Industrial Structure Dynamics and Optimal Trade Policy*

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Abstract

We focus on dynamic learning externalities among heterogeneous firms in a production network to study how economies with different industrial structures require different trade policies. We find that optimal trade policy depends upon the depth and the cross-sectoral distribution of the quality gap, upon the presence of multinationals and upon the degree of impatience. If trade protection is needed at all, it is always temporary, but it can be significantly high in certain periods. Even more interestingly, the optimal tariff path from protection to liberalization needs not be monotonic.

JEL-Classification: D51, D62, F12, F13

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1 Introduction

The antagonism between 'free trade' and 'protectionism' is often framed in static and general terms, but this approach, although useful for some purposes, does not allow to investigate the effects of trade policy on industrial structure and, conversely, to make optimal trade policy depend on it[1]. We argue that such aspects are relevant both to understand different historical development experiences and to provide trade policy advices that take into account the specific characteristics of an economy's industrial structure. Once a dynamic perspective is adopted, there is room for sequential policies ranging from a certain degree

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[1]See Baldwin and Forslid (1999).

of protection to trade liberalization. The antagonism between 'free trade' and 'protectionism' then becomes a matter of timing and speed of trade opening.

Historical examples show that there is not one single story capable of linking development and trade policy (see Rodrik, 2003). Indeed, most countries have implemented high but varying degrees of protection during their developing processes (Chang, 2002). England, for instance, passed from high protection when it was a catch-up economy to gradual liberalization until it reached the technological frontier, then to protection when it fell back away from it, and finally once more to liberalization when it approached the frontier once again. Other examples include Germany, France, Japan and most of industrialized countries. What is interesting about these example, and is difficult to rationalize on the base of the static and general antagonism between free trade and protectionism, is that the degree of protection varied over time, often in a non-monotonic way, and that the gap from the technological frontier seems to have played a relevant role in determining it.

We develop a framework that allows to study the dynamic interconnection between trade policy and industrial structure. We investigate the conditions under which immediate trade liberalization is preferable to temporary protection[2], and those under which the reverse is true, and discuss the optimal duration of protection and the optimal speed of its removal. An interesting finding is that under certain conditions optimal policy requires a non-monotonic time path of trade protection. Optimal trade policy in our framework depends on three main factors: first, on both horizontal and vertical characteristics of the industrial structure (in particular, on the cross-sectoral distribution of the quality gap from the frontier and on the depth of this gap); second, on the property structure of local firms, that is, on whether they are owned by domestic or by foreign citizens (this allows us to discuss the role of foreign direct investments, henceforth FDI); third, on the degree of impatience, which determines how to weight short and long run costs and benefits of different trade policies. The general intuition behind our results is that changes in trade policy may trigger structural changes in the economy (in particular, in its industrial structure), which in turn modify the optimal future path of trade policy.

Our results contribute to an open debate on the effects of the trade policy on production (GDP or productivity growth), a debate in which neither the empirical literature nor the theoretical research have yet yielded definitive conclusions. Section 2 reviews some key contributions to this debate and discusses how our framework relates to them[3]. Section 3 spells the model and analyzes its static equilibria. Section 4 compares different trade policies and states which of them is best suited for different combinations of initial industrial structure and impatience. Section 5 repeats this analysis changing the assumptions about

[2]The main reasons usually quoted to justify protection (external economies, increasing returns to scale, forward and backward linkages among local firms, and concave nature of learning curves) typically call for just temporary protection.

[3]Notice that we are not discussing the effects of trade on production but the specific role of trade policy. This is why we do not review either the huge literature on trade and growth nor on trade and productivity.

ownership structure, in order to establish how FDI change optimal trade policy. Section 6 concludes.

2 Trade policy and production

We focus on tariff protection by a small open economy[4]. Some new evidence seems to detect a negative relationship between trade barriers and growth (Dollar 1992, Sachs and Warner 1995, Edwards 1998, among others), but the findings of this literature are criticized by Rodriguez and Rodrik (2001) and contradicted by evidence of the opposite sign: using a sample of almost 100 countries between 1970 and 1997, Yanikkaya (2003) finds that both measures of trade volumes and of trade tariffs are positively correlated to growth, although they are negatively correlated to one another. In particular, he finds that 'developing countries with higher average tariffs grow faster than developing countries with lower tariffs' (p.74). What is therefore the sign of the tariff-growth relationship? If any, it appears as changing over time. Clemens and Williamson (2002) find that it has changed from positive (until World War II) to negative (since then), but still such a negative correlation is far from unconditional; in particular, it depends upon the average tariff rates fixed by trading partners, thus raising strategic concerns in tariff setting.

Other empirical inquiries into the effects of trade liberalization also supply ambiguous results. Tybout et al. (1991) find that in Chile, the slacker the protection of the industrial sector, the better its performance in terms of TFP once tariffs are reduced. Foroutan (1992) obtains similar results for Turkey. For Mexico, Tybout and Westbrook (1995) give statistical support to the idea that reduction in protection leads to gains in efficiency. Nevertheless, such evidence must be juxtaposed with other studies that find no clear relationship between productivity gains and trade reform (Harrison, 1990, Albornoz et al., 2003, among others). Independently of their conflictive findings, all these studies share a common limitation due to data availability: plant and firm level evidence is only available for few years and hence it only captures short term adjustments, rather than long run effects (Tybout and Erdem, 2003).

Theoretical research is not any more conclusive either. What is beyond any controversy is that once some kind of external economies from private experience or increasing returns to scale in production are taken into consideration, optimal tariff will be positive (see for instance Clemhout and Wan, 1970). Nonetheless, controversy arises about the relevance and extent of those externalities or increasing returns to scale. For instance, A. O. Krueger and B. Tuncer (1982) and more recently Roberts and Tybout (1996) and Tybout (2000), find small increasing returns at firm level and consequently no reasons for protection.

This last conclusion is problematic, though, since small increasing returns at firm level may generate great aggregate effects if firms are linked and form a

[4] This means that we let aside trade policies based on non-tariff trade barriers as, for instance, restrictive licences or quotas.

chain of intermediate input suppliers (as it is the case with industrial technologies), as recently pointed out by Ciccone (2002). Development of a chain may be buyer or producer driven (Gereffy, 2001) depending on the sense (backward and forward) of new activities. Backward and forward linkages are a classic concerns in economic development theory (Hirschman 1968 and 1992)[5].

Although shedding light on the relevance of linkages among firms this literature exclusively considers commercial linkages and conglomeration relies upon differences in cost production between differentiated and undifferentiated goods. For instance, in Krugman and Venables (1995) industrial conglomeration arises because transport costs are relatively higher for industrial differentiated goods. Nevertheless, this assumption conflicts with empirical evidence on transport costs (Davis, 1998)[6].

Innovation and case studies (Lundvall, 1993, Storper, 1995, Meyer-Stamer, 1998, Cassiolato and Lastres, 2000, Nadvi and Schmitz, 1999), and some incipient cross-sectional work (Lall and Ghosh, 2002), show that relationships among firms go beyond simple commercial exchange and that firm linkages constitute a crucial ingredient for knowledge diffusion[7]. In particular informal channels appear very important, especially because they are best suited to transmit tacit knowledge (Nonaka and Takeuchi, 1995; Ducatel, 1998; and Rullani, 2000). Fosfuri and Motta (1999) argue that, due to spatially bounded knowledge spillovers, multinationals may decide to locate in certain areas precisely to gain location-specific knowledge. In our model interaction within the network of local interconnected firms increases ability to improve own quality (we call this "networking effect").

Why do we associate industrialization with the quality gap? Scholars on development have identified a clear difference in the pattern of industrialization between the old industrialized and new (late) industrialized countries. Let us quote Amsden (1989): "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)[8]. Considering that invention and innovation are increasingly dependent on previous technological and scientific experience

[5] A forward linkage acts when existence of a firms producing product A stimulates appearance of new firms producing product B, which requires A as an input; a backward linkage is at work when existence of firms producing B, which requires input A, stimulates appearance of new local suppliers of A.

[6] Davis (1998) criticises empirically this assumption and demonstrates how the concentration result (or home market effect) vanishes once transport costs are similar for any kind of goods, which hints at the fact that industrial conglomeration should be explained by different economic mechanisms other than simply differences in transport costs.

[7] This phenomenon of great systemic significance is reflected in a vast literature, which emphasizes different aspects of firms' dependence on their environment. We can mention, among others, those approaches which concentrate on clusters (Nadvi 1999, Schmitz, 1995 and 1999, Nadvi, K. and H. Schmitz (1994 and 1999)), on the global commodity chains (Humphrey and Schmitz, 2001, Gereffi, 2001), on advanced outsourcing (Coriat, 1992), as well as the literature about innovation systems, either national (Freeman, 1994 and 1995, Metcalfe 1995), local (Scott, 1996, Camagni, 1991) or social (Amable, Barré and Boyer, 2001).

[8] "Backward" countries were the South-Eastern Asian countries (especially Korea).

(Nelson, 1995), which implies important path dependency and risky investment, it is straightforward to consider that the strategies of industrializing countries belong to the learning-based strategy. This is why our variable of development is the quality gap.

The relevance of the networking effect depends upon three margins: an extensive margins, which captures the geographical (or inter-sectorial) extension of the network of interconnected firms; an intensive margin, which captures how deep interconnected firms in the network are; and a local gap margin, which captures the technological gap between advanced and backward local firms, and therefore tells us how much the latter ones are able to learn from the former ones and how much, in turn, these ones have to 'teach' to the other ones before they are able to converge to a similar technological level. If knowledge transfer is locally based – as evidence seems to indicate (Keller 2002, and Bottazzi and Peri 2003) – there will be spatial externalities, which means that, given the intensive and the local gap margins, the more extended the network of local interconnected firms, the better they will be able to develop.

If a policy of trade liberalization induces a substitution of foreign for local suppliers, this may have in principle two contrasting effects: on one side, the possibility to make use of better imported inputs amounts to an efficiency gain[9]; on the other side, replaced backward local sectors are prevented from developing, and also their beneficial contribution to the development of other interconnected sectors goes lost. Since such contribution is low as long as they are still backward, and becomes more relevant as they approach the technological frontier in their country[10], it is easy to see that trade liberalization may have short run benefits but long run costs. That is why the degree of impatience plays a relevant role in determining optimal trade policy[11].

One last observation is that FDI may play a crucial role in determining a country's development (they appear to be crucial, for instance, in China and in Brazil, even if not so much in Korea and in Argentina[12]). Therefore, we study how optimal trade policy changes when we pass from a situation in which local advanced firms belong to local owners to one in which they belong to foreign owners[13]. Because of the link of multinational corporations' branches with their headquarter, firms that are the result of FDI may have an advantage over other local firms, since they depend less upon the network of (backward) local producers and therefore are better able to keep the pace of development of frontier firms. On the other hand, foreign ownership implies that profits (or

[9]One could say that manufacturing firms gain access to a more global production function.

[10]They may still be far from the international technological frontier, but they play a key leadership role for local development.

[11]It is interesting to speculate that in several developing countries the degree of impatience might be related to the conditions of political stability and of citizens' trust in their government. Although admittedly fuzzy, such interpretations are tempting. Anecdotal evidence suggests, for instance, that Japan in the Fifties was much more patient than Argentina in the Seventies, and that Slovenia today is much more patient than Bulgaria.

[12]See for instance Aitken and Harrison, 2002 and Chudnovsky and Lopez, forthcoming.

[13]To our knowledge the effects of FDI on optimal trade policy have not been directly studied by the literature yet.

at least a part of them) go abroad. These two effects alter the distribution of costs and benefits of a given trade policy over the short and the long run, and therefore affect optimal trade policy[14].

Our results are related to the old-fashioned 'infant industry' argument (coming from John Stuart Mill, 1848 and Bastable, 1921), but the emphasis here is on the role played by developing input sectors in the generation of new abilities and on clearly stating the conditions under which an infant industry is worth defending. As it has been pointed out by Lucas (1984), "in the end, only a careful weighing of intertemporal, social costs and benefits can discern whether infant industry protection might be justified".

3 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, and where a continuum $[0, 1]$ of goods are produced. Good 1 is a consumption good, produced and sold by a perfectly competitive representative firm; goods $[0, 1)$ are intermediate goods, produced and sold by monopolistic firms. Intermediate goods are differentiated both horizontally (they are different commodities) and vertically (they are produced at different quality levels). For simplicity, we assume that intermediate goods are produced with labor only and that the consumption good is produced with intermediate goods only. We study the dynamics of quality improvement and look at whether and how trade opening may lead our economy to converge to the world quality frontier. The way we introduce heterogeneity allows us to distinguish among the effects of trade opening on countries with very different industrial structures and thus to draw policy conclusions that are different for different countries. In Sections 3 and 4 we maintain that all firms belong to the local population, so that their profits go to the representative consumer. In Section 5, in order to study the impact of FDI on optimal trade policy, we allow for foreign ownership of a fraction of intermediate firms, which implies that their profits go abroad.

