NONLINEARITIES IN THE OPENNESS AND GROWTH LINK: INSIGHTS FROM A NORTH-SOUTH MODEL

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Abstract

Some relatively recent models show that the openness-growth link may be nonmonotonic. I extend this literature allowing for the possibility that the two trading economies have attained a different development level. It is shown that higher protection (represented by "ad valorem" tariff on the imports of differentiated consumption goods) leads to a higher stock of foreign capital in the poorer economy. Moreover, when R&D spillovers are global, trade liberalization is not necessarily growth promoting (the relationship between the tariff rate and growth being actually U-shaped due to contradictory effects on domestic and foreign sales); but, when externalities have a purely local nature and R&D is agglomerated in the North, trade policy affects growth also through the impact on location, so that higher protection may be monotonically associated to lower growth for plausible tariff rate levels and parameter values. Finally, numerical simulations show that higher protection always exerts a negative impact on welfare, even when a U-shaped link with growth exists.

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1. Introduction

Though the impact of trade policy on growth and development is a traditional topic in international economics, the effects of trade liberalization remain a controversial issue. Given the lack of sound empirical regularities (see Harrison and Hanson, 1999, or Rodriguez and Rodrik, 2000), economists seem not to be able to offer unambiguous answers in the debate about the potential benefits or dangers of globalization. Interestingly, some recent contributions focus on the possibility that the link between openness and growth may be non linear, and even nonmonotonic, which could help explain why econometric evidence (generally based on the assumption of a linear and monotonic relationship linking trade protection measures and growth) provides no robust results and conclusions. Rivera-Batiz and Romer (1991) extend the original Romer's (1990) model about endogenous technological change in a two-country framework and show that the balanced growth rate has a U-shaped link with an "ad valorem" tariff rate imposed on the imports of a set of intermediate goods. More recently, Baldwin and Forslid (1999, henceforth BF) and Baldwin and Sbergami (2000, henceforth BS) have proposed again (in a different and probably simpler theoretical framework) the issue of the existence of nonmonotonicities in the openness-growth link, studying the impact of different kinds of trade impediments ("ad valorem" and specific tariffs as well as traditional "iceberg" costs). In particular, BF consider the case in which trade policy measures affect the imports of a set (a CES aggregate) of differentiated intermediate goods which are combined with labour, (according to a Cobb-Douglas technology), to produce a final consumption good; on the contrary, BS consider the case in which the differentiated goods subject to trade policy restrictions are consumption goods (which again constitute a CES aggregate in the utility function). In both cases it is shown that (under certain assumptions about whether tariff revenue is redistributed or not) growth has the same U-shaped link with "ad valorem" tariffs found by Rivera-Batiz and Romer (1991), while the relationship with specific tariffs is bell-shaped. Moreover, empirical results contained in BS show that allowing for nonlinear effects actually has a relevant impact on the significance of econometric estimates (trade policy coefficients are not significant when purely linear relationships are estimated, but become significant once quadratic terms are introduced into the regression).

In this paper I extend this literature along basically two lines. First, all these papers discussing the possible existence of nonmonotonicities in the trade and growth link consider the case of equally developed (symmetric) countries, in the sense that the two considered economies produce the same number of (intermediate or final) differentiated goods. Here I allow for the possibility that the two trading locations differ in the number of the locally produced differentiated goods, transforming thus the original symmetric models in a sort of "North-South" framework. Introducing asymmetry in the sense above is interesting in itself (given that the current debate about globalization, growth and inequality concerns primarily the relationships between industrialized and developing economies) and allows us also to study how location choices and growth rates interact and are simultaneously affected by trade protection. In this way, this paper is intended also as a contribution to the growing literature of models where growth and location are endogenous and interacting processes; in this respect, it may be intended as an extension of the model developed by Martin and Ottaviano (1999, henceforth MO).[1]

Secondly, I study how the properties of the model are influenced by the assumptions concerning the technological externalities characterizing the R&D sector of the economy. In particular I consider the two extreme cases of perfectly global or completely local geographical externalities (in the first case the scientific knowledges developed abroad have exactly the same influence on the productivity of the R&D sector as the domestic innovations; in the second case there are no international spillovers at all). It will turn out that, when countries are not equally developed, the assumptions about the geographical extent of the technogical externalities do not affect only the possible agglomeration of the research activities but also the way trade policy and growth are linked each other.

The paper is organized as follows. The basic assumptions and some key intermediate results of the two-country model are described in Section 2. I determine in Section 3 the equilibrium allocation of the labour force and the trajectory of the balanced growth path under the assumption of global spillovers, while Section 4 considers the opposite case in which technological spillovers are completely localized. Section 5 and Section 6 analyze respectively the welfare and stability properties of the model. Finally, Section 7 contains a brief summary of the results of the paper and discusses their implications. Proofs of some of the analytic results presented hereafter have been introduced in the Appendices at the end of the paper.[2]

2. Basic assumptions and intermediate results

The world economy consists of two countries; intertemporal preferences of the representative consumer are represented in each economy by:

[1] These contributions merge the common features (especially the Dixit-Stiglitz monopolistic competition framework) shared by the geography models à la Krugman (1991) on the one side and the growth models of Romer (1990) and Grossman-Helpman (1991) on the other side. Walz (1996), Baldwin and Forslid (2000) and Martin and Ottaviano (2001) are just a few examples of this line of research.

[2] Derivation and proofs of other results are contained in a Supplemental Guide to Calculations available upon request.

(1) $U = \int_0^\infty \log\left(C_Z^{\ 1-\alpha} C_X^{\ \alpha}\right) e^{-\rho t} dt$

where ρ is the time-preference parameter, C_Z is the consumption of good Z , C_X is the consumption of a composite good represented by a CES aggregate of a number N_T of differentiated consumption goods x_j:

(2) $C_X = \left[\sum_{j=1}^{N_T} x_j^{\left(\frac{\sigma-1}{\sigma}\right)} \right]^{\left(\frac{\sigma}{\sigma-1}\right)} \qquad \sigma > 1$

and, indicating by N_j the number of intermediates produced in country j, $N_T = N_1 + N_2$.

