Tariff Protection and Industrial Structure*

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Abstract

In a small open economy with heterogeneous firms, in which tariffs determine the mass of active firms, the gains from trade liberalization depend positively on the level of firm vertical heterogeneity (quality heterogeneity) and negatively on transportation costs. The benefits from temporary protection depend on the quality gap: for a given mass of backward firms, the relative gains from protection increase with their quality and decrease with the quality of advanced firms; for given production quality levels, the relative advantage of protection increases with the mass of backward firms.

JEL-Classification: D51, D62, F12, F13

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1 Introduction

The trade liberalization-protection debate has been one of the most controversial in the trade and development literature. The empirical literature is far from conclusive (Rodriguez and Rodrik, 2001 and Hallak and Levinsohn, 2008) and sound theoretical arguments can be found either to justify further trade openness or to promote protection of some industries. The debate becomes more ardent as far as developing economies are concerned and, again, successful development stories provide a mixed picture about the usages of either protection or trade liberalization as key elements of a development strategy (Chang 2003, Rodrik, 2004).

It seems clear that the advantages of any degree of protection are conditional upon the characteristics of the economy to be protected or liberalized. These characteristics may be associated with the institutional environment (Aghion et. al., 2005), the level of competition (Leahy and Neary, 1999), the co-existence of modern and traditional sectors (Sauré, 2007) and the capacity of firms to increase efficiency over time (Clemhout and Wan, 2000 and Melitz, 2005). On top of these dimensions, the benefits of liberalization or protection may also depend on how far domestic industries are from the technological frontier and, therefore, on the mass and production quality of firms that remain active after liberalization. To investigate the implications of this aspect on the benefits of tariff protection relative to trade liberalization, we provide a model of a small economy where industries differ in their technological gap with respect to the frontier and show that whether trade liberalization dominates trade protection depends on vertical heterogeneity of the industrial structure, on the mass of backward industries and on their level of backwardness.[1]

We emphasize the fact that a domestic and a foreign variety of a good in a given industry have a higher degree of substitutability than goods of different industries. A Chinese and an American T-shirt are obviously more

[1]The idea that reactions to trade liberalization depend on how far firms are from the technological frontier is present in Aghion et. al. (2005), although their focus is on industry differences in labor regulation

substitutable than a T-shirt and a tire.[2] The fact that developing countries produce manufactures that are highly substitutable with foreign ones, but produced at different quality or efficiency levels, is present in the standard Ricardian trade model with a continuum of goods, but it is mostly overlooked by the recent literature on trade with heterogeneous firms. We show that introducing perfect substitutability between domestic and foreign varieties, as in the Ricardian models, in a framework with CES preferences over different industry goods and efficiency or quality heterogeneity has relevant implications on the evaluation of the benefits associated with trade liberalization and protection.

We first analyze a static, small open economy, general equilibrium model with heterogenous industries and trade costs. We dispense with the traditional gains from trade due to either love of variety or increasing returns. This way, gains from trade for the small economy derive from vertical differentiation alone, because it allows to substitute higher quality imported goods for lower quality, domestically produced ones. As a consequence, if goods in developing countries are produced at lower quality or efficiency levels than their perfect substitutes in advanced countries, they have to rely on cost advantage to be competitive.[3]

Our first result on the effect of tariff protection is that whether protection is better than liberalization, or the other way around, crucially depends on the degree of vertical heterogeneity, that is, on the distance between sectors close to the technology frontier and sectors further away from it. Domestic vertical heterogeneity increases gains from trade and eventually makes liberalization desirable. In this case, local champions can emerge and compete internationally, and it is desirable to let international competition substitute high quality imported goods for low quality domestic ones. By contrast, protection tends to be preferable where the local industrial structure is more

[2]The empirical relevance of this distinction is apparent in the literature on imitation and development. This literature is motivated by the fact that many successful growth experiences are based on imitation. See, for example, Lewis (1954), Hirschman (1968), Schmitz (1989), Kim (1997) and Kim and Nelson (2000) .

[3]The positive relationship between per-capita income and quality production is illustrated by Hallak (2006).

homogeneous, since in this case gains from trade are lower and may be insufficient to compensate for trade costs. Our second result is that the lower transportation costs, the lower is the degree of heterogeneity required for free trade to be better. Thus globalization makes free trade a better policy for a wider range of industrial structures.

We next extend the static framework to include dynamic learning externalities.[4] In a recent paper, Melitz (2005) elaborates on the Mill-Bastable test to emphasize that the dynamic benefits of trade policy depend on firms' learning curves. If externalities arise from localized network interaction with other firms, liberalization adds dynamic costs to static trade costs if, when forcing several industries to close, it brings about a loss of relevant learning externalities.[5] This observation is developed by Baldwin and Robert-Nicoud (2006). They show that, if learning externalities increase in the number of locally active firms, free trade may be detrimental to growth, even if it initially raises productivity.[6]

We focus on localized learning externalities, implying a growth detrimental effect of trade. Of course, localized learning externalities may not be the main source of learning. We focus on them because, together with concave learning curves, they naturally yield a dynamic version of the infant industry argument.[7] In this context, which by assumption is dynamically favorable to protection, we ask the following question: how sensitive is the infant industry argument to the characteristics of a country's initial industrial structure, defined by the distribution of its sectors' quality?[8]

[4]The relevance of learning should be out of doubt. Amsden (1989) already observed: "If industrialization first occurred in England on the basis of invention, and if it occurred in Germany and the United States on the basis of innovation, then it occurs now among 'backward' countries on the basis of learning" (Amsden 1989:4). The evolution in the quality of Chinese or Indian exports is an example (Rodrik, 2006).

[5]The fact that learning externalities are highly localized has been recently emphasized by the empirical literature on innovation and growth, for instance by Keller (2002) and by Bottazzi and Peri (2003).

[6]In another recent paper, Greenwald and Stiglitz (2006) argue that learning in manufacturing can also spill over agriculture.

[7]Jones (1995) and Segerstrom (1998) have stressed that learning functions are concave in own knowledge, which in our context means that high quality products are harder to improve than low quality ones.

[8]Our work thus complements Baldwin and Robert-Nicoud (2006), whose focus is on the

As was true in the static model, our dynamic analysis confirms that, the higher trade costs, the narrower the range of initial industrial structures for which liberalization is dynamically preferable, and in particular the higher the initial degree of vertical heterogeneity necessary for this to hold. When there are two types of firms, technologically backward and technologically advanced, the relative gains to initial protection increase with the quality of backward firms (the cost of protection becomes lower), decrease with the quality of advanced firms (a lower level of heterogeneity reduces the benefits from free trade) and increase with the mass of backward firms (the loss of learning externalities would be higher). In essence, a rather homogeneous industrial structure, with all firms at a similar (and not too wide) quality gap from the frontier, is more worth protecting than a heterogeneous industrial structure, with a few very backward sectors and many relatively advanced ones.

We finally discuss how farsighted a policy maker should be to choose the right policy, and observe that this also changes with the initial industrial structure. Thus some countries are more exposed to policy mistakes than others, due to a stronger temptation to follow a policy that is better in the short run, but worse in the long run.

Our framework is complementary to the trade literature with heterogeneous firms. In this literature, varieties are imperfect substitutes and trade liberalization relocates resources towards the more productive firms, which in turn expand their production in order to serve foreign markets. Trade liberalization is then welfare-improving because it leads to higher average productivity and allows for a greater number of varieties available for consumers with intrinsic love for variety. Most of the recent models of trade with heterogeneous firms (e.g. Bernard et al. 2003; Chaney 2008; Melitz 2003; Melitz and Ottaviano 2007) focus on the reallocation effects of trade, rather than on optimal levels of protection. An important exception is Demi-

implications of different kinds of learning externalities, and the similar model developed by Gustavsson and Segerstrom (2007), who remove the strong scale effect present in Baldwin and Robert-Nicoud (2006). Changes in learning externalities and in transportation costs may explain why the sign of the correlation between tariffs and growth changes over time, as shown by Clemens and Williamson (2004).

nova and Rodriguez-Clare (2009), who provide a version of the Melitz model (with the same elasticity of substitution between any two goods) in a small open economy and study a variety of trade policies. Their main finding is that the optimal policy involves improving the terms of trade, for instance through an import tariff (or an export tax). We differ from their analysis because our emphasis on the high substitutability aspect of internationally competing goods (produced at different quality or efficiency levels) implies that, given the small economy assumption, there is a limit price at which foreign demand becomes perfectly elastic. This also implies that, for such a small economy to be open, returns must be (at least eventually) decreasing, since otherwise exporting industries would keep growing, putting pressure on wages until the cost advantage (and the possibility of export) disappears. While the combination of decreasing returns and monopoly is not justified on purely theoretical grounds, it accurately describes many realities in developing countries, possibly due to the scarcity of entrepreneurial capital as shown by Tybout (2000).