3.1 Consumption

The representative consumer maximizes $U = \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho}\right)^t \ln c(t)$, where $\rho \in (0, 1)$ is the intertemporal discount rate and $c(t)$ is consumption at time t. Since we do not consider any asset, the solution to this problem reduces to the solution of the static problem, so that the demand for good 1 (the consumption good) at time t is $y^d(1, t) = \frac{E(t)}{p(1,t)}$, where $E(t)$ denotes aggregate income and $p(1, t)$ the price of good 1, both at time t. Aggregate income $E(t) = W(t) + \Pi(t) + T(t)$

[14] It is important to emphasize that we do not study the optimality of attracting or not FDI, but we rather take the the ownership structure as given and study how it affects optimal trade policy.

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 firm m's profits at time t, and aggregate tariff revenue on imports $T(t)$, which will be specified below. The reason why we keep this specification so simple is that we are more interested in the production side rather than in the consumption side. Specifically, we focus on the dynamics of the industrial structure of our economy.

3.2 Quality dynamics

At each point in time intermediate goods producers pay a small fixed cost $f \in (0,1)$ to improve their product quality next period[15]. We make two basic assumptions about the dynamics of quality improvement: the first is that the returns to the investment in quality improvement are a concave function of own quality (i.e., there are decreasing returns to scale); the second is that firms learn to a relevant degree through network interaction with other local firms.

These two assumptions deserve some comment. The first one fits well with Jones' (1995) observation of a congestion effect in R&D, in the sense that notwithstanding the fact that R&D investment have constantly grown over time in industrialized countries, the rate of technological progress has remained more or less constant. While Jones' approach is based on horizontal differentiation, Segerstrom (1998) proposes a model of vertical differentiation where a similar kind of congestion effect is present. Our first assumption is close to it in spirit, but while Segerstrom assumes a hard to interpret negative externality of overall R&D investment in the economy on a firm's probability to improve its quality, we assume in a more natural way that to improve a good product is harder than to improve a bad one.

Our second assumption is well supported by recent empirical results. For instance, Keller (2002) finds that international technology diffusion among OECD countries is geographically localized: specifically, his estimations imply that the distance at which technology spillovers are halved lies between a lower bound of 162 kilometers and an average of 1200 kilometers in his preferred specification[16]. Using data on European Regions, Bottazzi and Peri (2003) find that R&D spillovers diffuse within 300 kilometers from the source region, but no effect spreads further than that. Moreover, such spillovers are found both intra-industry and cross-industry[17].

To capture these two ideas, denoting $v(m,t)$ good m's local quality and by $N(t) \subseteq [0,1)$ the set of locally active intermediate goods producers, we assume the following dynamics:

[15] We assume that $f \in \left(0, \frac{1}{\sigma}\right]$, where $\sigma > 1$ is a parameter whose meaning will be explained later.

[16] He also finds that technology diffusion has become less localized and more international over time, especially from the Seventies.

[17] Notice that while Keller studies the effect of R&D on countries' productivity, Bottazzi and Peri study its effect on countries' innovation.

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

where $\varphi \in (0,1)$ and $\epsilon \in (0, 1-\varphi)$ are parameters[18]. One way of looking at the network of interacting local firms is as a macro-industry, where learning externalities arise from formal and informal meetings, discussions among intermediate suppliers organized by their common client, reciprocal adaptation, transmission of tacit knowledge, and so on. The fact that such externalities are not maximized by specialization in one or few sub-sectors but rather by the local availability of several interacting sub-sectors within the same macro-industry corresponds to the experience of several industrial districts, where indeed several small or medium firms are very innovative and profit much from their proximity to other differentiated firms with which they significantly interact.

3.3 Production

Each intermediate good $m \in [0,1)$ is produced with labor according to the technology $y(m,t) = L(m,t) - f$, where f is the fixed cost mentioned above. It should be noted that the fact that the same parameter f appearing here also enters in the quality improvement equation plays no significant role for our analysis: it just simplifies notation. Total production of intermediate goods is constrained by the fixed labor supply: $\int_0^1 L(m,t)\mathrm{d}m = 1$. Labor is supplied inelastically, but it is perfectly mobile across sectors.

As mentioned above, intermediate goods, which are both horizontally and vertically differentiated, are the only input in the production of the unique consumption good, which is produced according to the technology

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

where $\sigma > 1$ captures the elasticity of substitution between any two different 'kinds' of intermediate goods and $h(m,t)$ is the 'effective input' of good m at time t. Such 'effective input', which may be either bought locally or imported from the rest of the world, is given by its quantity multiplied by its quality:

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

where $x(m,t)$ denotes local quantity, $v(m,t)$ local quality and m^* is the same 'kind' of good as m, but produced in the rest of the world at the quality frontier $v(m^*,t)$. We assume that any given 'kind' of intermediate good at any point in time can be either acquired locally or imported, but not both.

[18] φ captures the degree of decreasing returns to own quality and $\epsilon > 0$ is assumed in order to make the international quality frontier grow at decreasing rates under Assumptions 1 and 2 that will be introduced below.

3.4 Trade

Local intermediate goods have to compete with their perfect substitutes produced abroad at the quality frontier. Taking into account the presence of a trade tariff rate $\tau(t) \geq 0$ (possibly varying over time) and of transport costs $a \in (0,1)$, which render the price of an imported intermediate good equal to $p^*(m,t)[1+\tau(t)](1+a)$[19], the final good producer decides whether to buy locally or to import according to the best quality/price ratio: the set of locally acquired inputs 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

$$p_H(m,t) \equiv \frac{v(m,t)}{v(m^*,t)} p(m^*,t)[1+\tau(t)](1+a), \tag{4}$$

we have

$$D(t) = \{m \in [0,1) : \ p(m,t) \leq p_H(m,t)\}. \tag{5}$$

A similar production structure for the world economy implies that the final good producer in the rest of the world will be willing to import intermediate good m from our small economy only if the quality/price ratio is convenient. In particular, we assume that the tariff imposed to our economy by the rest of the world is the same as the local import tariff. Although admittedly somewhat arbitrary, this assumption is in our view the most meaningful to study dynamic tariff setting in the context of a small open economy. The reason is that strategic tariff setting makes no sense when our economy is infinitesimal with respect to the rest of the world, but it would also be meaningless to fix the world tariff at any exogenous rate, without letting it respond in any way to the changes over time in the local tariff. As a consequence, the best way to incorporate the main lessons of the literature on strategic tariffs in the context of a small open economy is probably to tie the two tariffs and letting them be equal is just the most obvious way to do it. Provided this, the set of potentially exportable intermediate goods for our small economy is $F(t) = \left\{m \in [0,1) : \frac{v(m,t)}{p(m,t)[1+\tau(t)](1+a)} \geq \frac{v(m^*,t)}{p(m^*,t)}\right\}$. Therefore, defining the threshold function

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

we have

$$F(t) = \{m \in [0,1) : \ p(m,t) \leq p_L(m,t)\}. \tag{7}$$

The reason why we talk about 'potentially exportable' goods rather than simply exports is that we make the following assumptions about foreign demand for local goods: if $p(m,t) < p_L(m,t)$, the rest of the world demands an arbitrarily

[19]Calling $M(t)$ aggregate imports at time t, this implies that the aggregate revenue from import tariff is $T(t) = \tau(t)p^*(m,t)(1+a)M(t)$.

large quantity of good m; if $p(m,t) = p_L(m,t)$, it just demands the difference (if positive) between the equilibrium production of good m, $\bar{y}(m,t)$, and its local demand, $x(m,t)$, i.e., foreign demand for m is $x^*(m,t) = \max\{0, \bar{y}(m,t) - x(m,t)\}$. The quantity $\bar{y}(m,t)$, which firm m takes as given when choosing its price, exactly as it takes as given the equilibrium wage and the equilibrium number of active firms, is indeed endogenously determined in equilibrium.

Due to the presence of vertical differentiation and to the discontinuities in demand implied by the price thresholds at which intermediate goods may be imported and exported, the derivation of demands and prices, although conceptually simple, is a bit more complicated than in a standard Dixit-Stiglitz model, and we carry it out in detail in Appendix A. In particular, while in a standard model the mark-up is 'exogenously' determined by the elasticity of demand, in our model it is endogenously determined in equilibrium. We now pass to the analysis of the static equilibria of our economy. The next section will then study various possible equilibrium dynamics, with their trade policy implications.

3.5 Static equilibria

We make the following assumptions on initial conditions. These assumptions will hold throughout the paper.

Assumption 1 *A fraction u of local intermediate 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. Formally, $\exists\ u, \beta \in [0,1] :\ \forall m \in [0,u),\ v(m,0) = \beta v(m^*,0)$ and $\forall m \in [u,1),\ v(m,0) = v(m^*,0)$.*

Assumption 2 *We normalize at the beginning the international quality frontier for each sector: $\forall m^* \in [0,1),\ v(m^*,0) = v^*(0)$.*

Taking the final good produced abroad at time $t = 0$ as numeraire, i.e., $p(1^*,0) = 1$, this last assumption implies that, letting $p^*(t)$ be the common price of all intermediate goods produced abroad at time t, the foreign marginal cost of producing the final good is $P^*(0) = \frac{p^*(0)}{v^*(0)} = p(1^*,0) = 1$, so that $p^* = v^*$, and it is easy to show that this property does not only hold at time 0, but for every $t \geq 0$.

In a previous version of the paper, available from the authors upon request, we studied the case in which all local firms have the same quality level, i.e., $u = 1$, and we proved three results: first, there exists a unique (symmetric) equilibrium, in which all intermediate goods producers sell locally at the same price and there is no international trade; second, there may exist (asymmetric) equilibria such that only a measure $n \in (0,1)$ of intermediate good producers are active and they even export, whereas the remaining intermediate firms stay closed and the corresponding goods are imported; third, while the (asymmetric) trade equilibria tend to be Pareto-superior to the (symmetric) no-trade one from a static point of view, they tend to be Pareto-inferior from a dynamic point of view, because closing firms generate a negative dynamic externality on the speed of quality development in open ones.

We now focus on the case in which intermediate firms are heterogeneous. This means that a fraction $u \in (0,1)$ of intermediate goods may be produced at a low quality level and a fraction $1-u$ at a high quality level. We shall denote by β_L and β_H the ratio of local to international quality, by $p_L(L)$ and $p_L(H)$ the lower price threshold and by $p_H(L)$ and $p_H(H)$ the higher price threshold, for 'bad' and 'good' firms, respectively[20]. We shall restrict our attention to symmetric equilibria. By 'symmetric' we mean that all firms with the same quality gap make the same choice. Since intermediate goods producers cannot stay all closed at the same time in general equilibrium (there would be excess supply of labor), we distinguish four types of equilibria[21]:

Type of equilibrium	**'Good firms'**	**'Bad firms'**
Export and die	sell locally and export	stay closed
Export and survive	sell locally and export	just sell locally
Survive and die	just sell locally	stay closed
Survive and survive	just sell locally	just sell locally

In Appendix B we establish existence for some parameter values of each of these four types of equilibria, and we also make some comparative statics exercises. Since our main interest is in the dynamics of our economy, though, we do not go deeper here into the mathematical details of the static equilibria and of their welfare comparison. Rather, we directly pass to the analysis of equilibrium dynamics and of policy implications.

Before doing this, though, it is useful to notice that, as Appendix B makes clear in detail, our model may display wage indeterminacy in equilibrium. This depends upon the fact that the mark-up is endogenously determined: given a firm's quality and equilibrium variables, it may find it optimal to price below the standard mark-up either to gain access to the export market (if the wage is low enough to make it internationally competitive notwithstanding its quality gap), or to be able to sell on the local market without being replaced by imports (if, say, the wage is in some intermediate range), as well as it can find it optimal to stay closed. Therefore, the possibility of threshold pricing, combined with perfect mobility of labor across sectors, makes some equilibria compatible with an entire wage range. In this case, given the tariff, the quality gap distribution and all other exogenous parameters, it is also possible that multiple, structurally different equilibria exist: for instance, it is possible to have a 'survive and die' equilibrium with high wages and an 'export and survive' one with lower wages.

This multiplicity problem makes trade policy more interesting to study, since it is not just reduced to set a tariff, but it also involves an important coordination role, which may or may not succeed. For instance, anecdotal evidence suggests

[20] Observe that $p_H(L) < p_L(H) \Leftrightarrow \frac{\beta_L}{\beta_H} < \frac{1}{[(1+\tau)(1+a)]^2}$, where $\frac{\beta_L}{\beta_H}$ denotes the ratio of 'bad' firms' quality to 'good' firms' quality.