The final good Z is supplied in a competitive market and produced according to a constant returns to scale technology, which employs exclusively labour with a unitary input-output requirement. As Z is also the chosen numeraire, this pins down the wage rate w, so that $w = 1$ in both economies provided that each country produces Z (Appendix 3 shows that this is actually the case for any set of economically meaningful parameter values). The differentiated goods (X-) sector is characterized by monopolistic competition: each variety is offered by a single, firm which hires workers to produce it. By choice of units, I assume that the input-output labour requirement is just equal to 1 in the X-sector too. There exists a third sector, the R&D sector, which employs labour (researchers) and performs the task of introducing new varieties of differentiated goods; this innovation process, expanding the consumption possibilities of the economic agents, represents the growth mechanism of the world economy. Newly introduced varieties are protected by infinitely lived patents, so that owners of these patents enjoy monopoly power in their markets. As common in the recent literature on trade and growth, the final homogeneous good Z is freely traded. On the contrary, differentiated goods are subject to an "ad valorem" tariff, with a positive tariff rate t. I suppose that tariff revenue is returned lump-sum to consumers in each country. Tariff rates and all parameters characterizing the two economies (including the size of the total labour force) are the same.

The labour market constraint in each country is:

(3) $L = L_Z + L_X + L_R$

where country indexes are omitted, L is the total labour force supply and L_Z, L_X and L_R represent workers employed respectively in the Z-, X- and R&D sectors. Though the model allows no international labour mobility, the labour force is homogenous and mobile across the different sectors within a given country. Also, the population and the labour force supply coincide in each country and are constant over time.

The two locations differ only in the number of patents owned by their residents (which in turn, as we will see below, implies also a corresponding difference in the number of the locally produced differentiated goods). Denoting by K_i is the total number of firms owned by residents of Country i (i =1,2) and by K_T the total number of firms existing in the world economy (so that: $K_1 + K_2 = K_T = N_T$), I assume in the following that $K_1 > K_2$, so that Country 1 may be considered as the "North", the richer economy, while Country 2 is the South, the backward one.

I assume perfect capital mobility, in the sense that agents are free to borrow or lend in an integrated world capital market as well as to hold foreign assets (in other terms, patents are freely tradable). A further important assumption is that the holder of the patent of a new variety of differentiated goods is free to choose the production location: the country from which a given variety is supplied to the world is not necessarily the country where this variety was introduced due to research investments. Also, relocation is free: firms are free to change their production location at no cost.

As workers own the entire stock of financial wealth, the preceding assumptions imply that capital is internationally mobile but capital owners are not. This hypothesis (which may be justified noting that in the real world capital has a higher degree of mobility than labour) has important technical and economic implications: its introduction allows to avoid the "catastrophic" (core-periphery) outcomes which often characterize the "new economic geography" (see for example Krugman, 1991 or Baldwin and Forslid, 2000) and to focus on (stable) interior but asymmetric equilibria in which both locations host producers of the monopolistic competition sector. As discussed by MO, this seems to be a more realistic result than that of complete agglomeration found in other models.

Given the hypothesis above, denoting by E_i nominal expenditures of country i residents, by x_{ii} and x_{ij} the demand in country i of a variety produced respectively in countries i and j (i, j =1,2; $j \neq i$), recalling that $\tau \equiv 1+t$, and taking into account that the elasticity of demand of each variety is σ, it follows that the optimal prices for each variety of locally and imported diffrentiated goods are respectively $p = \sigma/(\sigma-1)$ and $p^* = p\tau$, while equilibrium demands are:

(4a) $$x_{ii} = \left(\frac{\sigma-1}{\sigma}\right)\frac{\alpha E_i}{N_i + N_j \tau^{1-\sigma}}$$

(4b) $x_{ij} = \left(\frac{\sigma - 1}{\sigma}\right)\frac{\alpha E_i \tau^{-\sigma}}{N_i + N_j \tau^{1-\sigma}}$

As x_{ii} and x_{ji} denote respectively the local and foreign demand faced by each firm located in Country *i*, its operating profits are given by: $\pi_i = (p - w)x_{ii} + ((p^*/\tau) - w)x_{ji}$. Remembering that the wage rate *w* is equal to 1, this means that:

(5a) $\pi_1 = \frac{x_{11} + x_{21}}{\sigma - 1}$

(5b) $\pi_2 = \frac{x_{22} + x_{12}}{\sigma - 1}$

As firms are free to choose their production location, no location can offer higher profits in the long run equilibrium (when both the allocation of labour within each country and the international distribution of firms are constant). This implies that ($x_{11} + x_{21}$) and ($x_{22} + x_{12}$), which are the global demands for X-sector firms located respectively in Country 1 (North) and Country 2 (South), have to be equal. It follows that: $(x_{11} - x_{12}) = (x_{22} - x_{21})$, and thus, after some algebric manipulations, we get that the number of producers and the expenditures of each location are related by this condition:

(6) $\frac{E_i}{N_i + N_j \tau^{1-\sigma}} = \frac{1}{(1 + \tau^{1-\sigma})}\frac{E_T}{N_T}$ $\qquad i = 1,2;\ j \neq i;$

where E_T represents world nominal expenditures ($E_T \equiv E_1 + E_2$).

Exploting the same notation used in BF and BS, the generic sum of local and foreign demand (that is the total demand) for each variety is then:

(7) $x_{ii} + x_{ji} = \alpha(\sigma - 1)M\,\frac{E_T}{N_T}$ $\qquad M \equiv \frac{1}{\sigma}\left[\frac{1 + \tau^{-\sigma}}{1 + \tau^{1-\sigma}}\right]$

and operating profits are:

(8) $\pi = \frac{\alpha M E_T}{N_T}$

Defining *m* the share of firms located in the South and exploiting Eq.(7), we have also that:

$$(9)\;\; E_1 - E_2 = \frac{\left(1-\tau^{1-\sigma}\right)}{\left(1+\tau^{1-\sigma}\right)}\left(1-2m\right)E_T \qquad\qquad m \equiv \frac{N_2}{N_T}$$

which makes clear that the equilibrium allocation is such that the majority of the firms is located in the richer economy (as: $m < 1/2 \leftrightarrow E_2 < E_1$). The tendency of the producers to locate in the largest market is usually labelled as the "home market effect" (from Krugman, (1980)); rearranging Eq. (9), it is also easy to note that the sensitivity of this effect to the differential in nominal expenditures is decreasing in the level of trade barriers.

