost-reduction innovation depends on the quantity produced, since it determines the amount of saved resources following such an innovation.

Given that the quantity produced determines the innovation effort, the way in which quantities are decided is fundamental for growth. This is in equation (8). In particular, we are interested in understanding the effect of a change in the number of firms on the incentives to innovate. In our model, an increase in the number of firms generates two different, opposite forces. On the one hand, the market share of each firm reduces, which can be seen in the last term of condition (8), since l goes down. This is the *size effect* or the market share effect. On the other hand, the markup $\frac{1}{\theta}$ depends positively on the *perceived elasticity of demand* $\frac{n}{1-\alpha}$. Consequently, an increase in the number of firms has a positive effect on quantities by increasing the inverse of the markup, represented by the first term on the right hand side of (8). This is the *competition effect.*

The labor market clearing condition is

$$
nN(L_t^x + L_t^z) + L_t^y = L. \tag{11}
$$

The financial market-clearing condition implies that the aggregate asset demand LA_t is equal to the stock market value of firms:

$$
LA_t = nNV_t. \tag{12}
$$

Finally, let us impose the market-clearing condition in sector Y:

$$LE_t^y = L_t^y. \tag{13}$$

2.2 Balanced growth path

At a Balanced Growth Path (BGP) equilibrium all variables are constant a part from q_t, z_t, v_t and p_t, which all grow at constant rates. The following proposition shows existence and unicity of a BGP.

Proposition 1 *An interior BGP exists and is unique*

Proof. Combining (3), (8), (9) and (10), under $\dot{L}_t^z = 0$, we get

$$\theta\gamma(L^z)^{\gamma-1} lE = \rho.$$

Substituting the latter equation, (2), (4), (8), and (13) into the labor market-clearing condition (11), it becomes

$$f(L^z) \equiv \left(\frac{1+\theta}{\theta}\right)\frac{\rho}{\gamma}(L^z)^{1-\gamma} + L^z = l. \tag{14}$$

Since $f(.)$ is monotonically increasing, and satisfies the limit conditions $\lim_{x\to 0} f(x) = 0$ and $\lim_{x\to l} f(x) > l$, existence and uniqueness derive directly from the intermediate value theorem. ■

In Appendix B, we also show the economy jumps to its BGP at the initial time.

2.3 Output growth

In this economy, production in sectors Y and X do not grow at the same rate. Consistent with national accounts, let us define growth by the mean of a Divisia index, meaning that the growth rate of real output is equal to the growth rate of both final sectors weighted by the share of each sector on nominal output. Since the homogeneous sector is not growing, and preferences are logarithmic, the growth rate of output is

$$g = \frac{1}{2}\frac{\dot{q}}{q} = \frac{1}{2}\frac{\dot{z}}{z} = \frac{1}{2}(L^z)^\gamma.$$

Technical progress only affects sector X, making the growth rate depend on the amount of labor allocated to research in this sector.

θ is the inverse of the markup and may be seen as a measure of the degree of competition. By differentiating (14), the growth rate can be easily shown to be increasing in θ. This is what we have referred before as the competition effect. There is a positive relation between the degree of competition and the perceived elasticity of demand, which depends positively on both the number of firms n and the elasticity of substitution α. As we have commented before, an increase on θ leads firms to increase the quantity produced. Given that innovation can be exploited in a large number of produced units, firms increases innovation too. This result is the opposite to that found in monopolistic competitive models, where a rise in the elasticity of substitution decreases the markup and reduces the innovation rate. When incumbents carry out process innovation, the scale of operation becomes an important determinant of R&D decisions. The rise in the perceived elasticity of demand increases the quantity supplied and therefore the return to innovation.

3 Free trade

Let us assume that countries are identical. Since both economies are equal in factor endowments and initial stocks of knowledge no pattern of specialization from trade is observed and *all the gains from trade comes from an increase in competition.*

Let us assume that transportation costs are of the iceberg type; precisely, $(1 + \tau)$ units of the product must be shipped in order to serve 1 unit abroad, where $\tau \geq 0$ is the percentage of total production that disappears in the process of shipping. Notice that for foreign firms selling in the domestic market, the markup in autarky has to be larger than the transportation costs, meaning that there is trade iff $1 + \tau < \frac{1}{\theta}$. Let us assume it in the next.

Under international trade, firms are able to serve both markets so some clarification about the notation must be made. Let us define the quantity q_{ht}^{c} as the quantity supplied by a firm located in country h to market c, where $c, h \in \{A, B\}$. That is q_{Bt}^{A} is the quantity supplied by the B-firm to the A-market. Whenever only one superscript appears it indicates that the variable is defined for that economy, that is, E_t^{xA} would be the expenditure assigned to X by households located in country A.