[21] The fact that in the case with homogeneous quality no symmetric equilibrium exists in which any firm exports makes us confident that, in the case of heterogeneous quality, there is no symmetric equilibrium in which both 'good' and 'bad' firms are simultaneously able to export.

that some countries like Bolivia used all available instruments (in particular, low tariffs) to open up the economy, but they did not succeed to stimulate trade. More generally, while Latin America and East Asia had the same average tariff over the last thirty years, the latter succeeded to have much higher volumes of trade than the former, probably because, unlike Latin America, which put all the emphasis on import substitution, East Asian countries also emphasized export promotion (Yanikkaya, 2003). It is then tempting to think of a 'survive and survive' equilibrium as the result of a 'Latin American style' policy and of an 'export and survive' equilibrium as the result of an 'East Asian style' policy. We elaborate on the different emphasis on import substitution and export promotion in the next section. The instruments that can be used to achieve certain trade goals include, besides (possibly differentiated) import tariffs, non-tariff barriers, export subsidies, fiscal policy, foreign language teaching, cultural policy, and so on. We do not model all such instruments explicitly, but we have them in mind when we talk about the coordination role of government intervention. Since such coordination may succeed or fail, and since we believe that governments do not have full control over equilibrium selection in case of multiple equilibria, we do not treat equilibrium selection as a control variable: indeed, it would be quite unrealistic to imagine that the government can open and close entire sectors of the economy at pleasure. Therefore, although quality distribution is a state variable in our model, in the next section we do not study optimal policy with the tools of dynamic optimization, but rather solve the government's optimization problem conditional under reasonable equilibrium paths, that is, paths along which it never happens that a positive measure of sectors suddenly starts or stops producing. When the wage is undetermined in a certain equilibrium, we focus on the highest possible wage.

4 Dynamics and trade policy

We now compare four initial industrial structures to see what kind of trade policy is dynamically more adequate in each case. The four cases we distinguish differ in the initial measure of 'good' and 'bad' firms and in the initial quality gap of the latter ones. Specifically, we consider the possible combinations:

u	$\beta_L(0)$	**Initial industrial structure**
0.3	0.3	few 'bad' firms, but very bad
0.3	0.8	few 'bad' firms and not so bad
0.8	0.3	many 'bad' firms and very bad
0.8	0.8	many 'bad' firms, but not so bad

We are first going to compare first two basic trade policies:

- **'trade liberalization'**;
- **'temporary protection'**.

Subsequently, we shall consider the possibility of pursuing a mix of the goals of these two policies and therefore consider a third trade policy: **'import substitution and export promotion'**.

4.1 Trade liberalization vs. temporary protection

The basic idea is that a policy of trade liberalization, while allowing high quality firms to export, may imply the closure of low quality firms, which are not competitive. This may be good for consumers' welfare both because low quality local products are substituted by high quality imported goods and because high quality firms may be able to export, thus compensating the decline in the activity level due to the closure of low quality firms. On the other side, the fact that a relevant fraction of local sectors close implies that active local firms operate in a context that is less favorable for network learning and innovation, so that they suffer a negative dynamic externality on quality improvement. As a consequence, they may not be able to keep the growth pace of the world's quality frontier. The speed of such decrease in competitiveness depends on the measure u of firms forced to close by trade liberalization and its welfare cost depends on the representative consumer's intertemporal discount rate ρ.

By contrast, a policy of temporary protection may allow low quality firms to survive (thus working as an import substitution device), but this may be twice costly in terms of welfare: first, because protection does not allow 'bad' local products to be substituted by better imported goods; second, because network learning externalities imply that 'good' local firms bear the initial cost of 'bad' ones' quality improvement. In a way, under a protection regime 'good' firms play the role of 'teachers'. This has a short term cost in terms of decreased competitiveness, but it also generates a long term advantage, since, once initially heterogeneous local firms have converged to a similar quality level, they are all able to operate in a favorable environment for innovation and quality improvement. Moreover, since quality improvements become harder the higher the existing quality level, and since local firms, after converging to similar quality levels, still have a quality gap with respect to the rest of the world, they become able to improve their quality faster, so that in the long run the initial competitiveness loss by 'good' firms is compensated by a competitiveness gain by all firms. Once again, the speed of local convergence first and then of catch up with the world frontier depends on the initial measure u of low quality firms and on how low their quality is at the beginning, captured by $\beta_L(0)$. On the other side, welfare costs and gains crucially depend on how the representative consumer evaluates the long run relative to the short run, i.e., on her intertemporal discount rate ρ.

We now compare different equilibrium dynamics.

We give the following specification of the **'trade liberalization'** policy: set $\tau(t) = 0 \ \forall t$ and, in case of multiple equilibria, coordinate the economy on an 'export and die' equilibrium[22] (if many equilibria of this kind are possible, we

[22] In such an equilibrium, the consumption level depends negatively on the tariff, so that

consider the one with the highest wage[23]). If, at a given point in time, no 'export and die' equilibrium exists, we simply admit that such policy cannot be dynamically implemented; otherwise, we speak of an 'export and die' equilibrium dynamics. Since we are interested in welfare comparison, we consider equilibrium dynamics until the present discounted value of the stream of consumption $U = \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho}\right)^t \ln c(t)$ has numerically converged (all what happens beyond that point is welfare irrelevant).

As far as the **'temporary protection'** policy is concerned, we specify it as follows: at each time t set the tariff $\tau(t)$ that maximizes consumption in the 'survive and survive' equilibrium[24] and coordinate the economy on such an equilibrium if multiple are possible[25]. If, at a given point in time, no 'survive and survive' equilibrium exists, we say that such policy cannot be dynamically implemented; otherwise, we speak of a 'survive and survive' equilibrium dynamics and study it until U has converged.

With this in mind, we simulate these two equilibrium dynamics for the four possible initial industrial structures identified above, and we compare welfare, measured by U, in the different cases, holding constant the following parameters: transport costs $a = 0.1$, fixed costs $f = 0.1$, elasticity of substitution between different types of intermediate goods $\sigma = 4$, elasticity of the quality improvement to own quality level $\varphi = 0.3$, relevance of the network learning externality $\epsilon = 0.1$[26] and the initial value of international prices and quality $p^*(0) = v^*(0) = 1$. We consider two values of the intertemporal discount rate, $\rho = 0.1$ (impatient) and $\rho = 0.05$ (patient), for each of our four possible initial industrial structures. Simulations with these parameters yield the following results.

Lemma 1 ***'export and die' equilibrium dynamics*** *For each of the four initial industrial structures we consider, the 'trade liberalization' policy gives rise to an 'export and die' equilibrium dynamics, whereby at any point in time 'good' firms serve both the local and the international market, and 'bad' firms stay closed, the corresponding goods being imported. Welfare is independent of* $\beta_L(0)$. *The following table shows welfare results for the various combinations of* u *and* ρ.

the choice of $\tau = 0$ turns out to be optimal. We have no analytical proof for this, but, among the many numerical computations we conducted with different parameters and variables, we did not encounter a single case in which this is not true.

[23] Notice that in the 'export and die' equilibria the consumption level does not depend upon the wage. Therefore, the choice of the highest wage is of no relevance.

[24] In case of several maximizers, choose the lowest τ. Observe that this policy is optimal conditional upon the equilibrium being 'survive and survive'.

[25] In all the simulations we ran such an equilibrium is generically unique, that is, there exists at most a set of parameters of measure zero for which multiple 'survive and survive' equilibria are present. This implies that in our numerical simulations multiplicity is not an issue.

[26] The elasticity of the quality improvement to total local quality, i.e., to the aggregate quality of the network of local firms, is $1 - \varphi - \epsilon$. This implies that a low ϵ is associated to a relevant network externality. We repeated our simulations for a higher ϵ, namely for $\epsilon = 0.3$, i.e., for less relevant local network externalities, and found no qualitative differences in our results.

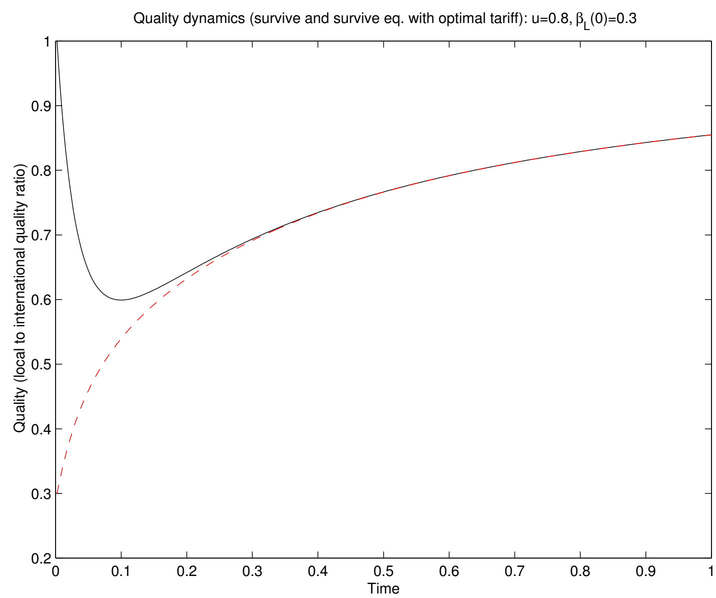
ρ	0.1		0.05	
u	0.3	0.8	0.3	0.8
U	6.6699	2.1768	24.5405	7.4534

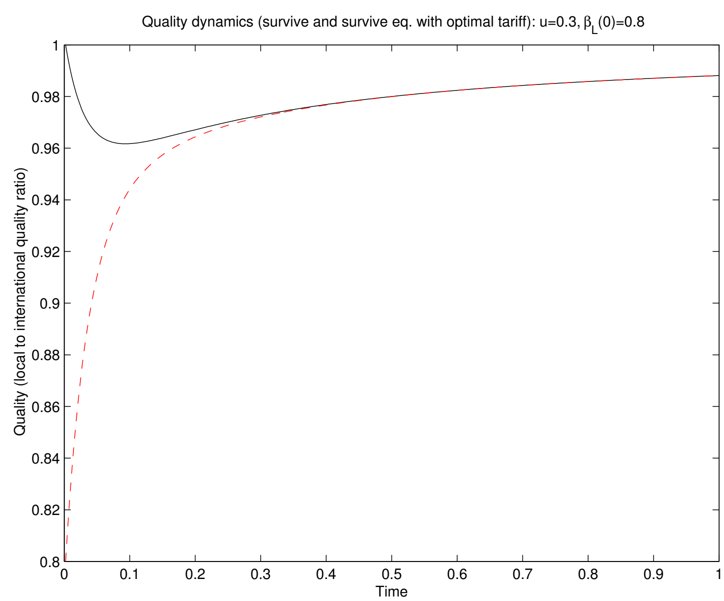
Lemma 2 ***'survive and survive' equilibrium dynamics*** *The 'temporary protection' policy cannot be dynamically implemented when there are few low quality firms (u* $= 0.3$*), which start with a high quality gap (*$\beta_L(0) = 0.3$*). When there are many low quality firms (u* $= 0.8$*), or when they are few (u* $= 0.3$*) but start with a smaller quality gap (*$\beta_L(0) = 0.8$*), it gives rise to a 'survive and survive' equilibrium dynamics, whereby at any point in time all local firms are active, but serve only the local market. Welfare results are summarized in the following table.*

ρ	0.1			0.05		
u	0.3	0.8	0.8	0.3	0.8	0.8
$\beta_L(0)$	0.8	0.3	0.8	0.8	0.3	0.8
U	9.0622	1.6669	6.7803	32.3184	19.2064	29.1744

A closer look at the 'survive and survive' equilibrium dynamics allows some more interesting observations. First, temporary protection allows local convergence at the beginning and then catch up with the international quality frontier. This is made clear by the two following graphs, which show the dynamics of local to international quality ratio for the 'survive and survive' equilibrium dynamics with $\rho = 0.1$, in the two cases in which $(u, \beta_L(0)) = (0.8, 0.3)$ and $(u, \beta_L(0)) = (0.3, 0.8)$, respectively: the first graph depicts the convergence process of an economy with a very bad initial industrial structure, whereas the second one considers a much better economy[27].

[27] The dashed and the solid lines describe the dynamics of $\beta_L(t)$ and of $\beta_H(t)$, respectively. The horizontal axis re-scales from 0 to 1 the time span from 0 to 450: U converges numerically at $t = 415$ in the first graph and at $t = 393$ in the second one.





The driving forces of this process are the network externality of quality development and the fact that the higher a firm's quality, the harder it is to further improve. Moreover, it is clear that 'good' firms pay the initial cost of local convergence, in the sense that they lose competitiveness with respect to the rest of the world, the more so the higher the measure of 'bad' firms in the economy and the higher their initial quality gap, but in the long run this allows all sectors in the economy to converge to the world frontier.

Second, while in the 'temporary protection' policy the protection degree is chosen optimally to maximize consumption each period, it indeed turns out to be temporary, since the tariff decreases gradually with time as local firms' quality converges. Specifically, independently of ρ, when $(u, \beta_L(0)) = (0.3, 0.8)$, initial protection is $\tau(0) = 32\%$ and then decreases until $\tau(t) = 0$ for $t \geq 18$. When $(u, \beta_L(0)) = (0.8, 0.3)$, initial protection is $\tau(0) = 43\%$ and then decreases until $\tau(t) = 0$ for $t \geq 40$. When $(u, \beta_L(0)) = (0.8, 0.8)$, initial protection is lower ($\tau(0) = 7\%$) and complete liberalization comes sooner ($\tau(t) = 0$ for $t \geq 9$).

On the base of the previous lemmas, we can now compare the two policies from a welfare point of view (we compare the results of equilibrium dynamics). Since when $u = 0.3$ and $\beta_L(0) = 0.3$ the 'temporary protection' policy cannot be dynamically implemented, we will limit our comparison to the other cases.