The remainder of this paper is organized as follows. Sections 2 and 3 introduce the model and discuss its static equilibria. Section 4 introduces the leaning dynamic and presents simulation results. Section 5 concludes.

2 The model

We consider a small open economy, populated by a measure 1 of identical individuals, each endowed with 1 unit of labor, which is supplied inelastically in a competitive labor market. There is a measure 1 of monopolistic industries.

2.1 Preferences and technologies

The representative consumer maximizes

$$U = \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho} \right)^t \ln c(t), \tag{1}$$

where $\rho \in (0,1)$ is the intertemporal discount rate and $c(t)$ is a Dixit-Stiglitz bundle of the goods produced in different industries at time t. Since we do not consider intertemporal transfers, the solution to this problem reduces to the solution of the static problem, so that demand for consumption at time t is $c(t) = \frac{E(t)}{P(t)}$, where $E(t)$ denotes aggregate income and $P(t)$ is the appropriate price index, both at time t. Aggregate income $E(t) = W(t) + \Pi(t) + T(t)$ is equal to the sum of aggregate wage income $W(t)$, which under full employment simply equals the wage rate $w(t)$, aggregate profits $\Pi(t) = \int_0^1 \pi(m,t)\,\mathrm{d}m$, where $\pi(m,t)$ denotes profits in industry m, and aggregate tariff revenue on imports $T(t)$, which will be specified below.

Goods are both horizontally and vertically differentiated, so that the DixitStiglitz composite is defined as

$$c(t) = \left[\int_0^1 h(m,t)^{\frac{\sigma-1}{\sigma}}\mathrm{d}m\right]^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

where $\sigma > 1$ captures the elasticity of substitution between the goods of any two different industries and $h(m,t)$ is the 'effective' consumption of good m at time t (or, which is the same, consumption of that good in efficiency units, measured by the product of quantity and quality). Since goods may be either bought locally or imported from the rest of the world, we have

$$h(m,t) = \begin{cases} x(m,t)v(m,t) & , \quad \text{if it is bought locally} \\ x(m^*,t)v(m^*,t) & , \quad \text{if it is imported} \end{cases} \tag{3}$$

where $x(m,t)$ denotes local quantity and $v(m,t)$ the quality of the domestically produced good m, and m^* is a perfect substitute to m, produced in the rest of the world at the quality frontier $v(m^*,t)$.

Each good $m \in [0,1]$ is produced with labor according to the decreasing returns to scale technology

$$y(m,t) = L(m,t)^{\alpha}, \tag{4}$$

with $\alpha \in (0,1)$. Even though we make this assumption for simplicity, it goes in line with the the empirical evidence suggesting that manufacturing firms in developing countries do not enjoy scale economies (Tybout, 2000).[9]

2.2 Trade

Domestic goods directly compete with their foreign perfect substitutes. Taking into account the presence of an import tariff $\tau(t) \geq 0$ (applying to landed import and the same for each variety at a given time) and of transport costs of the iceberg type $a \geq 0$, which render the buyer price of an imported good equal to $p(m^*, t)[1 + \tau(t)](1 + a)$, consumers decide whether to buy locally or to import according to the best quality/price ratio. The set of locally acquired goods, and indeed of domestic producers who are active at all, is $D(t) = \left\{ m \in [0, 1] : \frac{v(m,t)}{p(m,t)} \geq \frac{v(m^*,t)}{p(m^*,t)[1+\tau(t)](1+a)} \right\}$, where $p(m, t)$ denotes the price of good m at time t set by its local producer. Therefore, defining the threshold function

$$p_H(m, t) \equiv \frac{v(m, t)}{v(m^*, t)} p(m^*, t)[1 + \tau(t)](1 + a), \tag{5}$$

we have $D(t) = \{m \in [0, 1] : \ p(m, t) \leq p_H(m, t)\}$. Goods $m \in [0, 1] \setminus D(t)$ are not produced domestically and their foreign perfect substitutes are imported.

Calling $M(m^*, t)$ the quantity of good m^* imported at time t, aggregate tariff revenues on import are

$$T(t) = \int_{[0,1]\setminus D(t)} \tau(t) p(m^*, t)(1 + a) M(m^*, t) \mathrm{d}m^*.$$

A similar structure for the world economy implies that consumers in the rest of the world will be willing to import good m from our small economy only if its quality/price ratio is competitive. Letting $\tau^*(t)$ be the foreign

[9] Simplicity comes from the fact that decreasing returns allow us to easily introduce vertical differentiation in a small open economy model. Decreasing returns reinforce trade costs in our model, because specialization implies production on a higher, less efficient scale. Yet, since we explicitly introduce trade costs in the form of transportation costs, decreasing returns are not crucial for our results and most of them would hold even if we assumed a technology with initially increasing and eventually decreasing returns to scale. With globally non-decreasing returns they would probably still hold, but we would have to explicitly model the number of trading countries.

import tariff at time t, the set of exportable goods for our small economy is $F(t) = \left\{m \in [0,1] : \frac{v(m,t)}{p(m,t)[1+\tau^*(t)](1+a)} \geq \frac{v(m^*,t)}{p(m^*,t)}\right\}$ which defines the threshold function

$$p_L(m,t) \equiv \frac{v(m,t)}{v(m^*,t)} \frac{p(m^*,t)}{[1+\tau^*(t)](1+a)}, \tag{6}$$

and therefore we have $F(t) = \{m \in [0,1] : \; p(m,t) \leq p_L(m,t)\}$.

We assume the rest of the world immediately responds reciprocally to the tariff choice of the domestic economy, by imposing the same import tariff ($\tau^*(t) = \tau(t)$).[10]

Equations (5) and (6) then show that a higher level of tariff protection allows a greater number of domestic producers to survive, but at the same time reduces the number of them who may profitably export.

2.3 Demand

We now drop for notational simplicity the time index. The domestic producer of good $m \in [0,1]$ receives a local demand $x(m)$ and a foreign demand $x^*(m)$, so the total demand she receives is $y^d(m) = x(m) + x^*(m)$.[11] Letting P be the hedonic price aggregator, local demand is

$$x(m) = \begin{cases} \left[\frac{p(m)/v(m)}{P}\right]^{-\sigma} \frac{c}{v(m)} & , \text{ if } p(m) \leq p_H(m) \\ 0 & , \text{ if } p(m) > p_H(m) \end{cases} \tag{7}$$

At price $p(m) = p_L(m)$, local production is assumed to be first absorbed

[10] We regard this assumption as the most meaningful to study the dynamic effects of trade policy in the context of a small open economy model: keeping the tariff set by the rest of the world fixed would be dynamically implausible, but for a deeper analysis of the tariff choice problem of the rest of the world a different, more complicated, two country (or n country) model would be better suited than our small open economy model. Yet our interest is not on strategic trade policy, but rather on the interaction of different industrial structures and dynamic learning, and on its implications for policy. Another way to interpret this assumption that the economy can decide whether or not to become a member of the WTO and therefore benefit from the most favored nation status. We feel that our assumption reaches a good compromise between plausibility and simplicity.

[11] When necessary, we will write $x\left(m \,|p_L(m)\right)$ to denote local demand of good m at price $p_L(m)$ (and analogously for other prices), but we drop the price for notational simplicity whenever this does not create confusion.

by local demand and then exported for the reminder. Since we are dealing with a small open economy, foreign demand is infinitely elastic at $p_L(m)$:

$$x^*(m) = \begin{cases} \in [x(m\,|p_L(m)), \infty) & , \quad \text{if } p(m) = p_L(m) \\ 0 & , \quad \text{if } p(m) > p_L(m) \end{cases} \tag{8}$$

When $p(m) > p_H(m)$, good m is not bought locally and its perfect substitute m^* is imported. Local demand for imports is

$$M(m^*) = \begin{cases} \left[\frac{(1+a)(1+\tau)p(m^*)/v(m^*)}{P}\right]^{-\sigma} \frac{c}{v(m^*)} & , \quad \text{if } p(m) > p_H(m) \\ 0 & , \quad \text{if } p(m) \leq p_H(m) \end{cases} \tag{9}$$

While equation (8) follows from our assumptions, equations (7) and (9) are obtained from expenditure minimization given preferences for horizontally and vertically differentiated goods, as described in (2) and (3).