Under symmetry, first order conditions for country A under free trade are:

$$\left(\frac{lE_t^{xA}}{q_{At}^{A} + q_{Bt}^{A}}\right)^{1-\alpha} P_t^A \left(\frac{(n-(1-\alpha))\, q_{At}^{A} + nq_{Bt}^{A}}{n(q_{At}^{A} + q_{Bt}^{A})}\right) = (z_t^A)^{-1}, \tag{15}$$

$$\left(\frac{lE_t^{xB}}{q_{Bt}^{B} + q_{At}^{B}}\right)^{1-\alpha} P_t^B \left(\frac{(n-(1-\alpha))\, q_{At}^{B} + nq_{Bt}^{B}}{n(q_{At}^{B} + q_{Bt}^{B})}\right) = (z_t^A)^{-1}(1+\tau), \tag{16}$$

$$1 = \gamma v_t^A (L_t^{zA})^{\gamma-1} z_t^A, \tag{17}$$

$$\frac{\left(z_t^A\right)^{-2}\left(q_{At}^{A} + (1+\tau)q_{At}^{B}\right)}{v_t^A} + \left(L_t^{zA}\right)^{\gamma} = \frac{-\dot{v}_t^A}{v_t^A} + r_t. \tag{18}$$

Conditions (17), (18) are identical to conditions (9), (10) except from the fact that in (18), when computing the return on innovation, firms take into account quantities supplied to both markets. Conditions (15), (16) determine the optimal quantities supplied in each market and are analogous to condition (8), but one for each market. Notice that firms do not supply the same quantities to both market. B-firms solve an identical problem and their first order conditions are equal to those of country A but changing the subscripts and the superscripts, from B to A and viceversa.

In order to complete the definition of an equilibrium allocation, market clearing conditions need to be added:

$$nN(L_t^{xh} + L_t^{zh}) + L_t^{yh} = L, \quad h = \{A, B\}, \tag{19}$$

$$LA_t^h = nNV_t^h, \; h = \{A, B\}, \tag{20}$$

$$L(E_t^{yA} + E_t^{yB}) = L_t^{yA} + L_t^{yB}. \tag{21}$$

3.1 Balanced growth path

A balanced growth path for this economy is a symmetric equilibrium in which variables L_t^x, L_t^y, L_t^z, E_t, E_t^y, r_t, q_t^y are constant and variables z_t, $q_{At}^A = q_{Bt}^B$, $q_{Bt}^A = q_{At}^B$, v_t, p_t grow at a common constant rate (we have omitted some supraindexes).

Proposition 2 *Under* $\tau \in [0, \frac{1-\alpha}{n-1+\alpha}]$*, a balanced growth path exists and is unique*

Proof. See Appendix A. ■

As shown in the appendix, equilibrium conditions can be reduced to the following equation in L^z

$$f^*(L^z) \equiv \left(\frac{1+\theta^*}{\theta^*}\right) \frac{\rho}{\gamma} (L^z)^{1-\gamma} + L^z = l, \tag{22}$$

which is in fact the same equation than in autarky but with θ^*given by:

$$\theta^* = \frac{(2n-1+\alpha)(2(1-\alpha)(1+\tau) + \tau^2(1-\alpha-n))}{n(2+\tau)^2(1-\alpha)}. \tag{23}$$

The question is whether the growth rate of technological progress is higher under free trade than under autarky or, in another terms, whether $\theta^* \geq \theta$.

Proposition 3 *Under* $\tau \in [0, \frac{1-\alpha}{n-1+\alpha}]$, $\theta^* \geq \theta$.*(The growth rate under free trade is always higher than in autarky)*

Proof. See Appendix A. ■

Trade openness has no effect on the right hand side of (22) because neither local resources nor the local number of producers change. In other words, the increase in the number of competitors in each country has no size effect, since firms are selling in both countries. However, the increase in the number of competitors has an effect through competition. In the extreme case $\tau = 0$, the markup takes the same functional form as in autarky, but with $2n$ instead of n as the number of competitors. A reduction in markups puts the competition effect at work as already explained in the previous section. Even if firms are selling less in their domestic market than under autarky, the global quantity they supply is larger, because of the competition effect. Therefore, openness to international trade leads to more innovation and growth. Proposition 4 shows that the competition effect also works under trade frictions. It is important to notice that this result is not driven by any scale effect, since the number of workers per firm l is equal in both cases, under autarky and trade openness. Now, we proceed to discuss some comparative statics.