Proposition 1 *Consider an economy in which both the 'temporary protection' policy and the 'trade liberalization' one can be dynamically implemented.*

- *If the quality gap of backward sectors is not too high ($\beta_L(0) = 0.8$), then, no matter how many sectors are indeed backward (i.e., both with $u = 0.3$ and with $u = 0.8$), and independently of the degree of impatience (i.e., both with $\rho = 0.1$ and with $\rho = 0.05$), the 'temporary protection' policy is more efficient than the 'trade liberalization' one: the benefits of temporary protection are higher then its costs.*

- *If the quality gap of backward sectors is high ($\beta_L(0) = 0.3$) and, additionally, there are many such sectors ($u = 0.8$), then the preferability of one policy over the other one depends upon the degree of impatience:*

  - *if the representative consumer is impatient ($\rho = 0.1$), short run costs of temporary protection exceed long run benefits and therefore the 'trade liberalization' policy is more efficient than the 'temporary protection' one;*

  - *if the representative consumer is more patient ($\rho = 0.05$), the reverse is true.*

4.2 Import substitution and export promotion

Up to now we have emphasized the opposition between export promotion and import substitution, but these two goals need not necessarily exclude one another. It is therefore interesting to consider an intermediate policy, which we call **'import substitution and export promotion'**, aimed first of all at allowing all local firms to survive and develop, but also, if possible, at letting high quality firms export. Specifically, we consider the following trade policy: first, set at each time the tariff that maximizes consumption conditional upon the fact that no firm closes; second, coordinate the economy on the corresponding equilibrium[28]. If this policy can be dynamically implemented, i.e., if it gives rise to an equilibrium dynamics, we shall speak of an 'export or survive' equilibrium dynamics, since the chosen equilibrium may be either an 'export and survive' or a 'survive and survive' one[29].

Lemma 3 ***'export or survive' equilibrium dynamics*** *The 'import substitution and export promotion' policy cannot be dynamically implemented when there are few low quality firms (u =* 0.3*), which start with a high quality gap (*$\beta_L(0) = 0.3$*). When there are many low quality firms (u =* 0.8*), or when they are few (u =* 0.3*) but start with a smaller quality gap (*$\beta_L(0) = 0.8$*), it gives rise to an 'export or survive' equilibrium dynamics, whereby at any point in time all local firms are active and serve the local market, but high quality firms may also serve the international market. Welfare results are shown in the following table.*

ρ	*0.1*			*0.05*		
u	*0.3*	*0.8*	*0.8*	*0.3*	*0.8*	*0.8*
$\beta_L(0)$	*0.8*	*0.3*	*0.8*	*0.8*	*0.3*	*0.8*
U	*9.0622*	*1.6802*	*6.7815*	*32.3184*	*19.2238*	*29.1756*

As one can notice, welfare results are slightly better than those of the 'survive and survive' equilibrium dynamics. The fact that they are better is obvious, since we are enlarging the choice set; the fact that they are only slightly better depends upon our assumption of inelastic labor supply, which, equalizing labor supply in the 'survive and survive' and in the 'export and survive' equilibrium, renders small the gains of exporting over selling to the domestic market. Since this assumption is not crucial, though, and is made just for analytical simplicity, what is relevant here is the qualitative result.

The patterns of local and global convergence are qualitatively the same as in the 'survive and survive' equilibrium dynamics, but the tariff dynamics is different, because of the possible equilibrium switching. Since with $(u, \beta_L(0)) = (0.3, 0.3)$ the 'import substitution and export promotion' policy cannot be dynamically implemented and with $(u, \beta_L(0)) = (0.3, 0.8)$ the equilibrium is always 'survive and survive', we will focus on the case in which there are many backward sectors $(u = 0.8)$[30].

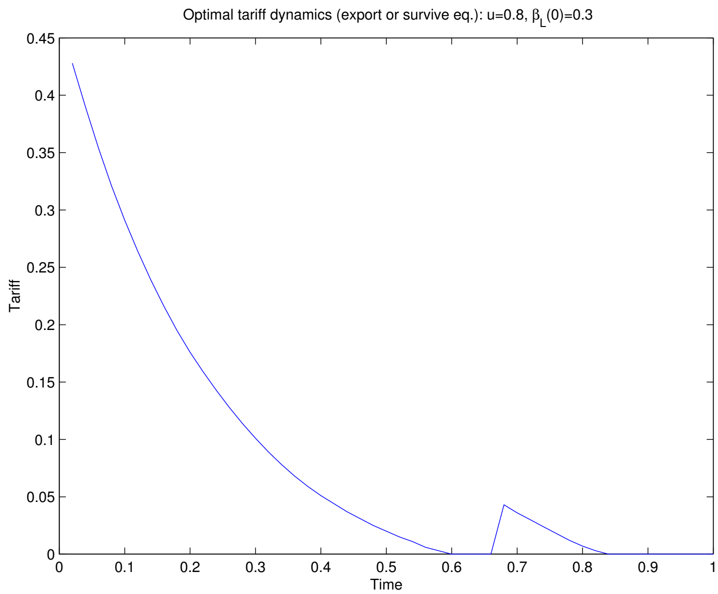
When $\beta_L(0) = 0.3$, the equilibrium is 'export and survive' until $t = 32$ and 'survive and survive' afterwards; the tariff first decreases from $\tau(0) = 43\%$ to $\tau(29) = 0$, remains at 0 until $t = 32$, but then, with equilibrium switching,

[28] In case of multiple consumption maximizing tariffs, choose the lowest. In case of multiple 'export and survive' equilibria for the chosen tariff, consider the one with the highest wage. In case of equal consumption in the two equilibria for the chosen tariff, consider the 'export and survive' one. Observe that this policy is optimal conditional upon the equilibrium being either 'export and survive' or 'survive and survive'. Therefore, by definition, it is not inferior to the 'temporary protection' policy.

[29] To study the properties of this new policy, we keep the same parameters as for the two previous ones.

[30] Moreover, observe that under the 'import substitution and export promotion' policy the tariff dynamics does not depend on the degree of impatience.

raises again to $\tau(33) = 4\%$ and finally decreases until $\tau(40) = 0$. This is shown in the following graph[31].



The intuition behind this result is straightforward. A high protection is initially needed to let low quality firms survive. Since most firms have initially a very low quality, wages are bound to be low, so that, even with this high protection, high quality firms are initially able to set internationally competitive prices and therefore to export. As time goes, though, they pay part of the cost of 'bad' firms' quality improvement. Therefore, while 'good' and 'bad' firms' quality converge to one another, we observe two phenomena: on one side, 'good' firms become internationally less competitive, since their quality cannot keep the pace of the international quality frontier[32]; on the other side, since most local firms, which are initially 'bad', experience a faster improvement[33], domestic demand sharply increases. This implies that a lower tariff protection is needed to let them survive, while letting 'good' firms export. But the optimal tariff reaches zero before 'bad' and 'good' firms' quality have converged, so that there is a period in which, while the tariff remains fixed at zero, 'good' firms keep losing competitiveness in the international market and domestic demand keeps increasing. Both effects eventually induce 'good' firms to stop exporting and to sell exclusively to the local market. When this happens, the equilibrium switches

[31] The horizontal axis now re-scales between 0 and 1 the time horizon between 0 and 50: U converges numerically at $t = 415$ when $\rho = 0.1$, but the tariff is $\tau(t) = 0$ for $t \geq 40$. The fact that the tariff path is not smooth is due to the numerical limitation to integer percentage points.

[32] Recall that the patterns of quality dynamics are similar to those of our first graph: one can check that β_H declines from 1 to a minimum of 0.6 in the first 50 periods.

[33] β_L increases from 0.3 to roughly 0.55 in the first 50 periods.

from 'export and survive' to 'survive and survive', but now, given that no firm exports, there is no need for the optimal tariff to be zero; rather, a moderate degree of tariff protection allows the economy not to be invaded by foreign products at a time in which all of its firms, which are now close to one another in terms of their quality, are just starting the process of catch up with the international quality frontier. Specifically, this new moderate protection is just temporary: it decreases as local convergence proceeds and it stops when local firms are close enough in quality, so that the cost of 'bad' firms' development paid by 'good' ones is low enough and 'good' firms stop losing competitiveness, but rather start to gain from local interaction with sufficiently developed other firms.

Finally, when $\beta_L(0) = 0.8$, the equilibrium is 'export and survive' only until $t = 2$ and 'survive and survive' afterwards, the reason being that, when local firms are very similar, it cannot happen in equilibrium that some of them export and the other ones just sell locally; in the initial phase of 'export and survive' equilibrium, it is optimal to promote good firms' exports by a zero tariff policy ('bad' firms are anyway able to survive even without protection), but at $t = 3$, with the equilibrium switching and all firms just selling locally, it is optimal to raise a temporary trade protection, which starts with $\tau(3) = 4\%$ and gradually decreases to $\tau(9) = 0$.

These results allow us to formulate the following proposition.

Proposition 2 *A sophisticated trade policy, such as the 'import substitution and export promotion' one, can temporarily reconcile the aims of allowing high quality firms to export and low quality firms to survive. In several cases, this requires a non-monotonic tariff setting over time. The welfare properties of such a policy are are slightly better than those of the 'temporary protection' one, but they compare with the 'trade liberalization' policy in exactly the same way, as established by Proposition 1.*

5 Foreign direct investments

Up to this point we have assumed that all firms belong to local consumers. We now study the effects of foreign direct investments (FDI) and assume that some intermediate firms belong to foreign owners. Such firms differ from other local firms in two respects: first, their profits go abroad rather than to local consumers; second, they are better able to learn from their mother firm: this changes the dynamics of their quality improvement, making them less dependent upon interaction with the network of other local firms, and alleviating the effect of decreasing returns to scale to own quality. Formally, our introduction of FDI amounts to three changes in the framework used so far:

- we assume that initially 'good' firms are the result of FDI: following Assumption 1, this means that firms $[u, 1)$ have foreign owners;
- the dynamics of their quality improvement follows equation (1), but with $\varphi_F \in (\varphi, 1)$ in place of φ;

- their profits go abroad: this reduces aggregate income to $E(t) = W(t) + \int_0^u \pi(m,t)\,\mathrm{d}m + T(t)$.

It is immediate to notice that, from a static point of view, the fact that some firms belong to foreign owners, and therefore their profits go abroad, makes the representative consumer worse off, as compared to the case in which those same firms, with the same quality level, are locally owned, since it trivially subtracts resources to the economy. But of course this is not the entire story, since FDI can have two further effects: first, they can make some sectors jump from a state of backwardness to one of high quality (formally, we can think, for instance, of a jump from $u = 0.8$ to $u = 0.3$); second, they can give rise to interesting dynamics, due to the special link of daughter firms with their mother firm. It is important to emphasize here that we are not going to study the effect of FDI from the first point of view, but only from the second one, the reason being that we do not contrast here the policy choice between promoting or contrasting FDI, but we rather restrict ourselves to the comparison between a policy of trade liberalization and one of temporary protection under the two alternative regimes of local ownership and FDI. The analysis of the impact of FDI on u remains in our future research agenda, but in the present work we take u as given.

At the end of Appendix B we discuss existence of the four types of equilibria under the new assumptions on FDI. Here we consider the relationship between trade policy and equilibrium dynamics. Once again, we will focus on the four industrial structures, the three trade policies and the two possible degrees of impatience already discussed in Section 4.

5.1 Trade liberalization vs. temporary protection

Proceeding in an analogous way as we did above, we can show the following.

Lemma 4 ***'export and die' equilibrium dynamics with FDI*** *For each of the four initial industrial structures we consider, the 'trade liberalization' policy gives rise to an 'export and die' equilibrium dynamics. Since welfare is independent of $\beta_L(0)$, we can contrast welfare results between the case of local ownership and that of FDI in the following way.*

	$\rho = 0.1$		$\rho = 0.05$	
	$u = 0.3$	$u = 0.8$	$u = 0.3$	$u = 0.8$
Local ownership	*6.6699*	*2.1768*	*24.5405*	*7.4534*
FDI	*6.5156*	*3.4353*	*26.7742*	*15.9878*

It is clear that, except for the case in which very few firms close and the consumer is impatient, the 'trade liberalization' policy does better under FDI than under local ownership, the reason being that FDI-firms are better insulated from the negative externality imposed by closing firms.

Lemma 5 ***'survive and survive' equilibrium dynamics with FDI*** *The 'temporary protection' policy cannot be dynamically implemented when* $u = 0.3$ *and* $\beta_L(0) = 0.3$. *In all other cases, it gives rise to a 'survive and survive' equilibrium dynamics. The following table contrasts this policy's welfare results between the case of local ownership (*U_{LO}*) and that of FDI (*U_{FDI}*).*

ρ	*0.1*			*0.05*		
u	*0.3*	*0.8*	*0.8*	*0.3*	*0.8*	*0.8*
$\beta_L(0)$	*0.8*	*0.3*	*0.8*	*0.8*	*0.3*	*0.8*
U_{LO}	*9.0622*	*1.6669*	*6.7803*	*32.3184*	*19.2064*	*29.1744*
U_{FDI}	*6.3614*	*-1.1445*	*6.2210*	*28.4037*	*15.7511*	*28.2699*

One can see that the 'temporary protection' policy performs better under local ownership than under FDI, due to the fact that FDI-firms' profits go abroad, whereas those of locally owned firms remain in the country. Of course, this comparison, by taking u as given, ignores the potential role of FDI in moving u downwards. While we admit that this is a relevant aspect, its analysis is beyond the scope of the present work and remains for future research. Taking u as given, the two previous Lemmas allow us to compare from a welfare point of view the 'temporary protection' policy with the 'trade liberalization' one. Since when $u = 0.3$ and $\beta_L(0) = 0.3$ the former policy cannot be dynamically implemented, we will limit our comparison to the other cases.