Total gross expenditures (imports) in Country *i* for differentiated goods produced in Country *j* are given by $p^* x_{ij} N_j$. Exploiting Eqs.(4b) and (6), we have:

$$(10)\;\; p^* x_{ij} N_j = \alpha S^* (E_T / N_T) N_j \qquad\qquad S^* \equiv \frac{\tau^{1-\sigma}}{1+\tau^{1-\sigma}}$$

Note that, for any Country *j*'s firm, *S** is the ratio of the (tariff inclusive) value of sales abroad to the total value of sales, representing thus a measure of the relevance of foreign markets for each producer. Note also that $((\tau-1)/\tau) p^* x_{ij} N_j$ is the tariff revenue level (denoted by R_i) which Country *i* obtains due to imports from Country *j*; we may write:

$$(11)\;\; R_i = \alpha\eta (E_T / N_T) N_j \qquad\qquad \eta \equiv \frac{\tau^{1-\sigma} - \tau^{-\sigma}}{1+\tau^{1-\sigma}}$$

Then, total gross expenditures in the North for southern differentiated goods are given by $\alpha m S^* E_T$ and the tariff revenue deriving from these imports is $R_1 = \alpha\eta m E_T$. By symmetry, the (tariff inclusive) value of exports of X-sector goods from the North to the South is $\alpha\left(1-m\right)S^* E_T$ and tariff revenue perceived by southerners is equal to $R_2 = \alpha\eta(1-m)E_T$. It follows that the total (world) tariff revenue level is: $R_T = \alpha\eta E_T$ (where: $R_T = R_1 + R_2$).

As trade has to be balanced at the world level, national accounting implies: $E_T = Y_T + R_T - I_T$, where I_T is total investment in research ($I_T = wL_{RT}$, the income earned by the total number of worldwide employed researchers, L_{RT}, as labour is the only factor employed in the R&D sector) and

Y_T is in turn the worldwide level of factor incomes, represented by the sum of wages ($2wL$) and total operating profits (πN_T): $Y_T = 2L + \alpha M E_T$. Using these results, it turns out that total expenditures in the world are:

$$(12)\quad E_T = \frac{2L - L_{RT}}{\left[1 - \alpha\left(\eta + M\right)\right]}$$

In order to close the model it has still to be established how the labour force is allocated across the different sectors in both countries. The allocation equilibrium of workers depends critically on the assumptions about the geographical extent of the technological externalities characterizing the R&D sector. It is supposed that the number of already available differentiated goods is a measure of the total stock of scientific knowledge, so that such a number influences also the productivity of the workers engaged in the R&D sector. In general terms, it is assumed that in Country i the amount F of labour required to introduce a new variety of intermediates is equal to:

$$(13)\quad F = \frac{a}{N_i + \lambda N_j} \qquad 0 \le \lambda \le 1 \qquad (i, j = 1,2;\ j \ne i),$$

where a is a positive constant and λ is a parameter measuring how much scientific knowledges developed abroad influence the productivity of the domestic R&D sector . When λ is equal to 1, technological externalities are perfectly "global" in the sense that knowledge developed abroad has the same impact as domestic scientific advances; when λ is equal to zero, the productivity of domestic R&D sector depends entirely on the number of firms located there and externalities are purely "local". Finally, according to the standard terminology, spilovers are "partially localized" when $0<\lambda<1$. Though there is some evidence (Eaton and Kortum, 1996) supporting the idea that technological externalities are actually "imperfect" (or partially localized) in the sense outlined above, for analytical convenience I treat the two polar cases of completely global or completely local spillovers.[3]

[3] With partially localized spillovers, perfect capital mobility would imply the same agglomeration of the R&D sector we will observe in the local spillovers case (unless the two locations host exactly the same number of firms, which is exactly the knife-edge hypothesis of symmetry discussed in BF and BS and removed here).

3. Growth and location with global spillovers

When technological externalities are global ($\lambda=1$), researchers have clearly the same productivity independently on where they are employed (the creation of a new firm lowers the costs of research in both economies no matters where this firm is located). Under the standard hypothesis of free-entry in the R&D sector, the value v of a new patent is equal to the cost a firm has to face in order to obtain it, so that: $v = wa/N_T$. Furthermore, with perfect capital mobility and denoting by r the interest rate on a riskless bond, the no-arbitrage condition and the solution of the intertemporal consumption problem imply that the following equality has to hold: $r = \pi/v + \dot{v}/v = \dot{c}/c + \rho$, where c is the individual consumption level and dots indicate time derivatives. As all consumers share the same preferences, the growth rate of consumption is equal to the growth rate of total nominal expenditures, which in a steady state with a constant allocation of the labour force is simply zero; moreover, the value of each firm, v, decreases exactly at the same rate at which new differentiated gods are introduced (in other terms, the capital gain, $\dot{v}/v$, is negative and equal in absolute value to the growth rate of the total number of differentiated goods). Thus, intertemporal utility maximization and equilibrium in the financial markets imply:

(14) $$\frac{\alpha M E_T}{a} - g = \rho$$

where g is the growth rate of N_T. With the total number of available X-sector goods growing at a rate g, the worldwide number of researchers L_{RT} has to be:

(15) $$L_{RT} = I_T = ag$$

Taking into account eqs (11), (14) and (15), it is easy to see that: $E_T = 2L + \rho a + \alpha\eta E_T$; so, equilibrium total expenditures are:

(16) $$E_T = \frac{2L + \rho a}{1 - \alpha\eta}$$

while the steady state growth rate is:

(17) $g = \frac{\alpha M}{a}\left[\frac{2L+\rho a}{1-\alpha\eta}\right]-\rho$

The growth rate turns out to be a nonmonotonic, U-shaped function of the protection level, as measured by τ. This can be easily shown taking into account that $\eta = 1-\sigma M$ and noting that g is an increasing function of the term M, which in turn is a nonmonotonic, U-shaped function of τ (note also that the growth rate is exactly the same with completely free trade, τ =1, or complete autarky, $\tau = \infty$). In particular we have:

(18) $\frac{dg}{d\tau} = \frac{\alpha}{a}\frac{(1-\alpha)}{(1-\alpha\eta)}E_T\frac{\partial M}{\partial \tau}$

which is negative for sufficiently low values of τ, but positive beyond a critical trade protection level.

In order to explain this result, BF and BS note that the impact of any increase in the tariff rate on the profit rate (and then on the growth rate) may decomposed into three parts: the increase in local sales (due to higher protection of the domestic market), the corresponding decrease in sales abroad (as we are considering symmetric variations in τ) and finally the decrease in the value of net sales abroad for any given level of foreign demand. The net sum of the first two effects is called the "sales effect" and it is shown to be always positive, while the third term, called the "procompetitive effect" (as a higher τ lowers the profit margin on exports evaluated at consumer prices) is always negative. Starting from free trade, when foreign markets are quantitatively important for sales and profits, the loss in the foreign market shares due to higher trade protection is such that the procompetitive effect outweighs the sales effect; this lowers the profit rate, the returns from investment in reserch and finally the growth rate. But if the initial protection level is sufficiently high, so that profits coming from sales abroad have a limited quantitative influence, a further increase in τ may boost local sales up to the point where the sales effect dominates the procompetitive effect and the net outcome is a higher profit and growth rate. As a consequence the link between the "ad valorem" tariff rate and growth is U-shaped, and it also shown that any analysis simply comparing the polar cases of free trade and autarky may provide us with misleading conclusions.