Transportation costs are a barrier for foreign competitors reinforcing the market power of domestic firms and making the competition effect less effective, as shown in the proposition below.

Proposition 4 *An increase in transportation costs has a negative impact on the rate of innovation*

Proof. It can be easily shown by differentiating (23) with respect to τ. ■

Finally, the difference between R&D investment in both regimes, autarky and free trade, is small when the number of firms is large. This is due to the fact that n has a non-linear impact on produced quantities; while for a small number of firms the increase in quantities due to trade openness is important, for a large number of firms it has a very small impact. The main mechanism operates through the perceived elasticity of demand and its effect on the markup; increasing the number of firms affects the growth rate of productivity through the inverse of the markup, which derivative with respect to n decreases with n. Notice that there are no gains from trade in the extreme case of $n \geq \frac{1+\tau}{\tau}(1-\alpha)$, since free trade requires $\tau \leq \frac{1-\alpha}{n-1+\alpha}$. In the limit, when n approaches $\frac{1+\tau}{\tau}(1-\alpha)$, the competition effect vanishes.

4 Conclusions

This paper develops an endogenous growth model with firm specific innovation, Cournot competition on a continuum of oligopolistic markets and free trade between identical economies. It shows that international trade induces growth in participant countries through an increase in competition; openness to trade generates a reduction in markups, inducing firms to innovate more to profit from the associated increase in market size. This research reinforces the view that at least for the case of developed countries trade openness enhances innovation and growth through a pro-competitive effect.

By restricting the analysis to identical economies, the present paper may be seen as a contribution to the understanding of the growth effect of regional integration agreements among similar countries, as it is the case of France and Germany in the European Union. A natural extension will be the study of economies with different initial conditions (i.e. different technological levels) or different factor endowments. This would make possible the study of the interaction between developed and developing economies, as it is the case of Mexico and the US in NAFTA or the accession of Ireland and Spain to the EU. Differences in the initial stock of knowledge determine the initial differences in marginal costs and market shares; differences in market size depend upon differences in factor endowments. The pro-competitive effect of trade in both economies will be determined by the interaction of these two forces. In the extreme case of unilateral trade policies, we expect a reduction of growth rates in the liberalizing country since the increase in competition coming from this policy is more than offset by the creation of an artificial comparative advantage to foreign firms. However, preferential trade liberalization agreements, will enhance growth in the liberalizing countries reducing growth in protectionist third countries due to the fact that the reduction of trade barriers between the two liberalizing countries increases competitiveness of their firms in both economies with respect to third country firms.[9]

A final interesting extension would allow for sectorial differences. In this case, it would be possible to identify sectors having larger gains from trade. Considering, for simplicity, intersectorial independence, we suspect that the less competitive sectors will have larger gains from trade.

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A Free Trade

Proposition 3 Under $\tau \leq \frac{1-\alpha}{n-1+\alpha}$, a *balanced growth path exists and is unique*

Proof. Under symmetry, $z_t^A = z_t^B = z_t$, $q_{At}^A = q_{Bt}^B = q_t$ and $q_{At}^B = q_{Bt}^A = \breve{q}_t$, for all t. Taking condition (15) for both countries, we get

$$\frac{(n-1+\alpha)q_t + n\breve{q}_t}{nq_t + (n-1+\alpha)\breve{q}_t} = \left(\frac{1}{1+\tau}\right),$$

implying

$$\breve{q}_t = \frac{(1-\alpha)(1+\tau) - n\tau}{1-\alpha+n\tau} q_t, \tag{24}$$

which requires

$$\tau \leq \frac{1-\alpha}{n-1+\alpha}$$

to q and $\breve{q}$ be simultaneously positive.

Under symmetry, $E_t^{xA} = E_t^{xB} = E_t$, $P_t^A = P_t^B = P_t$ and $p_{jt} = p_t$ for all j and t, implying that the inverse demand function (6) for any variety produced in any country becomes

$$p_t = \left(\frac{LE}{n(q_t + \breve{q}_t)}\right)^{1-\alpha} P_t = \frac{lE}{q_t + \breve{q}_t},$$

the last equality follows from the definition of the price index P. Substituting the latter condition and (24) in (15) and rearranging terms, it follows

$$q_t = \left(\frac{(1-\alpha+n\tau)(2n-1+\alpha)}{n(2+\tau)^2(1-\alpha)} \right) z_t l E \tag{25}$$

$$\breve{q}_t = \left(\frac{((1-\alpha)(1+\tau)-n\tau)(2n-1+\alpha)}{n(2+\tau)^2(1-\alpha)} \right) z_t l E. \tag{26}$$