The hedonic price index P that appears in (7) and in (9) takes into account the possibility of importing, so that

$$P = \left\{ \int_0^1 \left[\frac{p^F(m)}{v^F(m)}\right]^{1-\sigma} \mathrm{d}m \right\}^{\frac{1}{1-\sigma}}, \tag{10}$$

where

$$p^F(m) = \begin{cases} p(m) & , \quad \text{if } p(m) \leq p_H(m) \\ p(m^*)(1+\tau)(1+a) & , \quad \text{if } p(m) > p_H(m) \end{cases}$$

and

$$v^F(m) = \begin{cases} v(m) & , \quad \text{if } p(m) \leq p_H(m) \\ v(m^*) & , \quad \text{if } p(m) > p_H(m) \end{cases} .$$

Merging the previous equations yields total demand for good $m \in [0, 1]$:

$$y^d(m) = \begin{cases} \in \left[x\left(m\,|p_L(m)\right), \infty\right) & , \quad \text{if } p(m) = p_L(m) \\ x(m) & , \quad \text{if } p(m) \in (p_L(m), p_H(m)] \\ 0 & , \quad \text{if } p(m) > p_H(m) \end{cases} \tag{11}$$

Finally, recalling that D is the set of active domestic producers, the overall demand for labor is

$$L^d = \int_D [y(m)^{\frac{1}{\alpha}}]\mathrm{d}m. \tag{12}$$

2.4 Supply

We now solve the firms' profit maximization problem. Each potential local producer faces a discontinuous demand function. It first decides whether to produce or not and then, if it produces, it establishes its optimal quantity of production under the constraints imposed by technology (equation 4) and demand (equation 11). Defining the two thresholds $y_H(m) \equiv x(m\,|p_L(m))$ and $y_L(m) \equiv x(m\,|p_H(m))$, using inverse demand and letting $R(y(m))$ be the revenues and $C(y(m))$ the cost, one gets a profit function $\pi(m) = R(y(m)) - C(y(m))$, which is twice differentiable almost everywhere, it is continuous but not differentiable at $y_H(m)$, it is discontinuous at $y_L(m)$, and it is twice differentiable and concave within each of the ranges determined by these two thresholds, but it is not globally concave. Therefore, the usual condition of equality between marginal cost (MC) and marginal revenue (MR) is neither sufficient nor necessary to ensure optimality. Rather, the following result holds. For either sufficiently low or sufficiently high w, there exists a unique (local and global) profit maximizing quantity; for intermediate wage levels there may exist two local optima, one involving production just for the domestic market and one also involving exports. In such case a firm's choice is determined by direct comparison of the profitability of these two strategies.

The technical details of this analysis, together with the analytical expressions of the optimal quantities and the appropriate thresholds, are provided in Lemma 1 in Appendix A, which describes each firm's profit maximizing choice for any given wage level.[12] Notice that, although each firm takes wages as given, they are endogenously determined in general equilibrium in our model. Beyond technical complications, Lemma 1 yields a simple and intuitive result: firms with very low quality will remain inactive, firms with intermediate quality will produce to serve the domestic market, and firms with very high quality will also export.

To characterize the equilibria of the model, we first identify a candidate equilibrium and then check whether the profit maximization conditions established by Lemma 1 are satisfied.

2.5 Industrial Structure

We define a country's industrial structure as the distribution of its firms' quality. To keep the equilibrium analysis as simple as possible, we make the following assumptions on initial conditions.

Assumption 1 *We normalize at the beginning the international quality frontier for each sector:* $\forall m^* \in [0,1),\ v(m^*,0) = v^*(0)$.

Assumption 2 *A fraction u of local consumption good producers begins with a 'bad' quality, i.e., with a quality gap w.r.t. the international quality frontier. The remaining fraction $(1-u)$ starts with no quality gap.*[13] *Formally,* $\exists\ u,\beta \in [0,1] :\ \ \forall m \in [0,u),\ v(m,0) = \beta v^*(0)$ *and* $\forall m \in [u,1],\ v(m,0) = v^*(0)$.

While Assumption 1 is a simple normalization, Assumption 2 yields a two parameter representation of the horizontal and vertical dimensions of an industrial structure. For instance, advanced industrial structures may have

[12] While the proof is kept as compact as possible for the sake of space, in Albornoz and Vanin (2005) we also present a graphical analysis which clarifies the analytical steps.

[13] In the remainder of the paper we indifferently refer to these two groups of firms as 'backward' and 'advanced', 'low quality' and 'high quality', or 'bad' and 'good', respectively.

a low proportion u of 'bad' firms, whose quality gap $1-\beta$ w.r.t. the international quality frontier is also small, whereas backward industrial structures may have a high u and a low β.

Since over time both 'good' and 'bad' firms may learn, and the international quality frontier moves, we define the ratio of local to international quality at time t, $\beta_L(t) \equiv \frac{v(L,t)}{v^*(t)}$ and $\beta_H(t) \equiv \frac{v(H,t)}{v^*(t)}$, for 'bad' and 'good' firms, respectively.[14] We also denote by $p_L(L,t)$ and $p_L(H,t)$ the lower price threshold and by $p_H(L,t)$ and $p_H(H,t)$ the higher price threshold, for the two types of firms at a given point in time.[15]

3 Static Equilibria

We define an equilibrium as a collection of prices and quantities such that consumers maximize utility, producers maximize profits and all markets clear. We call an equilibrium symmetric when firms with the same quality level make the same choices. We restrict our attention to symmetric equilibria. We first discuss the symmetric equilibrium of our economy under autarky. We next let our small economy be open.

3.1 Equilibrium under autarky

Proposition 1 ***(Autarkic symmetric equilibrium)*** *There exists a unique symmetric equilibrium under autarky.*

Proof See Appendix A. ■

From the proof of Proposition 1 production and consumption patterns in the autarkic equilibrium are:

[14]Thus Assumption 2 means $\beta_L(0) = \beta$ and $\beta_H(0) = 1$. In some cases we relax Assumption 2 to allow for $\beta_H(0) \leq 1$.

[15]Observe that $p_H(L,t) < p_L(H,t) \Leftrightarrow \frac{\beta_L(t)}{\beta_H(t)} < \frac{1}{\{[1+\tau(t)](1+a)\}^2}$, where $\frac{\beta_L(t)}{\beta_H(t)}$ denotes the ratio of 'bad' firms' quality to 'good' firms' quality.

$$c_A = \left[uv(L)^{\frac{\sigma-1}{\alpha+\sigma(1-\alpha)}} + (1-u)v(H)^{\frac{\sigma-1}{\alpha+\sigma(1-\alpha)}}\right]^{\frac{\alpha+\sigma(1-\alpha)}{\sigma-1}} \tag{13}$$

$$y_A(L) = \left\{u + (1-u)\left[\frac{v(L)}{v(H)}\right]^{-\frac{\sigma-1}{\alpha+\sigma(1-\alpha)}}\right\}^{-\alpha} \tag{14}$$

$$y_A(H) = \left\{u\left[\frac{v(L)}{v(H)}\right]^{\frac{\sigma-1}{\alpha+\sigma(1-\alpha)}} + (1-u)\right\}^{-\alpha} \tag{15}$$

The autarkic consumption level c_A is a decreasing function of u and an increasing function of both $v(L)$ and $v(H)$ (and therefore, given $v(H)$, of the domestic 'bad' to 'good' quality ratio). It is also an increasing function of σ, since a higher elasticity of substitution allows a reallocation of production and consumption from low to high quality goods.

The autarkic production patterns have the following properties: $y_A(L) < 1 < y_A(H)$; both $y_A(L)$ and $y_A(H)$ are increasing functions of u; $y_A(L)$ is increasing in $\frac{v(L)}{v(H)}$; $y_A(H)$ is decreasing in $\frac{v(L)}{v(H)}$; $y_A(L)$ is decreasing in σ; $y_A(H)$ is increasing in σ. Thus the difference in production between 'good' and 'bad' domestic firms increases with the quality gap between them, and a higher elasticity of substitution yields a more intensive production and consumption of high quality goods (confirming analytically the intuition given above).

3.2 Equilibrium in the rest of the world

When we open our small economy, we consider the equilibrium in the rest of the world as determined under autarky. Taking the final good produced abroad at time $t = 0$ as numeraire, Assumption 2 and the definition of the price index P^* imply that, letting $p^*(t)$ be the common price of all goods produced abroad at time t, we have $P^*(0) = \frac{p^*(0)}{v^*(0)} = 1$, so that $p^*(0) = v^*(0)$. Our derivation of the autarkic equilibrium then implies that for any $t \geq 0$, foreign consumption is $c^*(t) = v^*(t)$, the common quantity of all goods produced abroad is $y^*(t) = 1$, prices are $P^*(t) = 1$, $p^*(t) = v^*(t)$, and the wage rate is $w^*(t) = \frac{\alpha(\sigma-1)}{\sigma}v^*(t)$.

3.3 Equilibrium for the small open economy

In the open economy, the sharp international competition implied by the perfect substitutability of goods at different quality levels within a given industry, combined with the presence of heterogeneous local producers, significantly complicates the (symmetric) general equilibrium analysis of the model. Since we consider two types of domestic producers, each of which has three basic alternatives (stay closed, serve just the local market or also export), and since it is easy to show that 'bad' firms cannot profitably export when 'good' ones do not, and cannot profitably stay open unless also 'good' ones can, there exist six types of structurally different potential symmetric equilibria, summarized in the following table.