It is worth hightlighting that, respect to the analysis conducted by BS, the non-monotonicity outcome here is indipendent on any assumption concerning whether tariff revenue is redistributed or not to consumers.[4] The difference comes from the fact that in their paper agents are supposed to consume exclusively the differentiated products subject to the tariff rate; in that case changes in τ have no impact on total expenditures when tariff revenue is redistributed to consumers, so that the profit and growth rates are not affected too. But if, as supposed here, agents consume also other types of goods which are not subject to trade restrictions, a part of the tariff revenue redistributed will be used to buy also these goods; as a consequence the net impact on the profit rate of the X-sector goods and on growth will not be zero. All these results are analyzed in detail in the Appendix.

Fig.1 reports the dynamics of the growth rate for different values of the tariff rate and for a given set of parameters $(\alpha = 0.8; k = 0.2; \rho = 0.05; L/a = 0.2; \sigma = 3)$.[5] Though the nonmonotonicity of the relationship clearly emerges, it should also be noted that the influence exerted by tariffs on growth seems quantitatively limited, especially respect to the case of local spillovers treated below (note that growth is measured along the left vertical axis for the global spillovers case and along the right one for the local spillovers case): the growth rate, which is equal to 0.07 with completely free trade, decreases when the tariff rate grows reaching a minimum value of approximately 0.0672, corresponding to a critical protection rate of about τ=1.675, and then keeps on increasing (remember that the growth rate is the same with completely free trade or autarky).

Finally, note that both the tariff revenue and nominal expenditures levels have a bell-shaped link with the tariff rate. The term $\alpha\eta$ is nothing but $\alpha((\tau-1)/\tau)S^*$, the ratio of worldwide tariff revenue to worldwide nominal expenditures. This term is bell-shaped as higher values of τ lower demand for differentiated goods produced abroad (that is, lower S^*), though implying at the same time higher fiscal pressure for any given quantity of imports. Which of these two effects prevails, depends on the actual tariff rate value. Anyway, this explains why total nominal expenditures have in turn a bell-shaped relationship with the "ad valorem" tariff rate (provided that tariff revenue be redistributed to consumers).

The last tasks are to determine the equilibrium allocation of firms, measured by *m*, and to analyze how international capital flows are affected by trade policy. The net stock of foreign capital in the South is expressed as the difference between the value of firms located in that economy and the total number of firms owned by residents of that same location at a given time. The nominal value

[4] In BS the U-shaped link emerges only under the hypothesis that tariff revenue is wasted, that is imposing η=0; if on the contrary tariff revenue is fully redistributed, growth is unaffected by changes in τ.

[5] In order to make easier to compare the results, I have taken exactly the same parameters as in the base case studied by MO. Anyway, computations based on alternative values, show that Fig.1 is representative of the general pattern emerging from this simulation exercise.

of this stock is: $FDI_2 = v\left(N_2 - K_2\right)$. Let us denote by *k* the constant share of the total number of firms owned by southern residents ($k \equiv K_2/K_T$). Then, in the steady state with constant values of *m* and *k*, the value of cumulated net capital flows into the South may be expressed as:

(19) $FDI_2 = a(m-k)$

which is a constant as the value of existing firms decreases at the same rate at which new varieties (and firms) are created.

In order to determine the equilibrium allocation of firms measured by *m*, the share of firms locating in the backward economy, note first that total income from investment, $\rho v N_T$ (the total stock of patents, vN_T, multiplied by the return level ρ), is equal to ρa, which is also the difference between total profits and total investment. The total expenditures of northern and southern consumers may be expressed as the sum of the different income sources plus (redistributed) tariff revenue, that is respectively $E_1 = L + \rho a(1-k) + \alpha\eta m E_T$ and $E_2 = L + \rho a k + \alpha\eta\left(1-m\right)E_T$. It follows that:

(20) $E_1 - E_2 = \left(1-2k\right)\rho a - \alpha\eta\left(1-2m\right)E_T$

Comparing (9) and (20), noting that $m - k = (1/2)\left[(1-2k)-(1-2m)\right]$, we may write:

(21a) $m - k = \left[\dfrac{1-2k}{2}\right]\left[1 - \dfrac{\rho a}{(2L+\rho a)}\dfrac{(1-\alpha\eta)}{(\Delta+\alpha\eta)}\right]$ $\qquad \Delta \equiv \dfrac{1-\tau^{1-\sigma}}{1+\tau^{1-\sigma}}$

or alternatively:

(21b) $m = (1/2) - \left[(1/2) - k\right]\left[\dfrac{\rho a}{(2L+\rho a)}\dfrac{(1-\alpha\eta)}{(\Delta+\alpha\eta)}\right]$

It is easy to see that: $k < 1/2 \leftrightarrow m < 1/2$, confirming that the majority of the firms is located in the richer country, and that the number of producers would be symmetric if and only if the ownership of existing firms were equally distributed between northern and southern residents.

Eqs.(21a) and (21b) deserve some comments. First, it may be shown that in the equilibrium the share *m* of firms locating in the South as well as the difference $m-k$ are increasing in the protection level (see Appendix 2). This is a common result in the "new economic geography": higher trade barriers lead producers to spread across countries in order to better satisfy demand, while lower trade costs create a tendency to agglomeration; also, higher trade barriers lead to higher FDI. Secondly, and not surprisingly, *m* is also increasing in *k*, the share of firms owned by southern residents. Finally, the difference $m-k$ may be negative, which would imply net capital flows from the South to the North. Discussing this ambiguity in the direction of net capital flows, MO note that two contradictory forces are at work: on the one side firms want to locate in the advanced economy as northerners own a larger share of the total stock of patents and have higher expenditure levels (the "capital income effect"); on the other side, location in the South has the advantage to face less competition because of the lower capital base (this is a "competition effect").