Proposition 3 *Consider an economy in which 'good' firms are the result of FDI and both the 'temporary protection' policy and the 'trade liberalization' one can be dynamically implemented.*

- *If the quality gap of backward sectors is not too high (*$\beta_L(0) = 0.8$*), then the preferability of one policy over the other one depends upon both the degree of impatience and the industrial structure:*
  - *if either the representative consumer is patient enough (*$\rho = 0.05$*) or there are sufficiently many backward local firms (*$u = 0.8$*), then the 'temporary protection' policy is more efficient than the 'trade liberalization' one;*
  - *but if there are few local firms that can gain from protection (*$u = 0.3$*) and the representative consumer is impatient (*$\rho = 0.1$*), then the reverse is true, because the short run costs imposed by temporary protection on 'good' firms are higher than its long run benefits.*
- *If the quality gap of backward sectors is high (*$\beta_L(0) = 0.3$*) and, additionally, there are many such sectors (*$u = 0.8$*), then, independently of the degree of impatience (i.e., both with* $\rho = 0.05$ *and with* $\rho = 0.1$*), the 'trade liberalization' policy is more efficient than the 'temporary protection' one.*

5.2 Import substitution and export promotion

We now consider the more sophisticated policy, which lets all firms survive, but at at the same time promotes exports whenever possible, fixing the tariff in order to maximize consumption.

Lemma 6 ***'export or survive' equilibrium dynamics with FDI*** *For each of the four initial industrial structures we consider, the 'import substitution and export promotion' policy gives rise to an 'export or survive' equilibrium dynamics. The following table contrasts this policy's welfare results between the case of local ownership (U_{LO}) and that of FDI (U_{FDI}), when such comparison is possible, i.e., except for the case of $u = 0.3$ and $\beta_L(0) = 0.3$*[34].

ρ	0.1			0.05		
u	0.3	0.8	0.8	0.3	0.8	0.8
$\beta_L(0)$	0.8	0.3	0.8	0.8	0.3	0.8
U_{LO}	9.0622	1.6802	6.7815	32.3184	19.2238	29.1756
U_{FDI}	6.9529	-0.3236	6.4959	29.3911	16.9482	28.6318

Again because FDI-firms' profits go abroad, whereas those of locally owned firms remain in the country, the 'import substitution and export promotion' policy performs better under local ownership than under FDI. This just confirms the intuition already gained above. Welfare results and convergence patterns are once again similar to those yielded by the 'temporary protection' policy. What is interesting to notice is that, as we found in the case of local ownership, the result that in several cases the tariff dynamics is not monotonic still holds in the case of FDI.

This implies that Proposition 2 still holds in this case.

6 Conclusion

The relationship between trade policy and production is complicated and depends on multiple factors. We emphasize that changes in trade policy may lead to changes in industrial structure, which in turn call for subsequent changes in trade policy, and we develop a model that studies this dialectic relation between trade policy and industrial structure dynamics. Our analysis goes beyond polar contrapositions of 'free trade' and 'autarky' to investigate optimal dynamic paths of trade protection. In particular, we point out that optimal trade policy depends on two main aspects of an economy's industrial structure: on side, the depth and cross-sectoral distribution of its quality gap from most advanced economies; on the other side, its ownership structure. Moreover, since, under certain conditions, trade liberalization may have short run benefits but long

[34] When $u = 0.3$ and $\beta_L(0) = 0.3$, welfare is $U = 2.7205$ if $\rho = 0.1$ and $U = 23.4630$ if $\rho = 0.05$.

rung costs, the degree of impatience turns out to play an important role for the design of optimal trade policy.

Such costs and benefits depend on the fact that trade liberalization may have two contrasting effects: on one side, it allows to substitute imported goods of higher quality for locally produced ones of lower quality, and it therefore increases efficiency; on the other side, this same substitution process, which implies the closure of some backward local firms, may have negative dynamic effects not only on the development possibilities of the corresponding sectors, but also on those of interconnected sectors, provided that the latter ones are better able to learn from local interaction than from abroad (as evidence seems to show). Horizontal and vertical characteristics of the industrial structure determine how many sectors would be forced to close by trade liberalization and what costs (in terms of both resources and time) should be paid to let these sectors survive and develop.

The reason why ownership matters is that branches of multinational corporations differ from local firms in at least two respects. First, they are better able to learn from their headquarters, and are therefore less influenced by local network interaction (which often involves lower quality firms). Second, a significant part of their profits goes abroad (in our model, for simplicity, all of them). The first aspect makes trade liberalization more attractive under FDI than under local ownership. The second one implies that, ceteris paribus (i.e., with the same horizontal and vertical characteristics of the industrial structure), local ownership would be preferable to FDI, but what is interesting in this respect is that FDI change the industrial structure and that they are endogenously determined by the combination of fiscal, industrial and trade policy: the analysis of such aspects is in our future research agenda.

In our framework optimal trade protection, if positive at all, is always temporary, but it can be significantly high in certain periods and, even more interestingly, optimal tariffs need not follow a monotonic time path. This means that an economy may optimally start with a high protection, then gradually remove it, subsequently rise it again and eventually open up. These changes correspond to different phases of its economic development, which we discuss in terms of catch up with the frontier, of import-export patterns and of growth of domestic demand[35].

Our results have been obtained focusing on two main engines of economic development and catch up with the frontier: network interaction among local firms and concavity of learning curves as functions of own quality. In other words, after paying a fixed innovation cost firms learn to improve their quality from other firms and from their own quality, with decreasing returns to the latter. While these factors are well supported by empirical evidence, many other factors could play an important role and would be worth a deeper investigation.

[35]An historical analysis of England's trade policy shows a similar policy pattern, but England first approached the technological frontier, then fell behind it and finally came back close to it, whereas we derive a non-monotonic optimal policy even along a monotonic path of catch up with the frontier, and this is due to the changes in equilibrium exports and domestic demand.

This remains for future research. We limit ourselves here to point out some extensions that could be achieved with minor changes from our framework.

The first, obvious change, would be to endogenize the fixed cost, allowing firms to optimally choose the amount of resources they want to develop to R&D. We do not do that because our present interest is not in a firm's individual optimization problem, but rather on the aggregate interaction between industrial structure dynamics and optimal trade policy. For this reason, and as a first approximation, it is much more convenient to study a simple quality dynamics, rather than to make firms solve a complicated discontinuous dynamic optimization problem[36]. Of course, we are well aware of the fact that firm profitability is essential to determine effort of learning and innovating, so that this effort is indeed endogenous: this is a basic ingredient of endogenous growth models (for instance, Aghion and Howit 1999). Moreover, firm profitability is the main mechanism driving improvements in production in an incipient literature on the relationship between trade liberalization and economic development (Aghion, Burgess, Reading and Zilibotti, 2003, Gancia 2003). This paper provides a complementary framework shedding light on the external effects of learning.

While it seems reasonable to study the trade policy of a catch up economy modelling it as a small open economy, the two assumptions that the rest of the world fixes the same tariff as our economy and that this tariff if the same for each sector could be interestingly slackened, for instance allowing for a fixed world tariff and for sectorally differentiated local tariffs, which correspond to actual practices of most countries.

Further, while we did not emphasize the possibility of specialization in production of goods where our economy has a comparative advantage, a result that is indeed possible in our model, but which is not the focus of our investigation at the present stage, it would not be too difficult to introduce an agricultural sector or a non-tradables sector and to study their interplay with the elements we discussed here to determine optimal trade policy.

Moreover, patience in our model might reflect, in a broader sense, the degree of consensus that protectionism is able to generate. This could be a relevant factor in explaining the differences between successful protectionism in South-Eastern Asia and failed protectionism in Latin-America. Our results on the relevance of patience for optimal policy suggest that this is an interesting line of research, but a deeper analysis of the issue would require a political economy model of consensus formation.

Finally, our results also suggest possible complementarities between trade and industrial policies. On one side, when industrial policy is oriented to enhance information circulation, production quality improves faster and protection duration becomes shorter. On the other side, an industrial policy aimed at attracting FDI might alter the cross-sectional distribution of the quality gap. In our study, although comparing four possible initial configurations of such cross-sectional distribution, we always considered it as exogenous, but it would be

[36] They already solve a discontinuous static problem deciding each period upon prices and exports

interesting to let it vary endogenously in response to the combination of trade and industrial policy.

Appendix A

We derive here demand and prices, omitting the time index for simplicity.

Demand

The representative consumer demands the quantity of consumption good

$$y^d(1) = \frac{E}{p(1)}. \tag{8}$$

The producer of intermediate good $m \in [0, 1)$ receives a local demand $x(m)$ and a foreign demand $x^*(m)$, so that the total demand she receives is

$$y^d(m) = x(m) + x^*(m), \tag{9}$$

where

$$x^*(m) = \begin{cases} \infty & , \quad \text{if } p(m) < p_L(m) \\ \max\{0, \bar{y}(m) - x(m)\} & , \quad \text{if } p(m) = p_L(m) \\ 0 & , \quad \text{if } p(m) > p_L(m) \end{cases} \tag{10}$$

and

$$x(m) = \begin{cases} p(m)^{-\sigma} \left[v(m)P\right]^{\sigma-1} y(1) & , \quad \text{if } p(m) \leq p_H(m) \\ 0 & , \quad \text{if } p(m) > p_H(m) \end{cases} \tag{11}$$

While equation (10) just follows from our assumptions, equation (11) is obtained from cost minimization given the technology described in (2) and (3). The term P that appears in (11) is a price index corresponding to the marginal cost of production of good 1 and is determined taking into account the fact that prices must be weighted by quality and that there is the possibility to import intermediate goods:

$$P = \left\{ \int_0^1 \left[\frac{p^F(m)}{v^F(m)} \right]^{1-\sigma} \mathrm{d}m \right\}^{\frac{1}{1-\sigma}}, \tag{12}$$

where

$$p^F(m) = \begin{cases} p(m) & , \quad \text{if } p(m) \leq p_H(m) \\ p(m^*)(1+\tau)(1+a) & , \quad \text{if } p(m) > p_H(m) \end{cases} \tag{13}$$

and

$$v^F(m) = \begin{cases} v(m) & , \quad \text{if } p(m) \leq p_H(m) \\ v(m^*) & , \quad \text{if } p(m) > p_H(m) \end{cases}. \tag{14}$$

Merging the previous equations yields total demand for good m:

$$y^d(m) = \begin{cases} \infty & , \quad \text{if } p(m) < p_L(m) \\ \max\{\bar{y}(m), x(m)\} & , \quad \text{if } p(m) = p_L(m) \\ x(m) & , \quad \text{if } p(m) \in (p_L(m), p_H(m)] \\ 0 & , \quad \text{if } p(m) > p_H(m) \end{cases} \tag{15}$$

Finally, recalling that N is the set of locally active intermediate good producers, the overall demand for labor is

$$L^d = \int_N [y(m) + f]\mathrm{d}m. \tag{16}$$

We can now solve the firms' profit maximization problem and thus determine prices.

Prices

The final good producer operates in a perfectly competitive market and thus sells its product at its marginal cost:

$$p(1) = P. \tag{17}$$

Intermediate goods producers are monopolists facing a discontinuous demand function and a capacity constraint due to total labor supply. This implies that they establish their price by way of comparison among the results of profit maximization in each of the price regions where the profit function is continuous. Letting w be the wage rate, if firm m were able to match demand at any price, its profits would simply be

$$\pi(m) = [p(m) - w]y^d(m) - wf. \tag{18}$$

Observe first that, if there were no capacity constraint and demand $y^d(m)$ were continuous and with elasticity σ, firm m would price according to the markup rule

$$p_M = \frac{\sigma}{\sigma - 1} w. \tag{19}$$

In such case, and more generally in any price range where the capacity constraint is not binding and $y^d(m)$ is differentiable and has elasticity σ, we have

$$\frac{\partial \pi(m)}{\partial p(m)} > 0 \Leftrightarrow p_M > p(m). \tag{20}$$

Now, consider first the range $p(m) < p_L(m)$. At any such price, firm m faces an infinite demand. If the wage is low enough, i.e., if $w < p_L(m)$, and if its production is high enough, i.e., if $y(m) > \frac{wf}{(p(m)-w)}$, at any price $p(m) \in (w, p_L(m))$ it makes positive profits. When this is the case, it is optimal to fix a price as close as possible to $p_L(m)$, but, given the discontinuity in $y^d(m)$, there is no profit-maximizing price in this range. Moreover, since profits are increasing in production $y(m)$, firm m has an incentive to offer a wage slightly above w in order to attract as many workers as possible, but even if the entire population were working for firm m, it would not be able to produce more than $y(m) = 1 - f$, so that in the price range $(0, p_L(m))$ profits have an upper-bound of $\bar{\pi}(m) = (p_L(m) - w)(1 - f) - wf$.