	Type of symmetric eq.	**'Good firms'**	**'Bad firms'**
EE	**Export and export**	sell locally and export	sell locally and export
ES	**Export and survive**	sell locally and export	just sell locally
ED	**Export and die**	sell locally and export	stay closed
SS	**Survive and survive**	just sell locally	just sell locally
SD	**Survive and die**	just sell locally	stay closed
DD	**Die and die**	stay closed	stay closed

The following proposition summarizes results on existence and uniqueness of symmetric equilibria. In its derivation, as well as in the remainder of the paper, we take (initial) foreign consumption as numeraire.

Proposition 2 *(***Equilibrium for the small open economy***)*

- *If an ED equilibrium exists, then it is unique and its consumption and production patterns are*

$$c_{ED} = \frac{(1-u)^{1-\alpha} p_L(H)}{P_{ED} - u\tau(1+a)[(1+a)(1+\tau)]^{-\sigma} P_{ED}^{\sigma}}, \quad \text{where} \qquad (16)$$

$$
\begin{aligned}
P_{ED} &= \left\{u[(1+a)(1+\tau)]^{1-\sigma} + (1-u)[(1+a)(1+\tau)]^{\sigma-1}\right\}^{\frac{1}{1-\sigma}} \\
y_{ED}(L) &= 0 \\
y_{ED}(H) &= (1-u)^{-\alpha}
\end{aligned}
$$

- *If tariff protection is sufficiently high, then there exists an SS equilibrium with the same production and consumption patterns as in autarky, namely those described by equations (13), (14) and (15). We call it henceforth 'autarky-like SS equilibrium'.*
- *For some parameter values, there exists a different SS equilibrium, which we call 'limit price SS equilibrium', whose consumption and production patterns are*

$$
\begin{aligned}
c_{SS} &= \left[uv(L)^{-\frac{1}{\alpha}} + (1-u)v(H)^{-\frac{1}{\alpha}}\right]^{-\alpha} \\
y_{SS}(L) &= \left\{u + (1-u)\left[\frac{v(L)}{v(H)}\right]^{\frac{1}{\alpha}}\right\}^{-\alpha} \\
y_{SS}(H) &= \left\{u\left[\frac{v(L)}{v(H)}\right]^{-\frac{1}{\alpha}} + (1-u)\right\}^{-\alpha}
\end{aligned}
$$

- *No other type of symmetric equilibrium exists.*

Proof We sketch the proof of the first three results in Lemmata 2 and 3 in Appendix B. The details and the proof of the last result are contained in Albornoz and Vanin (2005), to which we refer the interested reader. ■

The intuition behind these results is as follows. No EE and ES equilibria exist, because their high demand for labor would push up wages too much to allow even 'good' firms to profitably export. Recall that, because in our model we rule out any gains from trade due to specialization or product differentiation, the only competitive advantage of domestic firms is labor costs.

For some parameter values, an ED equilibrium exists (and it is unique). In other words, in a symmetric equilibrium of this economy, exporting is only compatible with the existence of some inactive local firm. Exit of backward firms reduces labor demand, allowing advanced firms to enjoy a cost advantage and therefore to export. Parameter restrictions come from the fact that, for 'good' firms to profitably export when 'bad' ones find it optimal to stay closed, the quality gap between them must be sufficiently high.

Since in an SS equilibrium there is no international trade, taking foreign consumption as a numeraire opens the possibility that, for some values of the parameters (in particular, of the tariff), there is an entire range of one price compatible with equilibrium. Under autarky, taking a numeraire was sufficient to uniquely determine all prices. Yet for an open economy, when the numeraire is taken in the foreign economy, and there is no international trade, one price in the domestic SS equilibrium remains analytically undetermined. Every value of that price then defines a potential SS equilibrium, and one has to check whether nobody has an incentive to deviate. We perform this check and find that there may exist a continuum of SS equilibria, corresponding to values of the undetermined price within a given interval. We show that this is true both for the SS equilibrium with autarkic production quantities and for that with higher quantities and limit pricing.[16] We further show that in both cases any equilibrium in the corresponding range displays the same production quantities and consumption levels, independently of the particular price chosen in the equilibrium interval.[17]

[16] In the working paper version of this paper we show that if, for a given tariff value, both an 'autarky-like SS equilibrium' and a 'limit price SS equilibrium' exist, then the former Pareto-dominates the latter. This is intuitive because, algebraically, a 'limit price SS equilibrium' corresponds to the autarkic equilibrium that would hold if there were no possibility of substitution between different goods. We also show that the 'limit price SS equilibrium' may exist for lower tariff values, for which the 'autarky-like SS equilibrium' does not exist.

[17] Therefore, given that our focus is on production and consumption patterns, in our numerical simulations we resolve this multiplicity issue by picking up one specific value for the undetermined price. For mathematical convenience, we take the undetermined price to be $p(L)$ in the former case and w in the latter case and, from the respective intervals where SS equilibria exist, we pick up the mean value of $p(L)$ and the highest

As far as SD equilibria are concerned we give conditions for them to exist and find numerically that they are never satisfied. Notice in any case that such equilibria are not very interesting from an economic point of view. Finally, we prove that no DD equilibrium exists, because there would be excess supply of labor.

3.4 Autarky versus Free Trade

Let us now compare, when an ED equilibrium exists, its consumption level with the autarkic one, i.e, c_{ED} with c_A, to identify for which industrial structures an ED equilibrium under free trade exists and yields a higher consumption than autarky. The best way to think of this comparison (and indeed the way that gives an ED equilibrium its best chances) is as one between the the two polar cases of high protection, which isolates the economy from the rest of the world, and of free trade, in the sense of zero tariffs.

Let $K \equiv \left\{ \frac{1-u}{u} \left[\left(\frac{u(1+a)^{2(1-\sigma)}+(1-u)}{1-u} \right)^{\frac{1}{\alpha+\sigma(1-\alpha)}} - 1 \right] \right\}^{\frac{\alpha+\sigma(1-\alpha)}{\sigma-1}}$.
Equations (13) and (16) yield

$$c_{ED} > c_A \iff \frac{v(L)}{v(H)} < K. \tag{17}$$

Notice that $0 < K < 1$ and that K is decreasing in a.[18] Therefore, we have the following proposition.

Proposition 3 *If under free trade an ED equilibrium exists, then it is Pareto-superior to the autarkic equilibrium if and only if the industrial structure displays sufficient vertical heterogeneity.*

Proof The result immediately follows from inequality (17). ■

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value of w. While this is clearly arbitrary, it is useful to stress once again that it has no consequences on the determination of production and consumption patterns, which is what we are interested in.

[18] To see that $K < 1$ calculate it for $a = 0$ and then observe that in that case a sufficient condition for $K < 1$ is $1 - (1-u)^{\frac{1}{\alpha+(1-\alpha)\sigma}} < u$, which is always satisfied for $u < 1$, due to strict convexity of the left hand side, to continuity and to equality of the two sides for $u = 0$ and $u = 1$.

This result states that the Pareto-dominance of free trade over autarky in a developing small economy depends on the mass of surviving firms $(1-u)$ and on the degree of vertical differentiation, the quality gap $\frac{v(L)}{v(H)}$. The intuition is that there is a trade-off between the costs of international trade, arising from transportation costs and from efficiency losses due decreasing returns to scale, and the benefits from trade, arising from specialization on the production of high quality goods. Such specialization tends to raise productivity and enables consumers to import high quality goods from abroad, thus raising the average quality of their consumption bundle. When vertical heterogeneity is high, this latter effect dominates the former and free trade is preferable to autarky. Observe that the trade-off would be mitigated in the absence of decreasing returns, in the sense that trade costs would be lower, but it would not disappear. In this sense, the result does not crucially hinge upon the assumption of decreasing returns. Rather, it depends on existence of some costs of trade. Notice that the relevance of vertical heterogeneity is twofold. Recalling that under free trade an ED equilibrium exists only if the industrial structure is sufficiently heterogeneous, a corollary on the effects of vertical heterogeneity follows immediately,

Corollary 1 *Vertical heterogeneity of the domestic production structure plays the double role of generating gains from trade and of allowing them to be reaped in equilibrium.*

Once the trade-off is clear, the following corollary is immediately intuitive.

Corollary 2 *As long as an ED equilibrium under free trade exists, a reduction in transportation costs makes free trade preferred to autarky for a wider range of industrial structures.*

Notice that a reduction of transport costs is a simple way of thinking of globalization. In this sense, globalization increases the gains generated by free trade. Although derived in a static framework, this result has the potential to offer a new rationale to the question of why the sign of the correlation between tariffs and growth changes over time, as shown by Clemens and Williamson (2004). It also cautions against imitation of development strategies that proved successful in the past. If some sort of protection was initially positive for the development of most industrialized countries, the current degree of trade integration reduces the appeal of trade barriers. If some countries geographically close to large markets, as Hong Kong or Ireland, enjoyed from trade liberalization, the same might not necessarily be as positive as for distant countries like Brazil or Argentina.