Interestingly, there is here a third effect, because differences in expenditures between North and the South are related not only to the differences in the endowments of financial wealth but also to those in tariff revenue (provided that it is redistributed to consumers). As the South imports a larger set of differentiated goods, southern consumers may dispose also of a higher tariff revenue level. So another factor which could offset the "capital income effect" (and which could be called the "tariff revenue effect") comes from trade policy: the redistribution of tariff revenue dampens the extent to which the differences in the shares of financial wealth are reflected in differences in the expenditure levels, contrasting thus the forces leading to the agglomeration of firms in the advanced country. This may be formally seen, as considering Eqs.(9), (11) and (20), we may compute the difference in tariff revenue levels:

$$(22)\; R_2 - R_1 = (1-2k)\rho a \frac{\alpha\eta}{\Delta + \alpha\eta}$$

which is clearly positive and decreasing in *k*: the difference in tariff revenue levels perceived by the residents of the South and of the North increases when the share of capital owned by the former is lower, contrasting the "capital income effect". Note also that the difference of Eq.(22) is decreasing in τ, as higher protection encourages a larger share of firms to locate in the South. On the balance, the difference $m-k$ may be negative only for sufficiently low levels of protection, being otherwise positive. Fig.2 reports the value of the net nominal stock of foreign capital in the South (measured in per-capita terms) as a function of the tariff rate; it is clear that this stock may be negative only at low values of τ, but beyond some critical level the South becomes a net recipient of foreign capital.

4. Growth and location with local spillovers

When technological externalities are local (λ=0), the required number of researchers in order to introduce a new variety of intermediates in Country *i* is a / N_i (i = 1,2); in this case the R&D costs depend on where research activities are conducted and in particular are lower in the advanced economy. As usual with local externalities and perfect capital mobility, for a balanced growth path with a constant international distribution of firms to exists, R&D activities have to be concentrated in the location with a higher number of producers, the North. Nevertheless, the number of firms producing in the South grows over time, as in each period some of the firms just created or already operating in the North find it profitable to locate in the poorer economy.

We have now: $I_T = L_{RT} = L_{R1}$, while the growth rate g of the total number of intermediates N_T is such that:

(23) $ga = (1-m)L_{R1}$

As $v = a / N_1$, the no-arbitrage condition and intertemporal utility maximization imply now:

(24) $\alpha(1-m)ME_T - ga = \rho a$

Taking into account the same accounting identity as before, we get the nominal value of worldwide expenditures:

(25) $E_T = \dfrac{2L + \rho a\left(1-m\right)^{-1}}{1-\alpha\eta}$

while the steady state growth rate with localized spillovers is:

(26) $g = \dfrac{\alpha M}{a}\left[\dfrac{2L\left(1-m\right)+\rho a}{1-\alpha\eta}\right] - \rho$

Note that the nominal value of total expenditures is higher than in the global spillovers case, as the nominal value of firms and then financial wealth are higher when the productivity of the research sector depends only on the domestic stock of knowledge (the income coming from the total stock of patents is now: $\rho a(1-m)^{-1}$, which is also the difference between total profits and total investment). As a consequence, the profit and growth rates may be higher with local than global externalities. However, for sufficiently high protection levels, the growth rate is always lower in the local spillovers case; this happens because with localized technological externalities and perfect capital mobility, investments in the R&D sector are concentrated in one country and their productivity depends exclusively from domestic scientific advances (as measured by the number of local producers). As a consequences forces leading to higher agglomeration of firms in the advanced economy (that is leading to lower values of *m*) have also a growth promoting impact, while any tendency to the dispersion of firms is harmful to growth. To see this point more clearly, note that the influence of the protection level on the growth rate is now:

$$(27)\quad \frac{dg}{d\tau}=\frac{\alpha}{a}\frac{(1-\alpha)}{(1-\alpha\eta)}E_T\frac{\partial M}{\partial\tau}-\frac{\alpha}{a}\frac{2LM}{(1-\alpha\eta)}\frac{\partial m}{\partial\tau}$$

The first term on the right hand side of Eq.(27) is similar to that of Eq.(18); the only difference is that total expenditures are now given by Eq.(25). On the contrary, the second term was absent from Eq.(18): with localized externalities the impact of trade policy on growth works also through the impact that protection exerts on the location of firms. As shown below, *m* is increasing in τ in the localized spillovers case too. This implies that, when technological externalities have a limited geographical influence, an increase in protection is harmful to growth, as it stimulates a stronger relocation process from the North to the South, reducing the productivity of the research sector in the advanced economy. As a result, the nonmonotonicity of the link between trade policy and growth is affected too; starting from high protection levels, a further increase in τ may be harmful to growth even when the sales effect is quantitatively more important than the procompetitive effect, as the difference may not to compensate the negative influence that higher protection exerts on growth through the relocation process of firms towards the backward economy.

These results are summarized by the dashed line in Fig.1 (recall that growth is measured now along the right vertical axis). The growth rate with local spillovers is even higher than that of the global externalities case for sufficiently low tariff rates (because with completely localized externalities the value of the stock of financial wealth owned by consumers is higher, so that expenditures and profits are higher too). But when tariff rates grow, a larger share of firms choose to locate in the South; as this lowers thus the productivity of the R&D sector, the growth rate keeps on decreasing for a larger range of tariff rate values (respect to what happens with global spillover case), before reaching some critical point beyond which it starts increasing. Numerical simulations show that this critical point is likely to be higher than protection rates chosen by very closed economies in the real world.[6] This result may have important implications on empirical work: if international technological externalities were limited or even not existent, we should expect the relationship between openness and growth to be monotonic for reasonable protection levels. Conversely, empirical results supporting the existence of nonmonotonicities in the trade and growth link could be taken also as evidence of significant international spillovers effect. It has also to be noted that the kind of trade barrier introduced in the model plays a key role. MO assume the presence of "iceberg costs"; this is virtually the only difference with the present paper, but it turns out to be a very important one: in MO, when externalities are global, trade costs do not affect growth at all and higher trade barriers always lead to lower growth if spillovers are completely localized. Given the diversity of these results, it seems that considering "iceberg costs" (as usually done in the "new economic geography") rather than some other form of trade barrier is far from being irrelevant.

The next task is to determine the equilibrium allocation of firms. Following the same steps as in the global externalities case, we have:

$$(28)\quad E_1 - E_2 = (1-2k)\rho a (1-m)^{-1} - \alpha\eta(1-2m)E_T$$

As (9) holds also in the local spillovers case, Eq.(21a) is now replaced by:

$$(29)\quad m - k = \left[\frac{1-2k}{2}\right]\left[1 - \frac{\rho a}{[2L(1-m)+\rho a]}\frac{(1-\alpha\eta)}{(\Delta+\alpha\eta)}\right]$$

which is clearly not linear. Rearranging terms, we obtain a quadratic equation. It may be shown that one of the roots is economically irrelevant and may be ruled out (as it implies $m > 1$ and a negative growth rate). The other root determining the equilibrium distribution of firms is:

$$(30)\quad m = \frac{z_1 - \sqrt{z_1^{\,2} - 16z_2}}{8}$$

where:

[6] The implied turning point corresponds here to about τ =3.150 (and is very high also under alternative assumptions on parameters). Though referring to the imports of intermediate rather than final goods, note that for none of the countries reported in Sachs and Warner (1995) the implied value of τ would be higher than 1.5 (excluding India, for which it would be equal to about 2.1).

$$z_1 \equiv 6 + 2\left(\rho a/L\right); \quad z_2 \equiv 2 + \left(\rho a/L\right)\left[1 - \frac{(1-2k)(1-\alpha\eta)}{(\Delta + \alpha\eta)}\right]$$

Once again it may be shown that the share *m* of firms locating in the backward country is increasing in τ. Thus a growth promoting effect of trade liberalization comes through a higher concentration of firms in the location where research activities take place, which in turns raises the productivity of the R&D sector itself.