Observe further that $y^d(m) = 0$ for $p(m) > p_H(m)$: in such price range, due to the fixed cost, profits would be negative and the monopolist would prefer to shut down (the fixed cost is not a sunk cost).

Finally, consider the range $[p_L(m), p_H(m)]$. For $p(m) = p_L(m)$, we have that $y^d(m) = \max\{\bar{y}(m), x(m)\}$. Remembering the expression for $x(m)$, we have that $\bar{y}(m) > x(m|p_L(m)) \Leftrightarrow \tilde{p}(m) < p_L(m)$, where $\tilde{p}(m)$ is the threshold price

$$\tilde{p}(m) \equiv \left\{ \frac{[v(m)P]^{\sigma-1} y(1)}{\bar{y}(m)} \right\}^{\frac{1}{\sigma}} \tag{21}$$

and $x(m|p_L(m))$ denotes local demand of good m when its price is $p_L(m)$. In this price range, firm $m \in [0, 1)$ therefore solves the problem

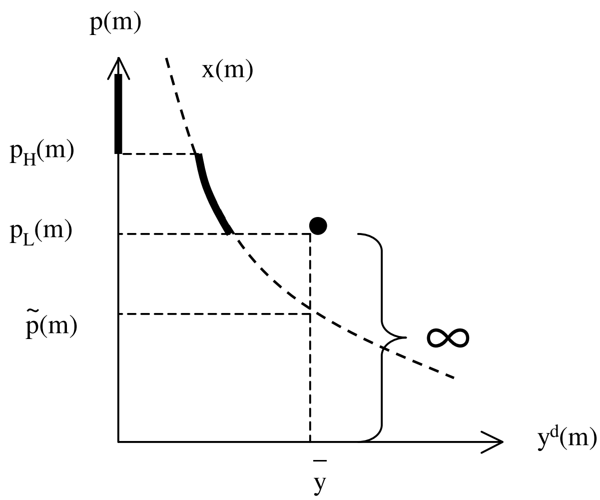
$$\max_{[p_L(m), p_H(m)]} \pi(m), \tag{22}$$

taking as given all the variables that are determined in equilibrium, and in particular the wage rate w, the set N of active firms and foreign demand at $p_L(m)$, as determined by equilibrium production $\bar{y}(m)$. Denote by $\hat{\pi}(m)$ the solution to this problem. If $\max\{\hat{\pi}(m), \bar{\pi}(m)\} < 0$, the firm shuts down; if $\max\{\hat{\pi}(m), \bar{\pi}(m)\} = 0$, it is indifferent between producing at the corresponding price and shutting down; if $\max\{\hat{\pi}(m), \bar{\pi}(m)\} > 0$ and $\hat{\pi}(m) \geq \bar{\pi}(m)$, it sets the price corresponding to $\hat{\pi}(m)$; if $\max\{\hat{\pi}(m), \bar{\pi}(m)\} > 0$ and $\hat{\pi}(m) < \bar{\pi}(m)$, there is no profit maximizing price.

We may now distinguish two basic cases, according to whether a firm receives a positive or a zero foreign demand if it prices at $p_L(m)$. Formally,

- $\tilde{p}(m) < p_L(m)$: in this case we have $\bar{y}(m) > x(m|p_L(m))$;
- $\tilde{p}(m) \geq p_L(m)$: in this case we have $\bar{y}(m) \leq x(m|p_L(m))$.

Case with possible export: $\tilde{p}(m) < p_L(m)$



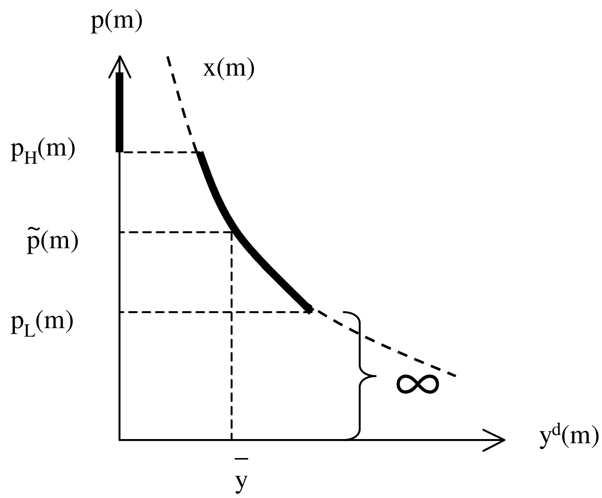
In this case it is easy to show that, conditional upon $\max\{\hat{\pi}(m), \bar{\pi}(m)\} = \hat{\pi}(m) \geq 0$, firm m chooses its price as follows:

$$p(m) = \underset{[p_L(m), p_H(m)]}{\text{argmax}} \; \pi(m) =$$

$$= \begin{cases} p_L(m) & , \quad \text{if } p_M \leq p_L(m) \\ p_M & , \quad \text{if } p_M \in (p_L(m), p_H(m)] \text{ and } \pi(m|p_M) > \pi(m|p_L(m)) \\ p_L(m) & , \quad \text{if } p_M \in (p_L(m), p_H(m)] \text{ and } \pi(m|p_M) \leq \pi(m|p_L(m)) \\ p_H(m) & , \quad \text{if } p_M > p_H(m) \text{ and } \pi(m|p_H(m)) > \pi(m|p_L(m)) \\ p_L(m) & , \quad \text{if } p_M > p_H(m) \text{ and } \pi(m|p_H(m)) \leq \pi(m|p_L(m)) \end{cases} \quad (23)$$

The reason is that, when $p_M < p_L(m)$, in the range $[p_L(m), p_H(m)]$ the firm would choose $p_L(m)$ even if it could only sell locally, so that a fortiori $p_L(m)$ is chosen if there is the possibility to export at that price. When $p_M \in (p_L(m), p_H(m)]$, we may have either $\pi(m|p_M) > \pi(m|p_L(m))$ or $\pi(m|p_M) \leq \pi(m|p_L(m))$, so one needs to check which condition is realized in equilibrium. Finally, when $p_M > p_H(m)$, we may have either $\pi(m|p_H(m)) > \pi(m|p_L(m))$ or $\pi(m|p_H(m)) \leq \pi(m|p_L(m))$ an again one needs to check this in equilibrium.

Case with no possible export: $\tilde{p}(m) \geq p_L(m)$



In this second case[37], there is no foreign demand for good m, so that, always conditional upon $\max\{\hat{\pi}(m), \bar{\pi}(m)\} = \hat{\pi}(m) \geq 0$, the chosen price is

$$p(m) = \underset{[p_L(m), p_H(m)]}{\text{argmax}} \ \pi(m) = \begin{cases} p_L(m) & , \quad \text{if } p_M \leq p_L(m) \\ p_M & , \quad \text{if } p_M \in (p_L(m), p_H(m)] \\ p_H(m) & , \quad \text{if } p_M > p_H(m) \end{cases} \tag{24}$$

Appendix B

Lemma 7 ***(existence of 'export and die' equilibria)*** *For some parameter values there exist equilibria such that only high quality firms are active and even export, whereas low quality firms stay closed and the corresponding goods are imported. In such equilibria the wage, within a certain range, is undetermined, but the consumption level, which is independent of it, is well determined at*

$$c = \frac{\beta_H p^*[1 - f(1-u)]}{P[(1+\tau)(1+a)] - u\tau(1+a)[(1+\tau)(1+a)]^{1-\sigma} P^{\sigma-1}}, \quad \text{where} \tag{25}$$

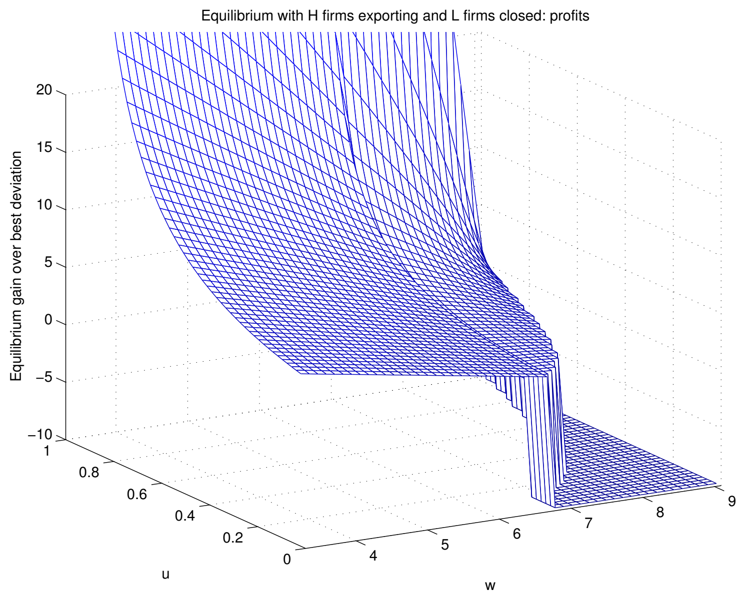
$$P = \left\{u[(1+\tau)(1+a)]^{1-\sigma} + (1-u)[(1+\tau)(1+a)]^{\sigma-1}\right\}^{\frac{1}{1-\sigma}}. \tag{26}$$

Proof of Lemma 7. The expression for P results from the fact that the first u goods are imported and the second $1-u$ ones are produced at $p_L(H)$. Since in equilibrium only 'good' firms are active, their equilibrium production

[37]The figure depicts the case in which $\tilde{p}(m) \in [p_L(m), p_H(m)]$, but the same price choice would hold if $\tilde{p}(m) > p_H(m)$.

is $\bar{y}(H) = \frac{1}{1-u} - f$ and their local demand is $x(H) = \frac{[(1+a)(1+\tau)]^{\sigma}}{\beta_H p^*} P^{\sigma-1} y(1)$. A necessary condition for them to export is $\bar{y}(H) > x(H)$. Another necessary condition for them to produce and sell at $p_L(H)$ is to make non-negative profits, and since $\pi(H) = p_L(H)\bar{y}(H) - \frac{w}{1-u}$, this condition imposes an upper bound on the wage: $w \leq p_L(H)[1 - f(1-u)]$. A lower bound on the wage is imposed by the condition that, if 'bad' firms were to produce at the given wage rate, they would make negative profits whatever price they may set, so that they indeed prefer to stay closed. Total demand for imports by the final good producer is $M = u\,[p^*(1+\tau)(1+a)]^{-\sigma}\,(v^*P)^{\sigma-1}\,y(1)$. Imports generate a tariff revenue of $T = \tau p^*(1+a)M$, which goes to the state and is then redistributed to the representative consumer, so that her income is $E = W + \Pi + T = p_L(H)[1-f(1-u)] + \tau p^*(1+a)M$. Notice that E is independent of the w and so is therefore $y(1) = \frac{E}{P} = \frac{\beta_H p^*[1-f(1-u)]}{P[(1+\tau)(1+a)] - u\tau(1+a)[(1+\tau)(1+a)]^{1-\sigma}P^{\sigma-1}}$. Substituting this expression allows to write all equilibrium quantities as functions of the parameters only. To check that this is indeed an equilibrium we still have to make sure that no intermediate firm is willing to deviate from its equilibrium choice. As far as high quality firms are concerned, notice first that there are no profitable deviations below $p_L(H)$, because, when $\pi(H|p_L(H)) \geq 0$, we also have $\pi(H|p_L(H)) \geq \bar{\pi}(H)$, so that the condition $\hat{\pi}(H) \geq \bar{\pi}(H)$ is satisfied. Now, if $p_M \leq p_L(H)$, we are sure that there is no profitable deviation; if $p_M \in (p_L(H), p_H(H)]$, the best possible deviation is to price at p_M; if $p_M > p_H(H)$, the best deviation is to price at $p_H(H)$. As far as low quality firms are concerned, if $p_M \leq p_L(L)$, their best deviation is to produce and sell at $p_L(L)$; if $p_M \in (p_L(L), p_H(L)]$, it is to produce and sell at p_M; if $p_M > p_H(L)$, it is to produce and sell at $p_H(L)$. The requirement that there are no profitable deviations for any firm imposes further restrictions on w as a function of the parameters, which can be checked numerically. In the following figure we draw the difference between 'good' firms' equilibrium profits and their profits from best deviation as a function of $u \in [0,1]$ and $w \in [p_H(L), p_L(H)]$. We highlight the region where there is a profitable deviation (that is, where the candidate equilibrium is not an equilibrium) by assigning to it a value of -10. The figure is drawn for the following parameter constellation: $a = 0.1,\ \beta_L = 0.3,\ \beta_H = 1,\ \sigma = 4,\ \tau = 0,\ f = 0.1,\ p^* = 10$[38].