4 Simulation Exercises on Dynamics

As mentioned in the introduction, the dynamic benefits of trade policy depend on firms' learning curves (Melitz, 2005). In the presence of learning by doing or of relevant cross-country learning externalities, either through imports or through exports, international trade and specialization would obviously favor dynamic learning. In turn, localized learning externalities, together with concave learning curves, set a dynamically favorable case for protection.

While being agnostic about the existence of localized learning externalities, we assume they exist; that is, we generate an environment in which firms learn faster in denser local industrial networks and in which high quality products are harder to improve than low quality ones. This is done to investigate how the validity of the infant industry argument, even in the most favorable environment, depends on a country's initial industrial structure. Next, we ask how it is affected by globalization and how different countries are exposed to policy mistakes.[19]

4.1 Learning

We assume the following learning dynamic

[19]The empirical literature has not yet offered a clear verdict about the main sources of learning in different sectors and countries, so that any specific assumption on the learning curve is to some degree arbitrary. Our assumptions are mainly dictated by the purpose of our analysis. Trade theory has considered both the implications of cross-country but industry-specific learning externalities, as in Krugman (1987), and of externalities which are both industry and country-specific, as in Brezis et al. (1993).

$$v(m,t+1) = v(m,t) + v(m,t)^{\varphi}\left[\int_{D(t)} y(i,t)v(i,t)\,\mathrm{d}i\right]^{1-\varphi-\epsilon} \tag{18}$$

where $\varphi \in (0,1)$ and $\epsilon \in (0, 1-\varphi)$ are parameters. The rest of the world learns according to the same dynamic, with its respective variables. Concavity of the learning function (granted by our parameter restrictions) implies, all else equal, a tendency to converge to the technological frontier. If free trade forces initially inefficient sectors out of the market, it may destroy a potentially important base for future development. Observe that the networking effect (captured by the term in brackets) depends on the production of domestic firms in efficiency units: while it is possible to learn something from any firm, one learns more from technologically more advanced partners.

4.2 Tariff Protection

We focus on two polar policies

1. Free Trade, under which $\tau(t) = 0$ for all $t \geq 0$;

2. Temporary Protection, which requires selecting, at each point in time, the minimum tariff that is necessary to keep all domestic firms active.[20]

These policies allow us to compare an outward-oriented development strategy, more associable to contemporaneous consensus, with an import substitution strategy (especially aimed at protecting infant industries), which was a common recommendation between World War II and mid Seventies.[21]

[20]Protection here is termed temporary because, due to concavity of the learning function, and therefore to convergence, the minimum tariff necessary to keep all domestic firms active converges to zero in finite time. Thus initially backward firms (infant industries), if protected, eventually become mature and are able to compete with imports even in the absence of tariffs.

[21]As shown in Proposition 2, given that we assume away any other source of gains from trade but vertical differentiation, as infant industries converge to the frontier, the small economy operates in autarky even absent tariffs. Yet this is irrelevant for the dynamic argument we make below.

4.3 Analysis

We compare these two policies when Free Trade gives rise to an ED equilibrium at any point in time, and when the Paretian ranking of the two policies' outcome is reversed when we pass from the static analysis of the initial industrial structure to the dynamic analysis over an infinite time horizon.[22] This tends to happen when static trade costs are low.[23]

From our assumptions it is immediate to derive the following result.

Proposition 4 *For any initial industrial structure, for which Free Trade is initially Pareto-superior to Temporary Protection from a static point of view, it holds that*

- *there exists a discount rate $\bar{\rho} > 0$, such that, for any $\rho < \bar{\rho}$, the present discounted value of the stream of consumption obtained in a sequence of SS equilibria under Temporary Protection is higher than that obtained in a sequence of ED equilibria under Free Trade;*[24]
- *consequently, for any value of $\rho < \bar{\rho}$, there exists a time $\bar{t}$, such that the partial sum of the difference in discounted utility between the two policies is negative until $\bar{t}$ and positive afterwards.*

In light of this result, one way of comparing Free Trade and Temporary Protection across different initial industrial structures is to ask how $\bar{t}$ changes with initial conditions. This way is interesting because in several cases it

[22] If, under Free Trade, at some point in time no ED equilibrium exists, or even no symmetric equilibrium exists at all, then the comparison is either trivial or impossible. If, in turn, one policy is better than the other both statically (given the initial industrial structure) and dynamically, then the analysis is again trivial. Finally, if at some time t for $\tau(t) = 0$ both an ED and an SS equilibrium exist, then we focus on the former under Free Trade and on the latter under Temporary Protection. Observe that our welfare measure is always given by equation (1).

[23] Therefore, we initially carry out our simulations assuming no transportation costs ($a = 0$).

[24] In all of our numerical simulations we find that, if an ED equilibrium under Free Trade is statically superior to an SS equilibrium under Temporary Protection for the initial industrial structure, then under Free Trade at each point in time along the entire dynamic there exists an ED equilibrium. Thus, existence of ED equilibria in this case is not an issue. Recall that SS equilibria always exist for a sufficiently high tariff.

is reasonable to assume that policy makers are myopic, in the sense that, although aware of the representative consumer's time discount rate, they only plan over a finite horizon.[25] Parameters are initially set at the following values: $\beta_H(0) = 1$, $p^*(0) = v^*(0) = 1$, $a = 0$, $\sigma = 4$, $\varphi = 0.3$ and $\epsilon = 0.1$.[26] In the following table we compare the values of $\bar{t}$ for four different initial industrial structure and two degrees of patience.[27]

$\bar{t}$	$u = 0.2$ $\beta_L(0) = 0.3$	$u = 0.2$ $\beta_L(0) = 0.7$	$u = 0.7$ $\beta_L(0) = 0.3$	$u = 0.7$ $\beta_L(0) = 0.7$
$\rho = 0.05$	30	12	22	7
$\rho = 0.1$	∞	14	39	7

The main message conveyed by this table is that, given consumers' patience, the planning horizon necessary to appreciate the dynamic advantages to protection (where they exist) is highly sensitive to the initial industrial structure.[28] In particular, quite intuitively, $\bar{t}$ is increasing in vertical backwardness $(1 - \beta_L(0))$, because the costs of protection have to be borne for more time before convergence makes its dynamic advantages prevail. More surprisingly, $\bar{t}$ is decreasing in horizontal backwardness (u), because, although a wider mass of backward firms raises the cost of Temporary Protection, it raises even more the cost of Free Trade, when such policy, by driving a greater number of firms out of business, substantially shrinks the industrial network and therefore surviving firms' development potential. In terms of the old debate on infant industries, the payoff to protection is higher when there are many backward firms, but it becomes smaller when these firms are very backward.

[25] A similar comparison might be done in terms of $\bar{\rho}$ rather than of $\bar{t}$, without considering any myopic policy maker. Qualitative results would obviously be the same.

[26] We have carried out a number of simulations, available upon request, in order to test the sensitivity of our results to changes in the parameters and they do not qualitatively change.

[27] The term ∞ appears because under the quadruple $(u, \beta_L(0), \beta_H(0), \rho) = (0.2, 0.3, 1, 0.1)$ both the gains from trade and the discount rate are too high to make Temporary Protection dynamically preferable to Free Trade.

[28] Obviously, the gains from protection increase with the level of patience (the lower ρ, the lower $\bar{t}$).

When also domestic advanced firms start with an initial quality gap from the international frontier ($\beta_H(0) < 1$), we find that, contrary to what one could expect, it now takes a shorter time to appreciate the dynamic superiority of Temporary Protection (obviously, when it exists). While at first sight surprising, this result is explained by the fact that a lower $\beta_H(0)$ implies a higher homogeneity of the initial industrial structure, which, as discussed above, reduces the relative gains to Free Trade.

When transportation or adoption costs increase, this obviously reduces the gains from trade and thus favors protection and reduces $\bar{t}$, but it does not alter the way $\bar{t}$ depends on the initial industrial structure.[29] If we interpret again globalization as a reduction of a, these results may help explain changes in the consensus on the benefits of protecting backward firms: with lower transport costs, the horizon over which Temporary Protection appears superior becomes longer, so that the ability of such policy to command political consensus decreases.

5 Conclusions

In this paper we investigate the static and dynamic effects of tariff protection on industrial structure in a context characterized by perfect substitutability between domestic and foreign varieties. This characteristic is common in developing economies and is consistent with many facts associated to trade liberalization: replacement of low quality inputs by better quality imports (Amiti and Konings, 2005), higher exit than entry resulting in a reduction of the mass of active firms (Alvarez and Vergara, 2005; Eslava et. al., 2005), entry of surviving firms into the export market (Bernard et. al., 2003, among others) and exporters' supply of higher quality products (Kraay et. al., 2002).