With completely localized spillovers the nominal value of the net stock of foreign capital in the backward economy is:

$$(31)\; FDI_2 = a\frac{(m-k)}{(1-m)}$$

This expression (which may be negative: see again Fig.2) is different from Eq.(19), as the value of a patent is now a function of the international distribution of firms, and surely increasing in *m*, which in turn is positively related to the tariff rate: the value of the foreign capital stock present in the backward location is again growing in the tariff rate level. We can also conclude that with localized R&D externalities, a higher inward stock of foreign capital in the South (or, alternatively, a higher outward stock of foreign capital owned by northern residents) is associated to lower growth; on the contrary, if externalities are global, the relationship between the cumulated stock of FDI in the South and growth is obviously U-shaped.

5. Welfare

As there exists a possibility that higher trade barriers lead to higher growth rates, we may ask whether the effect exerted upon consumer's welfare by different tariff rates is nonmonotonic too. In static trade models, protection has well-known adverse implications on individual utility due to the misallocation of resources, but in a dynamic context we could conceive that, to the extent to which trade protection raises growth rates, dynamic welfare gains offset static losses. Obviously this cannot be the case for low protection levels, given that increases in the "ad valorem" tariff rate are growth promoting only starting from sufficiently high trade barriers.

In order to analyze this issue, I derive indirect utilities of northern and southern consumers and then perform some numerical simulations. Taking into account Eq. (1) and demand functions, the indirect utility of a consumer living in Country *i* (*i* = 1,2) is:

$$(32)\ V_i = \frac{1}{\rho}\log\left[(1-\alpha)^{(1-\alpha)}\alpha^{\alpha}\frac{(E_i/L)}{P_i^{\alpha}}\right]+\frac{\alpha g}{\rho^2(\sigma-1)}$$

where

$$(33)\ P_i^{\alpha} = p^{\alpha}\left[N_i + N_j\tau^{1-\sigma}\right]^{\alpha/(1-\sigma)} \qquad (i,j)=1,2;\ j\neq i;$$

is the consumer price index in Country *i*, given the assumptions on preferences in Eq.(1). It is then straightforward to see that indirect utilities are the sum of two components, the first concerning individual real expenditures and the second one concerning growth. Consequently, the welfare impact of trade policy may be decomposed into a static effect (the effect upon real expenditures) and into a dynamic one (the impact upon the long run growth rate), which are the first and second terms on the right hand side of Eq.(32). The impact of tariff rates upon real expenditures in turn works through the influence on the price index (which grows with τ, lowering the real value of nominal consumption) and the influence exerted upon nominal expenditures. When externalities are global, income from investment does not depend on trade barriers and the only impact upon nominal expenditures is the one on tariff revenue (as said above, the relationship between τ and nominal tariff revenue is bell-shaped). As a consequence, individual real expenditures are surely decreasing in τ when the tariff rate is sufficiently high, while for low values of τ the sign of the derivative depends on the quantitative importance of the effects on the price index and on tariff revenue. Obviously, the dynamic welfare component is U-shaped in τ. As it is analytically difficult to compare the weight of these different effects, I have decided to rely on numerical simulations. These show that the impact of higher tariff rates upon individual real expenditures is negative and quantitatively more important than the potential positive dynamic effect, so that on the balance higher protection is welfare reducing even when it has a growth promoting influence. In the local spillovers case, this outcome holds “a fortiori”, as increases in tariff rates are pro-growth only starting from very high trade barriers. As a synthesis of these results, Fig.3 reports how indirect utilities of northern and southern consumers (respectively V_1 and V_2) are affected by increases in τ in the case global spillovers (under the same assumptions on parameters as before and assuming also an arbitrary value of N_T =100); the same monotonically negative pattern emerges using different parameters values and/or in the case of local spillovers.

6. Stability

The whole preceding discussion conducted is focused on a long run equilibrium in which the international distribution of firms is constant and determined by the condition that operating profits have to be the same in the two trading locations (due to capital mobility and the absence of (re)location costs). An intuitive condition for such an equilibrium to be stable is the following: if we are initially at the equilibrium and consider the relocation of one firm from one country into the other one, then the profits earned in the first location must become higher than those offered by the other one; in the opposite case, other firms would find it profitable to relocate and an agglomeration process would set in. This stability condition may be formally expressed as:

$$(37)\quad \frac{d(\pi_2 - \pi_1)}{dm}_{|m=m^*} < 0$$

where m^* is the steady state distribution of firms and the number N_T of totally available varieties is given. It may be shown (see Appendix 4) that this condition actually holds with both global and local R&D externalities. As discussed above, this is due to the critical assumptions of capital mobility (which is a stabilizing force) and no labour migration.

7. Summary and conclusions

Drawing on recent contributions about trade and growth, this paper discusses the possible existence of nonmonotonicities in the openness-growth link, introducing the assumption that the two trading economies differ in the attained development (wealth) level. In this sense, the theoretical framework may also be considered a North-South model in which both location choices and growth are endogenous and interacting processes. It is shown that, if technological externalities characterizing the R&D sector spill over completely from one country to the another one, the growth rate is not affected by the international distribution of firms; in this case, the link between the tariff rate of an "ad valorem" tariff on imports of differentiated goods and the balanced path growth rate is actually nonmonotonic (U-shaped). As discussed in the previous literature, this outcome is due to the different and contradictory effects that (symmetric) trade protection exerts upon foreign and local sales, and consequently on both the profit and growth rate. However, if spillovers are localized, so that in the equilibrium all R&D activities are agglomerated in the richer economy, location influences growth; in this second case, as higher trade protection implies higher relocation from the North to the South, there is a further mechanism linking (negatively) trade protection and growth and numerical simlations show that increases in the tariff rate may monotonically decrease the growth rate (at least for plausible values of the tariff rate itself), so that the U-shaped pattern is dampened or even disappears. Obviously, it becomes a pure empirical matter to understand which of the two outcomes is more relevant. Anyway, numerical simulations show also that higher trade protection is monotonically associated to lower individual welfare, no matters whether externalities are global or local.