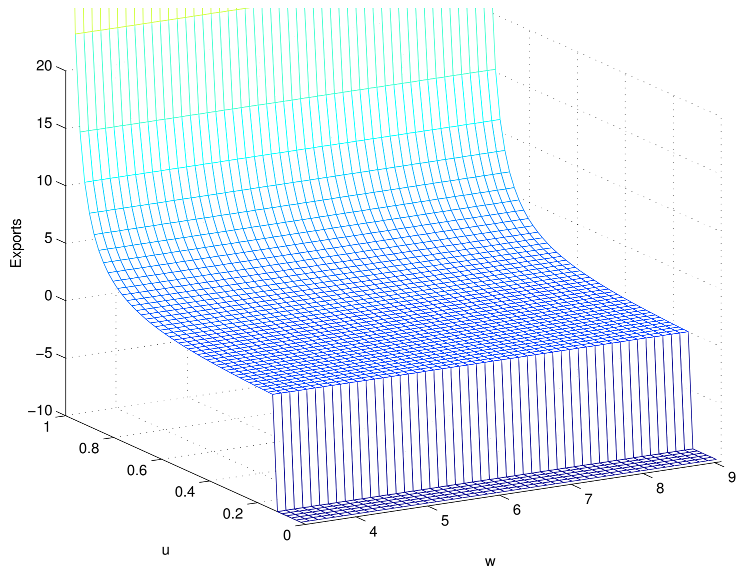
[38] Observe that, for graphical convenience, we focus on $w \geq p_H(L)$, which, given the parameters chosen, implies the optimality of 'bad' firms' decision to stay closed. The analysis can be easily extended to show that there is no equilibrium when the wage rate is too low.



Where the equilibrium strategy is optimal, its advantage over the best deviation is slightly decreasing in w and sharply increasing in u. This is due to the fact that a measure u of firms are closed in equilibrium and the available labor is distributed among the open ones, so that the higher u, the higher $\bar{y}(H)$ and the more open firms can gain from increasing returns.

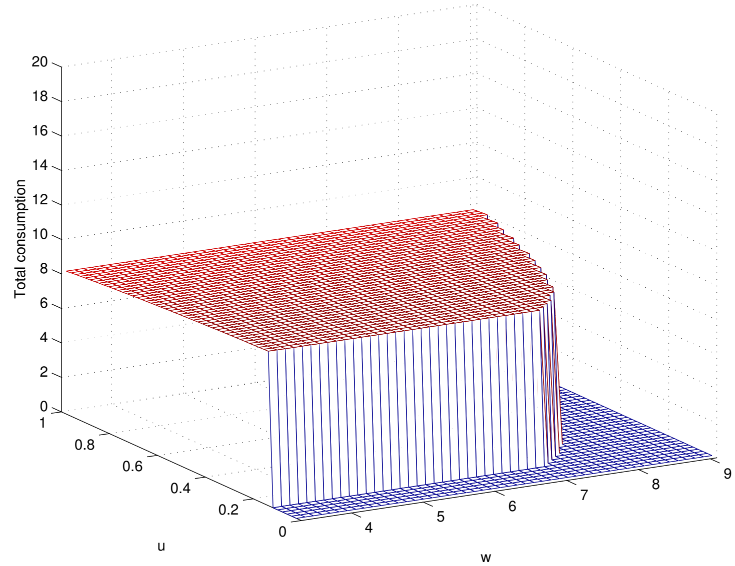
The next figure depicts exports, where they are positive, as a function of u and w, for the same parameter constellation. It highlights where the condition of positive exports is met by assigning a value of -10 to the area where it is not met. One sees that exports are positive except for very low values of u and that they are increasing in u.

Equilibrium with H firms exporting and L firms closed: exports

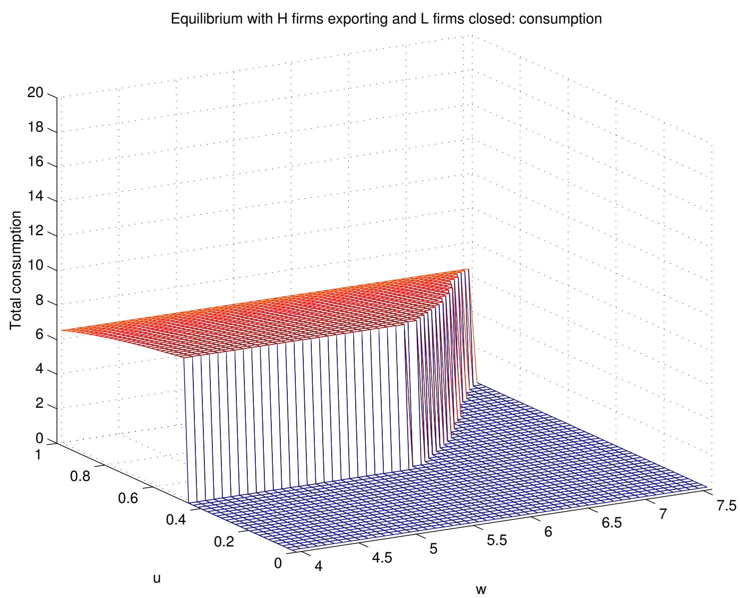


The next figure represents total consumption in the same spirit, with the convention of assigning a value of 0 where either of the previous equilibrium conditions fails to be met. In other words, the positive surface depicts equilibrium consumption for those combinations of u and w for which, given the other parameters, the candidate equilibrium is indeed an equilibrium. As noticed above, equilibrium consumption is independent of w, but we also see that it is insensitive to u. ■

Equilibrium with H firms exporting and L firms closed: consumption



Comparative statics for 'export and die' equilibria. If we start from this basic parametrization, we can make some exercises of comparative statics. An increase in β_L does not change equilibrium consumption, but it shrinks the wage range for which this equilibrium exists; a reduction in β_H reduces both equilibrium consumption and equilibrium wages; an increase in τ renders this equilibrium possible only for those economies where u is high enough and it has the effect of decreasing equilibrium consumption and of shrinking the range of admissible equilibrium wages (moreover, it renders consumption slightly decreasing in u). The next figure shows equilibrium consumption when $\tau = 0.2$ and all other parameters are unchanged.



Finally, a reduction of the transport cost a increases consumption and extends the range of admissible u; a reduction of the fixed cost f has negligible effects; a reduction in p^* sharply reduces consumption, since in equilibrium it amounts to a quality reduction of both imported goods and of locally produced goods; an increase of σ reduces the range of admissible u and sharpens very much the effect of a tariff. When the quality gap between 'bad' and 'good' local firms is lower, for instance for $\beta_L = 0.6$ and $\beta_H = 0.7$, there still exists a continuum of 'export and die' equilibria, provided that u is high enough, but the range of equilibrium wages shrinks and even disappears if we introduce a tariff protection of $\tau = 0.1$.

Lemma 8 ***(existence of 'export and survive' equilibria)*** *For some parameter values there exist equilibria such that high quality firms serve both the local and the international markets, whereas low quality firms are only active* *on the local market. Depending on the parameters and on the wage rate, such equilibria may be distinguished in three cases:*

- *if $p_M \leq p_L(L)$, low quality firms price at $p_L(L)$ and the consumption level is the following function of the wage rate:*

$$c = \frac{w(1-f)}{\frac{1}{(1+\tau)(1+a))} + w\left[\frac{u}{p_L(L)} + \frac{1-u}{p_L(H)}\right] - 1}; \tag{27}$$

- *if $p_M \in (p_L(L), p_H(L)]$, low quality firms price at p_M and the consumption level is the following function of the wage rate:*

$$c = \frac{p_L(H)(1-f)}{P + u[p_L(H) - p_M]p_M^{-\sigma}(\beta_L v^* P)^{\sigma-1}}, \quad \text{where} \tag{28}$$

$$P = \left\{u\left[\frac{p_M}{\beta_L v^*}\right]^{1-\sigma} + (1-u)[(1+\tau)(1+a)]^{\sigma-1}\right\}^{\frac{1}{1-\sigma}}; \tag{29}$$

- *if $p_M > p_H(L)$, low quality firms price at $p_H(L)$ and the consumption level, independently of the wage rate, is*

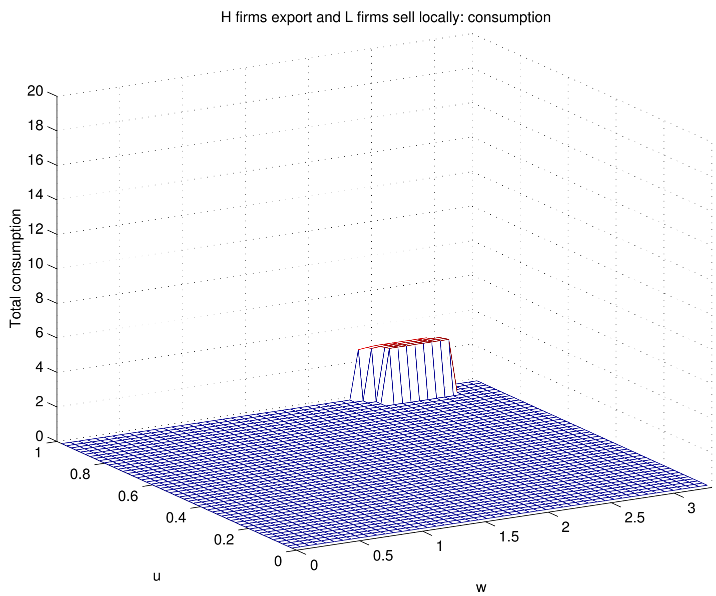
$$c = \frac{p_L(H)(1-f)}{P + u[p_L(H) - p_H(L)]p_H(L)^{-\sigma}(\beta_L v^* P)^{\sigma-1}}, \quad \text{where} \tag{30}$$

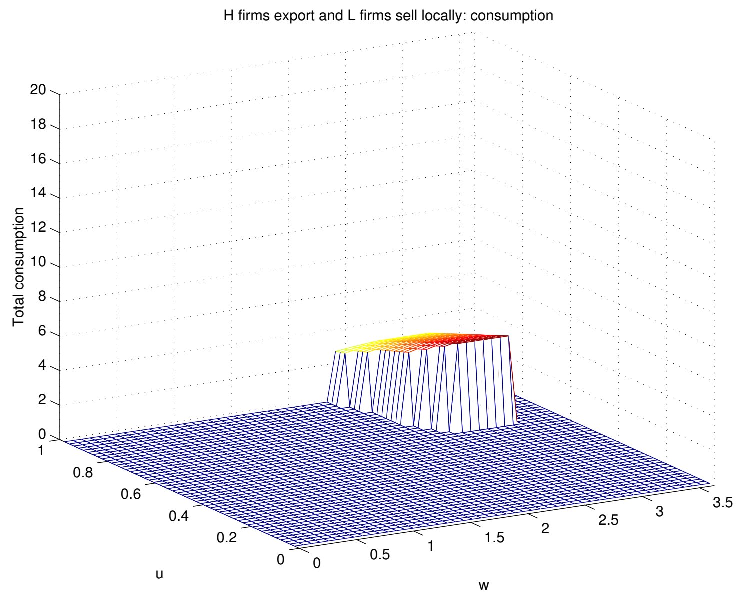
$$P = \left\{u[(1+\tau)(1+a)]^{1-\sigma} + (1-u)[(1+\tau)(1+a)]^{\sigma-1}\right\}^{\frac{1}{1-\sigma}}. \tag{31}$$

Proof of Lemma 8. In order to export, high quality firms set their price at $p_L(H)$. Equilibrium in the intermediate good markets served by low quality firms requires $p(L) = \tilde{p}(L)$, i.e., $\bar{y}(L) = x(L|p(L))$. Given that the price choice must be optimal, we have the three possible cases distinguished above. In the case of very low wages, i.e., when $p_M \leq p_L(L)$, the only optimal price for 'bad' firms is $p_L(L)$, so it must be the case that $p(L) = \tilde{p}(L) = p_L(L)$ and therefore $P = \frac{1}{(1+\tau)(1+a)}$. For intermediate wages, i.e., when $p_M \in (p_L(L), p_H(L)]$, it must be $p(L) = \tilde{p}(L) = p_M$ and so $P = \left\{u[\frac{p_M}{\beta_L v^*}]^{1-\sigma} + (1-u)[(1+\tau)(1+a)]^{\sigma-1}\right\}^{\frac{1}{1-\sigma}}$. For higher wages, i.e., when $p_M > p_H(L)$, it must be $p(L) = \tilde{p}(L) = p_H(L)$ and therefore $P = \left\{u[(1+\tau)(1+a)]^{1-\sigma} + (1-u)[(1+\tau)(1+a)]^{\sigma-1}\right\}^{\frac{1}{1-\sigma}}$. An upper bound to wages is posed by the condition that 'bad' firms must be able to survive and 'good' ones must be able to sell at $p_L(H)$, both making non-negative profits.

In all cases, labor market equilibrium requires $\bar{y}(H) = \frac{1-f-u\bar{y}(L)}{1-u}$. Local demand for high quality firms is $x(H|p_L(H)) = p_L(H)^{-\sigma}(\beta_H v^* P)^{\sigma-1}y(1)$ and their export is $\bar{y}(H) - x(H|p_L(H))$. Profits are calculated in the usual way and aggregate income is $E = w + u\pi(L) + (1-u)\pi(H)$. Equilibrium in the final good market requires $\frac{E}{P} = y(1)$, which, solving for $y(1)$, yields the above expressions for consumption in each case.