Our contribution to the debate between supporters of an outward-oriented development strategy, more associable to contemporaneous consensus, and

[29]To have a numerical feeling, with $u = 0.8$, $\beta_L(0) = 0.3$, $\beta_H(0) = 1$ and $\rho = 0.05$, passing from $a = 0$ to $a = 0.1$ makes $\bar{t}$ pass from 19 to 8. With $\beta_L(0) = 0.6$ these two values become 10 and 3, respectively.

of an import substitution strategy (especially aimed at protecting infant industries), which was a common recommendation between World War II and mid Seventies, consists in arguing that, even in the most favorable environment for protection, the choice should be context-dependent.

We find that free trade is preferred to autarky when an industrial structure is sufficiently heterogeneous. The level of heterogeneity required for free trade to Pareto-dominate temporary protection increases with transport costs. We also find that transport costs reduce the optimality of free trade in a dynamic setting. These results may help explain changes in the consensus on the benefits of protecting backward firms: with lower transport costs, the horizon over which temporary protection appears superior (when it eventually is) becomes longer, so that the ability of such policy to command political consensus decreases.

A main result emerging from our analysis is that the benefits of protection depend upon the level of backwardness in the following way: for a given mass of backward firms, the relative gains from protection increase with the quality of backward firms (the cost of protection is lower) and decrease with the quality of advanced firms (a lower level of heterogeneity reduces the benefits from free trade). On the other hand, for given production quality levels, the relative advantage of protection increases with the mass of backward firms. According to these results, for instance, the gains to protection are much higher for a quite homogeneous, not too backward industrial structure than for a heterogeneous one, with a few very backward firms and many relatively advanced firms.

Our findings do not constitute an overall assessment of the relative desirability of temporary protection vs. free trade. We could modify the learning function in a variety of ways that would modify the dynamic evaluation of trade policy. We could, for example, incorporate the possibilities of learning by exporting (which would favor trade liberalization policies) or the fact that tariff revenues might be used in productivity enhancing investments (e.g., infrastructure investment), which would favor trade protection. Rather, our dynamic analysis specifies how the dynamic costs and benefits of these two policies depend on several characteristics of the country to which they are applied, of its development process, and of the world trading environment. We thus see this work as a starting point for a new wave of careful and critical research on an old theme, rather than as a point of arrival.

References

[1] P. Aghion, R. Burgess, S. Redding, and F. Zilibotti. Entry liberalization and inequality in industrial performance. *Journal of the European Economic Association*, 3(2-3):291–302, 2005.

[2] F. Albornoz and P. Vanin. Local learning, trade policy and industrial structure dynamics. *University of Birmingham Discussion Papers*, 05-12, 2005.

[3] R. Alvarez and H. Gorg. Multinationals and plant exit: Evidence from Chile. *IZA Discussion Paper*, (1611), 2005.

[4] M. Amiti and J. Konings. Trade liberalization, intermediate inputs and productivity: Evidence from indonesia. *CEPR Discussion Papers*, (DP5104), 2005.

[5] A. Amsden. *Asia's Next Giant: South Korea and Late Industrialization.* Oxford University Press, New York, 1989.

[6] R. E. Baldwin and F. Robert-Nicoud. Trade and growth with heterogenous firms. *CEPR Disussion Papers*, (4965), 2006.

[7] A. Bernard, J. Eaton, J. B. Jensen, and S. Kortum. Plants and productivity in international trade. *American Economic Review*, 93(4):1268–1290, September 2003.

[8] A. B. Bernard, J. B. Jensen, and P. K. Schott. Falling trade costs, heterogenous firms and industry dynamics. *The Institute for Fiscal Studies*, WP03/10, 2003.

[9] L. Bottazzi and G. Peri. Innovation and spillovers in regions : Evidence from european patent data. *European Economic Review*, 47(4):687–710, 2003.

[10] E. S. Brezis, P. Krugman, and D. Tsiddon. Leapfrogging in international competition: A theory of cycles in national technological leadership. *American Economic Review*, 83(5):1221–1219, 1993.

[11] M. A. Clemens and J. Williamson. Why did the tariff-growth correlation reverse after 1950? *Journal of Economic Growth*, 9(1):5–46, March 2004.

[12] S. Clemhout and H. Wan. Learning-by-doing and infant industry protection. *Review of Economic Studies*, 37(1):33–56, 1970.

[13] M. Eslava, J. Haltiwanger, A. Kugler, and M. Kugler. Plant survival, market fundamentals and trade liberalization. 2005.

[14] P. Gustafsson and P. Segerstrom. Trade liberalization and productivity growth. *Stockholm School of Economics, Mimeo*, 2007.

[15] A. O. Hirschman. The political economy of import-substituting industrialization in Latin America. *Quarterly Journal of Economics*, 82(1):1–32, 1968.

[16] C. I. Jones. R&D-based models of economic growth. *Journal of Political Economy*, 103(4):759–784, 1995.

[17] W. Keller. Geographic localization of international technology diffusion. *American Economic Review*, 92(1):120–142, 2002.

[18] L. Kim. *Imitation to Innovation: The Dynamics of Korea's Technological Learning*. Harvard Business School Press, 1997.

[19] L. Kim and R. R. Nelson, editors. *Technology, Learning, and Innovation: Experiences of Newly Industrializing Economies*. Cambridge University Press, 2000.

[20] A. Kraay, I. Soloaga, and J. Tybout. Product quality, productive efficiency, and international technology diffusion: Evidence from plant-level panel data. *World Bank Policy Research Working Paper*, (2759), 2002.

[21] P. Krugman. The narrow moving band, the Dutch disease, and the competitive consequences of Mrs Thatcher: Notes on trade in the presence of dynamic scale economies. *Journal of Development Economics*, 27:41–55, 1987.

[22] W. A. Lewis. Economic development with unlimited supplies of labor. *Manchester School*, 22(2):139–91, May 1954.

[23] M. Melitz. The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71(6):1695–1725, 2003.

[24] M. Melitz. When and how should infant industries be protected? *Journal of International Economics*, 66(1):177–196, 2005.

[25] P. Sauré. Revisiting the infant industry argument. *Journal of Development Economics*, 84(1):104–117, 2007.

[26] P. S. Segerstrom. Endogenous growth without scale effects. *American Economic Review*, 88(5):1290–1310, 1998.

[27] J. R. Tybout. Manufacturing firms in developing countries: How well do they do and why? *Journal of Economic Literature*, 37(1):11–44, 2000.

Appendix A: Lemma 1 and Proof of Proposition 1

Lemma 1: Firms' profit maximization

Let $y_E(m) = [\frac{\alpha}{w}p_L(m)]^{\frac{\alpha}{1-\alpha}}$ and $y_M(m) = \left(\frac{\sigma-1}{\sigma}\cdot\frac{\alpha}{w}\right)^{\frac{\alpha\sigma}{\alpha+\sigma(1-\alpha)}}[v(m)^{\sigma-1}P^\sigma c]^{\frac{\alpha}{\alpha+\sigma(1-\alpha)}}$.

Lemma 1 $\forall m \in [0,1]$*, there exist positive thresholds* $w_0(m)$*,* $\widehat{w_1}(m)$*,* $\widetilde{w_1}(m)$ *and* $\overline{\tau}$*, such that*

1. *If* $w \leq \frac{\sigma-1}{\sigma}\widehat{w_1}(m)$*, then* m *produces* $y_E(m)$*.*
2. *If* $w \in (\frac{\sigma-1}{\sigma}\widehat{w_1}(m), max\{\widehat{w_1}(m), \widetilde{w_1}(m)\})$*, then* m*'s choice depends on a combination of wage and protection level.*
   - *For* $\tau \leq \overline{\tau}$*, we have two cases:*
     - *if* $w < \widetilde{w_1}(m)$*, then* m *compares* $\pi(y_E(m))$ *and* $\pi(y_M(m))$*;*
     - *if* $w \geq \widetilde{w_1}(m)$*, then* m *compares* $\pi(y_E(m))$ *and* $\pi(y_L(m))$*.*
   - *For* $\tau > \overline{\tau}$*, we have again two cases:*
     - *if* $w < \widehat{w_1}(m)$ *, then* m *compares* $\pi(y_E(m))$ *and* $\pi(y_M(m))$*;*
     - *if* $w \geq \widehat{w_1}(m)$*, then* m *produces* $y_M(m)$*.*
3. *If* $w \in [max\{\widehat{w_1}(m), \widetilde{w_1}(m)\}, w_0(m)]$*, then* m *produces* $y_L(m)$*.*
4. *If* $w > w_0(m)$*, then* m *stays inactive.*

Proof of Lemma 1

When deciding, each firm m considers other firms' choice and all equilibrium variables as given. Revenues and costs are

$$R(y(m)) = \begin{cases} 0 & , \text{ if } y(m) < y_L(m) \\ y(m)^{\frac{\sigma-1}{\sigma}}[v(m)P]^{\frac{\sigma-1}{\sigma}}(Pc)^{\frac{1}{\sigma}} & , \text{ if } y(m) \in [y_L(m), y_H(m)) \\ p_L(m)y(m) & , \text{ if } y(m) \geq y_H(m) \end{cases} \quad \text{and}$$