These results seem to shed some more light on those found in previous work. Respect to the contributions focusing on the existence of nonlinearities in the trade-growth link, we may conclude that the fact of considering symmetrically developed economies is not irrelevant, as in a North-South framework the nonmonotonicity outcome depends critically on the assumptions about the geographical externalities of the research sector. Moreover, respect to the recent literature about endogenous growth and endogenous location, it is apparent that the assumptions about the kind of trade barriers introduced in the model have a great influence upon the results of the model itself, and consequently on its both empirical and policy implications (due to nonlinearities, this holds especially when we consider changes in trade barriers and not simply compare free-trade vs autarky equilibria, as already stressed in BF and BS). It has also to be noted that in the real world (and differently from what assumed here) different type of trade barriers coexist and protection levels are not the same across different countries. To address these issues,[7] taking into account at the same time asymmetries in development levels, seems to be a challenging but important task for future theoretical and empirical research.

[7] Some results are already derived in BF.

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Appendix 1. The impact of trade protection on profits and growth

Each firm’s profits may be written as:

(A 1.1) $$\pi = \frac{\alpha}{\sigma}\left[1 - S^* + \frac{S^*}{\tau}\right]\frac{E_T}{N_T}$$

where S^* is the share of foreign (gross) sales on total sales of each firm (as: $p^* x^* = (\alpha S^* E_T)/N_T$), *1-* S^* is the share of local sales and the term in bracket is equal to σM .

The derivative of π respect to τ may be expressed as:

(A 1.2) $$\frac{d\pi}{d\tau} = \frac{\alpha}{N_T}\left[E_T + M\frac{\partial E_T}{\partial M}\right]\frac{\partial M}{\partial \tau}$$

and

(A 1.3) $$\frac{\partial M}{\partial \tau} = \frac{1}{\sigma}\left[\frac{\partial(1 - S^*)}{\partial \tau} + \frac{1}{\tau}\frac{\partial S^*}{\partial \tau} + S^*\frac{\partial}{\partial \tau}\frac{1}{\tau}\right]$$

where the first and second term in bracket represent the “sales effect” (the changes in respectively the local and foreign market shares due to the change in trade protection) and the the third term in bracket is the “procompetitive effect” (the change in net sales abroad for a given foreign market share). It is straightforward to see that the sales effect is always positive and that the procompetitive is negative, but the net impact depends on the value of τ .

Though total expenditures are inversely related to the term M, it is easy to see that the term in bracket of eq.(A 1.2) is equal to:

(A 1.4) $$E_T\left[1 - \frac{\alpha\sigma M}{1 - \alpha(1 - \sigma M)}\right]$$

which is clearly positive. As a consequence the sign of the derivative $d\pi/d\tau$ has to be the same as the sign of $\partial M/\partial\tau$. Finally note that when agents consume exclusively differentiated goods, so that we impose α =1, we get:

(A 1.5) $$\frac{\partial E_T}{\partial M}_{|\alpha=1} = -\frac{E_T}{M}$$

which implies $d\pi/d\tau$ to be zero, and thus no impact of trade policy on growth. This is exactly the case considered in Baldwin and Sbergami (2000): when tariff revenue coming from the imports of the X-sector goods are entirely redistributed lump-sum to the consumers and only differentiated goods are consumed, changes in τ do not affect sales and profits, so that trade policy turns out to be growth neutral.

Appendix 2. The share of firms locating in the South is increasing in the tariff rate

(A 2.1) $$\frac{dm}{d\tau} = -\left[\frac{1-2k}{2}\right]\left[\frac{\rho a}{2L+\rho a}\right]\frac{d}{d\tau}\left[\frac{1-\alpha\eta}{\Delta+\alpha\eta}\right]$$

Defining $\delta \equiv \tau^{1-\sigma}$ and remembering that $p = \sigma/(\sigma-1) > 1$, after some manipulations we get that:

(A 2.2) $$\frac{d}{d\tau}\left[\frac{1-\alpha\eta}{\Delta+\alpha\eta}\right] = \frac{\partial}{\partial\delta}\left[\frac{(1+\delta)-\alpha(\delta-\delta^p)}{(1-\delta)+\alpha(\delta-\delta^p)}\right]\frac{\partial\delta}{\partial\tau}$$

The term in bracket on the right hand side of (A 2.2) is higher than 1 and clearly increasing in δ, which in turn is inversely related to τ; this implies that *m* is unambiguously increasing in τ.

Appendix 3. Both economies produce the numeraire good

Suppose the South to be completely specialized in the production of *Z* (*m* = 0); in this case worldwide nominal expenditures would be given by eq.(16) independently on spillovers being global or local. It is straightforward to see that the supply of *Z* coming from the South (just equal to

L) would be less than the world demand of the same good, $(1-\alpha)E_T$, as the following inequalities hold:

(A 3.1) $1-\alpha\eta<1<2+(\rho a/L)$

This shows that market clearing requires the North not to be completely specialized in the production of differentiated goods and that part of the world supply of Z has to be produced in the richer location; this ensures in turn that w = 1 in the North too.

Appendix 4. Stability

Exploiting demand and profit functions given by Eqs. (4a), (4b) (5a) and (5b), the difference between profits obtained by two firms located respectively in the South and in the North is equal to:

(A 4.1) $$\pi_2-\pi_1=\frac{\alpha(1-\delta^p)}{pN_T}\left[\frac{E_2}{m+\delta(1-m)}-\frac{E_1}{(1-m)+\delta m}\right]$$

Recalling that $E_1=L+\rho a(1-k)+\alpha\eta mE_T$ and $E_2=L+\rho ak+\alpha\eta\left(1-m\right)E_T$, and taking into account that total nominal expenditures are given by Eqs.(16) and (25) with respectively global or local externalities, it is easy to see that the differential in operating profits given by Eq.(A 4.1) is decreasing in m (as the first term in bracket of Eq.(A 4.1) is decreasing and the second one is increasing). It is worth repeating that the redistribution of tariff revenue acts here as a stabilizing force, as the relocation of one firm tends to decrease the tariff revenue of the recipient country and to increase that of the economy where this firms was initially producing; so, contrary to what happens in other geography models, prodution shifting generates an expenditure shifting process which tends to offset the original shock. However, the model would be stable even without this mechanism (as we can see by imposing that tariff revenue be wasted, that is: η = 0).