At the balanced growth path, $r_t = \rho$ from (5), and $\frac{\dot{z}}{z} = (L^z)^\gamma$ from (3). From (17), (18), (25) and (26), we obtain:

$$\gamma \left(L^z\right)^{\gamma-1} \theta^* l E = \rho$$

where, by analogy with the autarky case,

$$\theta^* = \frac{(2n-1+\alpha)(2(1-\alpha)(1+\tau)+\tau^2(1-\alpha-n))}{n(2+\tau)^2(1-\alpha)}.$$

From the labor market clearing condition (19),

$$L^x + L^z + \frac{L^y}{nN} = l.$$

From (21) and (4), $L^y = LE$; from (2), $q + (1+\tau)\,\breve{q} = zL^x$. Substitution q and $\breve{q}$ by their expressions in (25) and (26), we get

$$f^*(L^z) \equiv (\frac{1+\theta^*}{\theta^*})\frac{\rho}{\gamma}\left(L^z\right)^{1-\gamma} + L^z = l,$$

i.e., is the same equation as in the autarkic model but with θ^* instead of θ. Interiority and uniqueness of the solution is therefore ensured by looking at the autarkic balanced growth path proof. ■

Proposition 4 Under $\tau \leq \frac{1-\alpha}{n-1+\alpha}$, $\theta^* \geq \theta$

Proof. From the definition of θ^* and θ,

$$\begin{aligned} \theta^* - \theta \quad &= \quad \frac{(2n-1+\alpha)(2(1-\alpha)(1+\tau)+\tau^2(1-\alpha-n))}{n(2+\tau)^2(1-\alpha)} \\ &\quad -\frac{n-1+\alpha}{n}, \\ &= \quad \frac{(1-\alpha)^2(1+\tau)+\tau^2 n(1-\alpha-n)}{n(2+\tau)^2(1-\alpha)}. \end{aligned}$$

It can be easily shown that the r.h.s. is decreasing in τ, with $\theta^* - \theta = 0$ when τ is at its maximum value$\frac{1-\alpha}{n-1+\alpha}$. ■

B Stability analysis under autarky

Let us combine equations (2), (8) and (11) to get

$$L^x = \theta l E$$

$$\frac{1+\theta}{\theta} L^x + L^z = l,$$

implying

$$E = \frac{l - L^z}{(1+\theta)\, l}.$$

By logdifferentiation,

$$\frac{\dot{E}}{E} = -\frac{L^z}{l - L^z}\frac{\dot{L}^z}{L^z}.$$

From (5),

$$r = \rho - \frac{L^z}{l - L^z}\frac{\dot{L}^z}{L^z}. \tag{27}$$

Adding (3) and (10), we get

$$\frac{\dot{z}}{z} + \frac{\dot{v}}{v} = r - \frac{q}{z}\frac{1}{zv} = r - \gamma\theta l\,(L^z)^{\gamma-1} E = r - \frac{\theta\gamma}{1+\theta}\,(L^z)^{\gamma-1}\,(l - L^z)\,. \tag{28}$$

The second equality emerges after substituting $\frac{q}{z}$ and $\frac{1}{zv}$ by their expressions in (8) and (9), respectively, and the last one after substituting the expression for E computed just above. Differentiating (9)

$$\frac{\dot{z}}{z} + \frac{\dot{v}}{v} = (1-\gamma)\,\frac{\dot{L}^z}{L^z}.$$

Substituting it and (27) in (28), we get

$$\frac{\dot{L}^z}{L^z} = \left(\rho - \frac{\theta\gamma}{1+\theta}\,(L^z)^{\gamma-1}\,(l - L^z)\right)\left(\frac{l - L^z}{(1-\gamma)\, l + \gamma L^z}\right).$$

The sign of the second term in the r.h.s. is positive since $L^z \leq l$. The unique interior steady state, let us denote it by L^*, is obtained by equalizing the first element of the r.h.s. to zero (condition (14)). As it can be easily seen, $\dot{L}^z \leq 0$ for $L^z \in (0, L^*)$ and $\dot{L}^z \geq 0$ for $L^z \in (L^*, l)$, implying that the interior steady state is unstable. Consequently, the only rational expectation equilibrium is $L^z_t = L^*$ for all $t \geq 0$.