$C(y(m)) = wy(m)^{\frac{1}{\alpha}}$, respectively. Thus marginal revenues and marginal costs are

$$MR(y(m)) = \begin{cases} 0 & , \quad \text{if } y(m) < y_L(m) \\ \frac{\sigma-1}{\sigma} y(m)^{-\frac{1}{\sigma}} [v(m)P]^{\frac{\sigma-1}{\sigma}} (Pc)^{\frac{1}{\sigma}} & , \quad \text{if } y(m) \in [y_L(m), y_H(m)) \\ p_L(m) & , \quad \text{if } y(m) \geq y_H(m) \end{cases} , \tag{19}$$

$$MC(y(m)) = \frac{w}{\alpha} y(m)^{\frac{1-\alpha}{\alpha}}. \tag{20}$$

Observe that MC is concave if $\alpha \in \left(\frac{1}{2}, 1\right)$, convex otherwise. Observe further that $\lim\limits_{y(m) \searrow y_L(m)} MR(y(m)) = \frac{\sigma-1}{\sigma} p_H(m)$ and $\lim\limits_{y(m) \nearrow y_H(m)} MR(y(m)) = \frac{\sigma-1}{\sigma} p_L(m)$. Notice that MC and MR do not necessarily cross. Four cases are possible:

1. If, for any $y(m) \geq 0$, $MC(y(m)) \geq MR(y(m))$, then firm m is either not active or, if and only if $\pi(y_L(m)) \geq 0$, it sells

$$y_L(m) = \left[\frac{p_H(m)/v(m)}{P}\right]^{-\sigma} \frac{c}{v(m)}$$

   at $p_H(m)$.

2. If $MC(y(m))$ and $MR(y(m))$ cross only once for strictly positive quantities, and if they cross in the open interval between $y_L(m)$ and $y_H(m)$, i.e., if $MC(y_L(m)) < \lim\limits_{y(m) \searrow y_L(m)} MR(y(m))$ and $MC(y_H(m)) \geq \lim\limits_{y(m) \searrow y_H(m)} MR(y(m))$, then there exists a unique (global) profit maximizer, $y_M(m) \in (y_L(m), y_H(m))$. Such quantity is entirely sold on the local market at price $p_M(m)$ defined in (22). Given that within this range, the equality between MC and MR is sufficient to ensure optimality, we can derive from (19) and (20) that:

$$y_M(m) = \left(\frac{\sigma-1}{\sigma} \cdot \frac{\alpha}{w}\right)^{\frac{\alpha\sigma}{\alpha+\sigma(1-\alpha)}} [v(m)^{\sigma-1} P^{\sigma} c]^{\frac{\alpha}{\alpha+\sigma(1-\alpha)}} \tag{21}$$

   and

$$p_M(m) = \left(\frac{\sigma}{\sigma-1} \cdot \frac{w}{\alpha}\right)^{\frac{\alpha}{\alpha+\sigma(1-\alpha)}} [v(m)^{\sigma-1} P^{\sigma} c]^{\frac{1-\alpha}{\alpha+\sigma(1-\alpha)}} \tag{22}$$

3. If between $y_L(m)$ and $y_H(m)$ $MC(y(m))$ lies below $MR(y(m))$, and crosses it afterwards, i.e., if $MC(y_H(m)) \leq \lim\limits_{y(m) \nearrow y_H(m)} MR(y(m))$, then there exists a unique (global) profit maximizer, $y_E(m) > y_H(m)$. Such quantity is sold at price $p_L(m)$, partly on the local market, which absorbs $y_H(m)$, and for the remaining part, $y_E(m) - y_H(m)$, it is exported. In this case the choice to export induces marginal cost pricing, which yields

$$y_E(m) = \left[\frac{\alpha}{w} p_L(m)\right]^{\frac{\alpha}{1-\alpha}}.$$

4. If either $MC(y(m))$ and $MR(y(m))$ cross twice for strictly positive quantities or if they cross once, but $MC(y(m))$ lies above $MR(y(m))$ between $y_L(m)$ and $y_H(m)$, i.e., if $MC(y_H(m)) > \lim_{y(m) \searrow y_L(m)} MR(y(m))$ and $MC(y_H(m)) < \lim_{y(m) \searrow y_H(m)} MR(y(m))$, then there exist two positive local maximizers, one in which firm m sells exclusively on the local market, choosing either $y_M(m)$ or $y_L(m)$, and one in which it also exports, choosing $y_E(m)$. Its choice in this case cannot be determined *a priori* at the present stage, but has to be determined in equilibrium by comparison of the two local maxima.

Explicit calculation allows us to find the thresholds mentioned in Lemma 1. Let us define

$$\begin{aligned}
w_0(m) &\equiv p_H(m)^{\frac{\alpha+\sigma(1-\alpha)}{\alpha}}[v(m)^{\sigma-1}P^{\sigma}y(1)]^{\frac{\alpha-1}{\alpha}}, \\
\widehat{w_1}(m) &\equiv \alpha[(1+\tau)(1+a)]^{-2\frac{\alpha+\sigma(1-\alpha)}{\alpha}}w_0(m), \\
\widetilde{w_1}(m) &\equiv \alpha\frac{\sigma-1}{\sigma}w_0(m), \\
\overline{\tau} &\equiv \frac{1}{1+a}\left(\frac{\sigma}{\sigma-1}\right)^{\frac{\alpha}{2[\alpha+\sigma(1-\alpha)]}} - 1.
\end{aligned}$$

These thresholds are defined such that

- $\pi(m|y_L(m)) \geq 0 \iff w \leq w_0(m)$,
- $MC(y_L(m)) = \lim_{y(m) \searrow y_L(m)} MR(y(m)) \iff w = \widetilde{w_1}(m)$,
- $MC(y_H(m)) = \lim_{y(m) \nearrow y_H(m)} MR(y(m)) \iff w = \widehat{w_1}(m)$
- $\widetilde{w_1}(m) > \widehat{w_1}(m) \iff \tau > \overline{\tau}$.

Given this, Lemma 1 just amounts to a re-writing of the results obtained above.

It is also easy to show that $w_0(m)$ is greater than both $\widetilde{w_1}(m)$ and $\widehat{w_1}(m)$, that all of them are increasing functions of $v(m)$, and that therefore, at a given w, firms with a very low quality will remain inactive, firms with intermediate quality will produce to serve the domestic market, and firms with a very high quality will also export.

Proof of Proposition 1

In closed economy, there is no competition with the rest of the world, which means that producers face a continuous demand with no threshold effects. Then the general equilibrium is easy to derive. Equilibrium in the goods market ($y(m) = x(m)$, $m = L, H$, according to (7)) and in the labor market ($L^d = 1$, according to (12)) yield c as a function of P and of the prices of low and high quality goods, $p(L)$ and $p(H)$, respectively. The definition of the price index P in (10) then yields c as a function of $p(L)$ and $p(H)$ alone. Such prices are determined by $p(m) = p_M(m)$, $m = L, H$, according to (22). This yields the wage rate w as a function of $p(L)$ and $p(H)$. Substituting for w, we can therefore express $p(H)$, w, P and c, $y(L)$, $y(H)$, all as functions of $p(L)$ alone. The real part of the equilibrium is independent from the nominal part: defining a variable $A \equiv \left\{ u \left[\frac{v(L)}{v(H)} \right]^{\frac{\sigma-1}{\alpha+\sigma(1-\alpha)}} + (1-u) \right\}$, which is decreasing in u and increasing in the domestic 'bad' to 'good' quality ratio $\frac{v(L)}{v(H)}$, we have $c = v(H) A^{\frac{\alpha+\sigma(1-\alpha)}{\sigma-1}}$, $y(L) = \left[\frac{v(L)}{v(H)} \right]^{\frac{\alpha(\sigma-1)}{\alpha+\sigma(1-\alpha)}} A^{-\alpha}$ and $y(H) = A^{-\alpha}$. The nominal part is defined by $p(H) = \left[\frac{v(L)}{v(H)} \right]^{\frac{(\alpha-1)(\sigma-1)}{\alpha+\sigma(1-\alpha)}} p(L)$, $w = \frac{\alpha(\sigma-1)}{\sigma} A^{1-\alpha} \left[\frac{v(L)}{v(H)} \right]^{\frac{(\alpha-1)(\sigma-1)}{\alpha+\sigma(1-\alpha)}} p(L)$ and $P = A^{\frac{1}{1-\sigma}} \left[\frac{v(L)}{v(H)} \right]^{\frac{(\alpha-1)(\sigma-1)}{\alpha+\sigma(1-\alpha)}} \frac{p(L)}{v(H)}$. Taking one good as numeraire, for instance setting $P = 1$, completes the characterization of the unique general equilibrium.