Fig.1 Tariff rates and growth

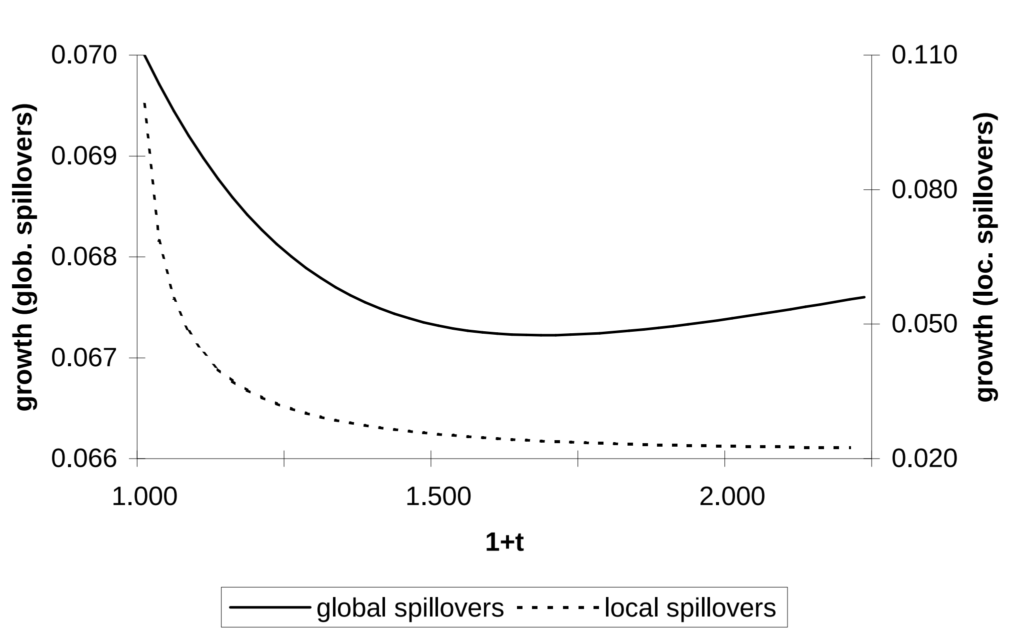
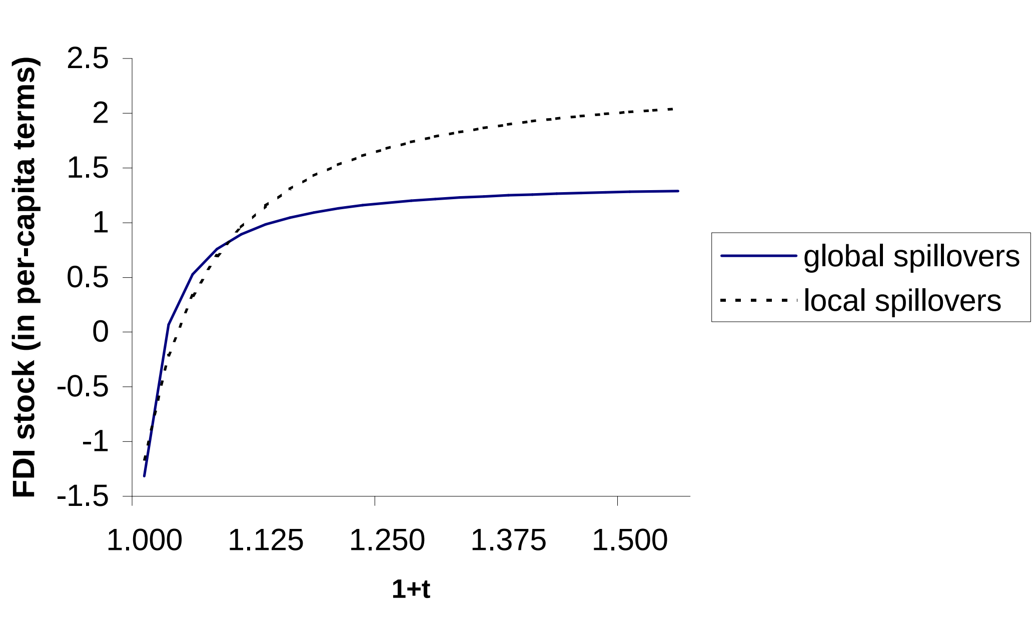


Fig.2 Tariffs and foreign capital in the South



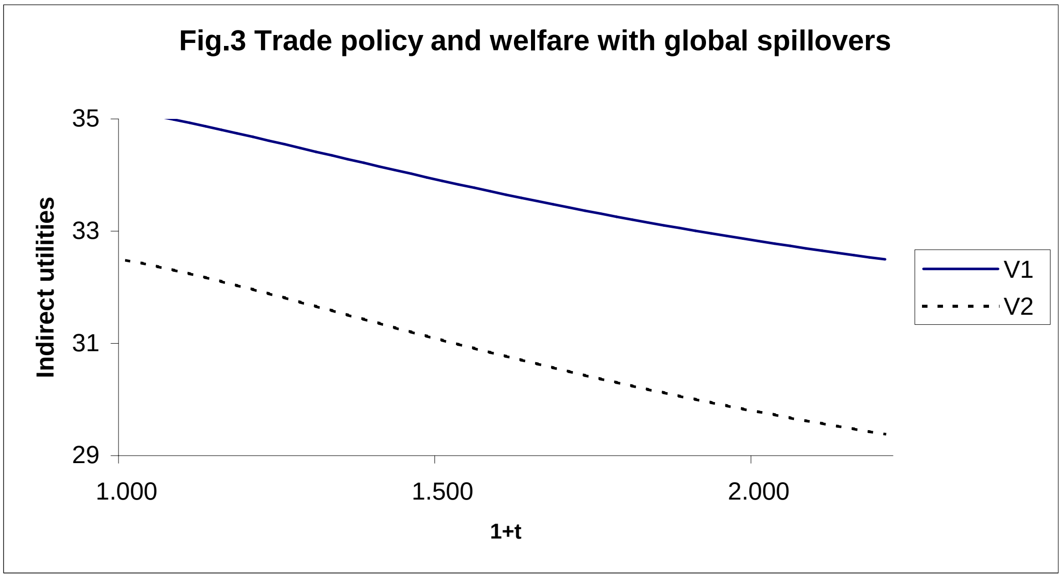


Fig.3 Trade policy and welfare with global spillovers
Indirect utilities
35
33
31
29
1.000
1.500
2.000
1+t
V1
V2