Appendix B: Existence and uniqueness of symmetric equilibria

Given the discontinuities and non convexities of the model we prove existence in two steps: first, we provide an analytical characterization of a candidate symmetric equilibrium of a given type, by assuming that every agent in the economy behaves in a specific way and by imposing that, given this, all markets clear; second, we study the conditions under which the candidate equilibrium is indeed an equilibrium, i.e., the conditions under which nobody wants to deviate. This second step amounts to checking whether the optimality conditions spelled out in Lemma 1 are satisfied in the candidate equilibrium. In what follows, we prove results on ED and SS symmetric equilibria, giving the general expressions that are necessary for the proofs. Explicit calculations, as well as results on the other types of symmetric equilibria, are given in Albornoz and Vanin (2005).

Lemma 2 ***(existence and uniqueness of 'export and die' equilibria)*** *For some parameter values there exists a symmetric equilibrium such that high quality firms both serve the domestic market and export, whereas low quality firms stay closed and the corresponding goods are imported. If it exists, such equilibrium is unique and its consumption level is*

$$c = \frac{(1-u)^{1-\alpha} p_L(H)}{P - u\tau(1+a)[(1+a)(1+\tau)]^{-\sigma} P^{\sigma}}, \tag{23}$$

where

$$P = \left\{ u[(1+a)(1+\tau)]^{1-\sigma} + (1-u)[(1+a)(1+\tau)]^{\sigma-1} \right\}^{\frac{1}{1-\sigma}} \tag{24}$$

Proof Suppose there exists an ED equilibrium. Advanced firms would produce $y(H) = [\alpha p_L(H)]^{\frac{\alpha}{1-\alpha}} w^{\frac{\alpha}{\alpha-1}}$ and sell it at $p_L(H)$. Labor market equilibrium $L^d = (1-u)y(H)^{\frac{1}{\alpha}} = 1$ yields $w = (1-u)^{1-\alpha}\alpha p_L(H)$. Equation (24) follows from the fact that backward firms stay closed and the corresponding goods are imported, and therefore their price for the domestic buyer includes both transportation costs and tariff. Profits are $\pi(H) = p_L(H)y(H) - wy(H)^{\frac{1}{\alpha}} = \frac{p_L(H)(1-\alpha)}{(1-u)^{\alpha}}$. As τ applies to landed imports, aggregate tariff revenue is $T = \tau p^*(1+a)Im$ where $M = uP^{\sigma}c[(1+a)(1+\tau)p^*]^{-\sigma}(v^*)^{\sigma-1}$ as stated by equation (9). Having determined $w, \pi(H)$ and T, we can now compute $E = w+(1-u)\pi(H)+T$. Equilibrium in goods market $c = \frac{E}{P}$ then yields c as stated in equation (23). This determines a unique candidate equilibrium. Therefore, if such equilibrium indeed exists, uniqueness is trivially proved. In Albornoz and Vanin (2005) we characterize the (necessary and sufficient) conditions under which nobody has incentive to deviate from the candidate equilibrium, that is, under which this is indeed an equilibrium, and provide abundant numerical examples of parameter constellations for which such conditions are satisfied. ■

Lemma 3 ***(existence of 'survive and survive' equilibria)*** *For any parameter constellation, if τ is sufficiently high, then there exist symmetric equilibria such that both high quality and low quality firms are only active on the local market. In such equilibria, each intermediate good producer m can either produce the same quantity as under autarky, $y_M(m)$, or produce the higher quantity $y_L(m)$. If both high quality and low quality firms produce $y_M(m)$, then the consumption level is*

$$c = \left[uv(L)^{\frac{\sigma-1}{\alpha+\sigma(1-\alpha)}} + (1-u)v(H)^{\frac{\sigma-1}{\alpha+\sigma(1-\alpha)}}\right]^{\frac{\alpha+\sigma(1-\alpha)}{\sigma-1}} \tag{25}$$

If they both produce $y_L(m)$, then the consumption level is

$$c = \left[uv(L)^{-\frac{1}{\alpha}} + (1-u)v(H)^{-\frac{1}{\alpha}}\right]^{-\alpha} \tag{26}$$

Proof Suppose that an SS equilibrium exists. Goods and labor market equilibrium implies $c = P^{-\sigma}\left\{u\left[p(L)^{-\sigma}v(L)^{\sigma-1}\right]^{\frac{1}{\alpha}} + (1-u)\left[p(H)^{-\sigma}v(H)^{\sigma-1}\right]^{\frac{1}{\alpha}}\right\}^{-\alpha}$. From Lemma 1 it is immediate to see that any firm m which chooses to sell only to the domestic market, has only two possible optimal choices: it either produces $y_M(m)$ and sells at $p_M(m)$, or it produces $y_L(m)$ and sells at $p_H(m)$. Such quantities and prices are defined in equations (21), (22), and, through (7), by $y_L(m) \equiv x(m|p_H(m))$ and (5), respectively.

Since there are two types of intermediate goods producers, we have four possible combinations of their choices. Only for expositional purposes, we restrict attention to the two cases in which either $y(L) = y_M(L)$ and $y(H) = y_M(H)$, or $y(L) = y_L(L)$ and $y(H) = y_L(H)$.

Consider first the former case, i.e., $y(L) = y_M(L)$ and $y(H) = y_M(H)$. The definition of the price index P in (10) allows to write c as a function of $p(L)$ and

$p(H)$ alone. Then (22) yields the wage rate w as a function of them. Substituting for w, we can therefore express $p(H)$, w, P, $y(L)$, $y(H)$, c, all as functions of $p(L)$ alone. In particular, defining a variable $A \equiv u\left[\frac{v(L)}{v(H)}\right]^{\frac{\sigma-1}{\alpha+\sigma(1-\alpha)}} + (1-u)$, which is decreasing in u and increasing in the domestic quality gap $\frac{v(L)}{v(H)}$, we find the following expressions:

$$
\begin{aligned}
p(H) &= \left[\frac{v(L)}{v(H)}\right]^{\frac{(\sigma-1)(\alpha-1)}{\alpha+\sigma(1-\alpha)}} p(L) \\
w &= \alpha\frac{\sigma-1}{\sigma}A^{1-\alpha}\left[\frac{v(L)}{v(H)}\right]^{\frac{(\sigma-1)(\alpha-1)}{\alpha+\sigma(1-\alpha)}} p(L) \\
P &= \frac{A^{\frac{1}{1-\sigma}}}{v(H)}\left[\frac{v(L)}{v(H)}\right]^{\frac{(\sigma-1)(\alpha-1)}{\alpha+\sigma(1-\alpha)}} p(L) \\
y(L) &= \left[\frac{v(L)}{v(H)}\right]^{\frac{\alpha(\sigma-1)}{\alpha+\sigma(1-\alpha)}} A^{-\alpha} \\
y(H) &= A^{-\alpha}
\end{aligned}
$$

and c is given by (25), which is the same as (13).

This proves that, if the equilibrium considered in this case exists, then its level of production is univocally determined, independently of $p(L)$. We now have to make sure that this candidate equilibrium is indeed an equilibrium, in the sense that nobody wants to deviate. This is going to determine a set of values of $p(L)$, for each of which such an equilibrium exists. In principle, this set can either be empty, or be a singletone, or have cardinality higher than one. We find two results: first, for τ sufficiently high this set is not empty. To see this, recall that the autarkic equilibrium always exists. Second, when it is not empty, this set is an interval, that is, there exists an interval of values of $p(L)$, for each of which there exists a symmetric SS equilibrium. Any such equilibrium displays the same production quantities as under autarky. For our purposes, thus, this multiplicity is more apparent than real, and it is due to the fact that we take foreign consumption as numeraire, but that in equilibrium there is no international trade. This means that the choice of the numeraire is not sufficient to pin down all equilibrium prices, but still the characteristics of the rest of the world influence our small economy, because they determine the range in which no agents wants to deviate. For instance, an SS equilibrium in which production quantities are the same as under autarky exists for the following constellation of parameters: $v^* = 1, v(H) = 1, v(L) = 0.8, u = 0.5, a = 10\%, \alpha = 0.9, \sigma = 4$ and $\tau > 85\%$.

Consider now the second possibility, i.e., $y(L) = y_L(L)$ and $y(H) = y_L(H)$. Prices are $p(L) = p_H(L)$ and $p(H) = p_H(H)$, so that $P = (1+a)(1+\tau)$. Goods and labor market equilibrium implies that c is given by (26). Knowing this, also $y(L)$ and $y(H)$ are univocally determined. Once again, we have a free price, in this case w. Therefore, each value of w defines a candidate equilibrium, and we have to check for which values of w nobody has an incentive to deviate (so that prices and quantities indeed constitute an equilibrium). In any such equilibrium, production quantities are the same, so that, if multiple such equilibria exist, once again for our purposes multiplicity is more apparent than real. For instance, an SS equilibrium in which both high and low quality firms produce more than under autarky exists for the following constellation of parameters: $v^* = 1, v(H) = 1, v(L) = 0.8, u = 0.5, a = 10\%, \alpha = 0.9, \sigma = 4$ and $\tau > 10\%$. ■