These calculations allow to determine a candidate equilibrium, but for it to be indeed an equilibrium, the following conditions have to be satisfied: first, that there is no profitable deviation for any firm, second, that exports are indeed positive. The next two graphs, drawn for the usual parametrization $a = 0.1,\ \beta_L = 0.3,\ \beta_H = 1,\ \sigma = 4,\ f = 0.1,\ p^* = 10$, show total consumption as a function of u and $w \in [0, p_H(L)]$, in the area where all equilibrium conditions are met, when trade tariffs are respectively $\tau = 0$ and $\tau = 0.1$. ■





Comparative statics for 'export and survive' equilibria. One can see that this kind of equilibrium exists only for an intermediate range of wages and when the fraction of 'good' firms that export is small. The reason is that only when there are few 'good' firms they are able to export, and that for high wages 'bad' firms cannot survive, whereas low wages offer some firm an incentive to deviate. A small tariff barrier on international trade widens the range of both u and w for which this equilibrium exists, but a high tariff would prevent 'good' firms from exporting. In this equilibrium, consumption appears to be a decreasing function of u. An 'export and survive' equilibrium (more precisely, a continuum of such equilibria for an intermediate range of w) tends to still exist when the quality gap between 'bad' and 'good' local firms is lower, for instance for $\beta_L = 0.6$ and $\beta_H = 0.7$, provided that u is high enough.

Lemma 9 ***(existence of 'survive and die' equilibria)*** *For some parameter values there exist equilibria such that high quality firms serve only the local market, whereas low quality firms stay closed. Depending on the parameters and on the wage rate, such equilibria may be distinguished in three cases:*

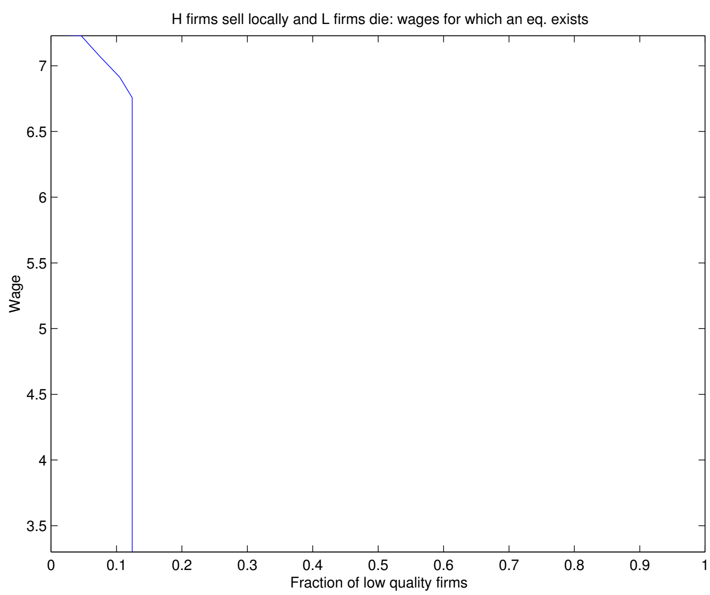
- *if* $p_M \leq p_L(H)$*, then* $p(H) = p_L(H)$*;*
- *if* $p_M \in (p_L(H), p_H(H)]$*, then* $p(H) = p_M$*;*
- *if* $p_M > p_H(H)$*, then* $p(H) = p_H(H)$*.*

The consumption level is given by

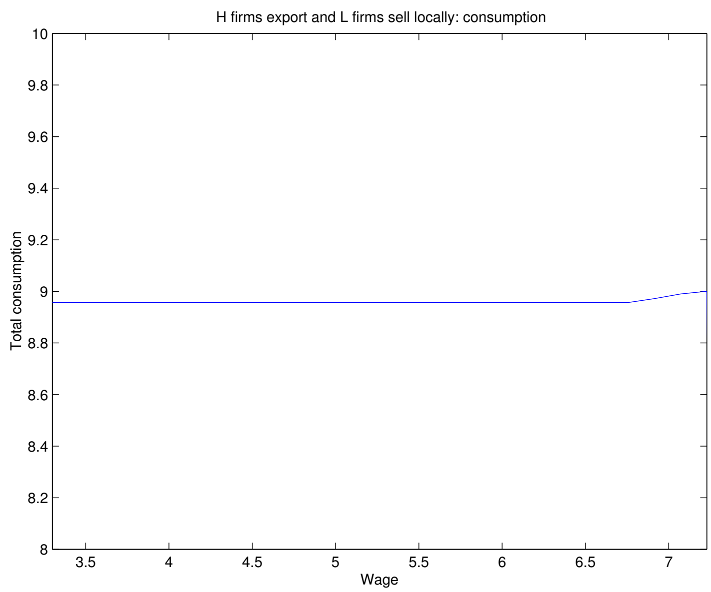
$$c = \frac{1-(1-u)f}{(1-u)p(H)^{-\sigma}(\beta_H v^* P)^{\sigma-1}}, \quad \text{where} \tag{32}$$

$$P = \left\{ u[(1+\tau)(1+a)]^{1-\sigma} + (1-u)\left[\frac{p(H)}{v(H)}\right]^{1-\sigma} \right\}^{\frac{1}{1-\sigma}}. \tag{33}$$

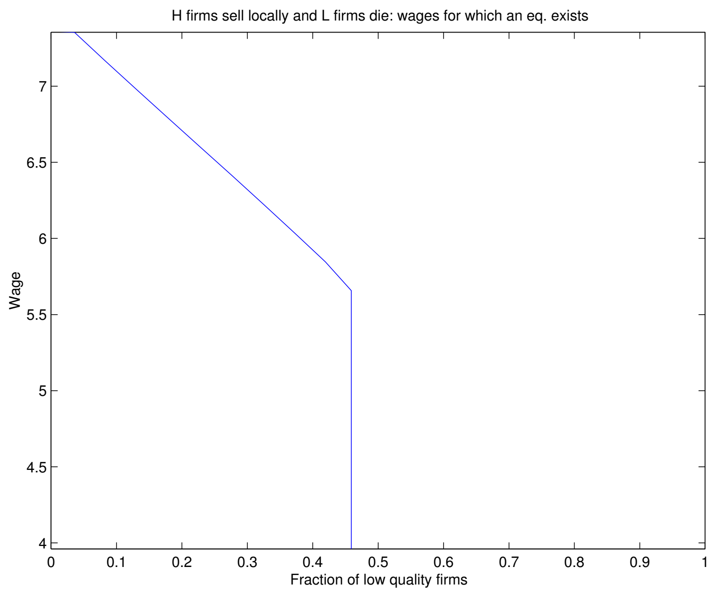
Proof of Lemma 9. If only high quality firms are active, labor market equilibrium requires that they produce the quantity $\bar{y}(H) = \frac{1}{1-u} - f$. Intermediate good markets equilibrium then requires $p(H) = \tilde{p}(H)$, and solving $\bar{y}(H) = x(H|p(H))$ yields the above expression for $y(1)$ as a function of $p(H)$. Depending on the wage, $p(H)$ is chosen as specified above, conditional upon making non-negative profits and upon $\hat{\pi}(H) \geq \bar{\pi}(H)$. The wage rate then must be such that the final good market clears, i.e., $y(1) = c = \frac{E}{P}$, where P is as specified above and E includes labor income, profits and import tariff revenue: $E = w + (1-u)\pi(H) + \tau(1+a)p^* M$, where $M = u[p^*(1+\tau)(1+a)]^{-\sigma}(v^* P)^{\sigma-1}y(1)$ denotes total imports. Since in this equilibrium low quality firms are closed, they must not find it profitable to start production whatever price they may set: if $p_M \leq p_L(L)$, their best deviation is to produce and sell at $p_L(L)$; if $p_M \in (p_L(L), p_H(L)]$, it is to produce and sell at p_M; if $p_M > p_H(L)$, it is to produce and sell at $p_H(L)$. The requirement that at such prices they do not make positive profits may or not be met by the wage that assures clearance of the final good market. As usual, we check numerically all equilibrium conditions. The next graph shows the wages for which an equilibrium exists as a function of u, starting from our basic parametrization, $a = 0.1,\ \beta_L = 0.3,\ \beta_H = 1,\ \sigma = 4,\ f = 0.1,\ p^* = 10$, for $\tau = 0$.

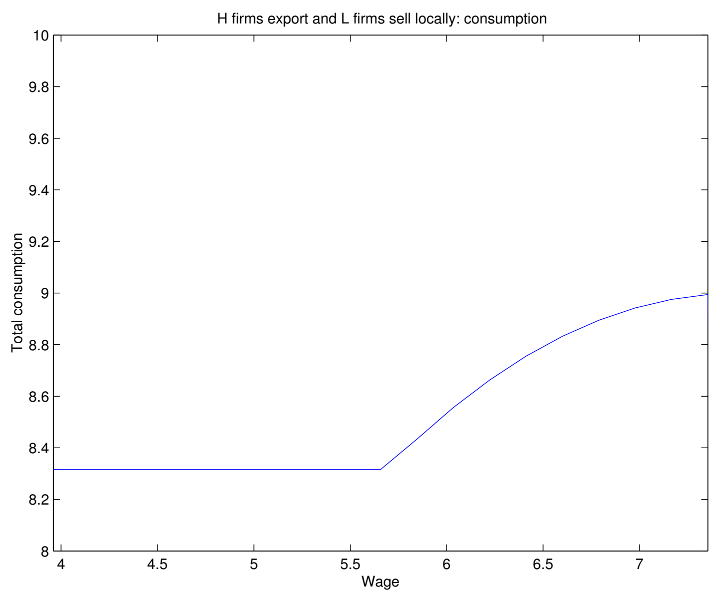


One sees that there is a value of u for which a continuum of equilibria exist (the vertical part of the curve). Such equilibria are characterized by the fact that $p_M \leq p_L(H)$ and therefore $p(H) = p_L(H)$: this implies that the consumption level is the same in each of these equilibria. The decreasing part of the curve corresponds to equilibria where $p_M \in (p_L(H), p_H(H)]$ and therefore $p(H) = p_M$, so that the consumption level depends on the wage. Notice, though, that in range of u corresponding to the downward sloping part of the curve the equilibrium is unique, in the sense that for every u there exists a unique equilibrium such that high quality firms serve only the local market and low quality firms stay closed. With this in mind, the next graph shows equilibrium consumption as a function of equilibrium wage. ■



Comparative statics for 'survive and die' equilibria. Observe that such an equilibrium exists only when the fraction of 'bad' firms is very low. Increasing tariff protection has the effect of widening the range of u for which such an equilibrium exists, but it also decreases equilibrium consumption. The next two graphs show what happens for the same parameters when $\tau = 0.2$.





When the quality gap between 'bad' and 'good' local firms is lower, for instance for $\beta_L = 0.6$ and $\beta_H = 0.7$, a 'survive and die' equilibrium tends not to exist, no matter the degree of tariff protection we choose.

Lemma 10 ***(existence of 'survive and survive' equilibria)*** *For some parameter values there exist equilibria such that both high quality and low quality* *firms are only active on the local market. In such equilibria the consumption level is*

$$c = \frac{1-f}{up(L)^{-\sigma}[\beta_L v^* P]^{\sigma-1} + (1-u)p(H)^{-\sigma}[\beta_H v^* P]^{\sigma-1}}, \quad \text{where} \tag{34}$$

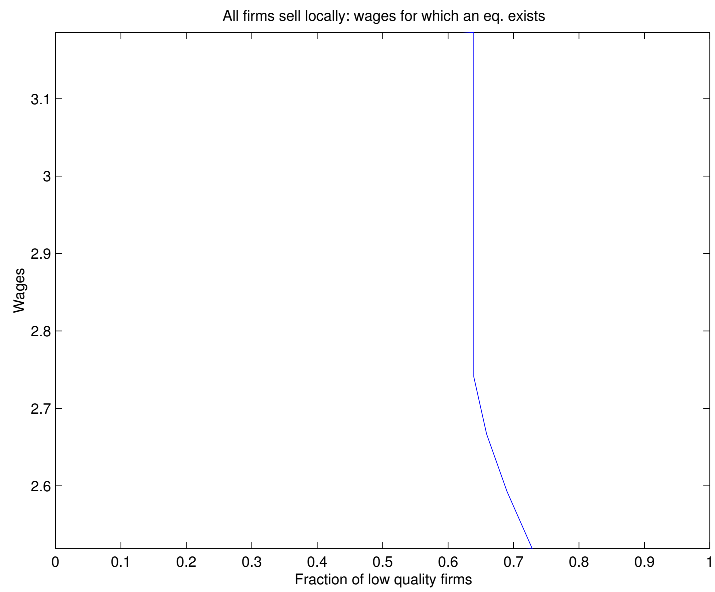
$$P = \left\{ u\left[\frac{p(L)}{v(L)}\right]^{1-\sigma} + (1-u)\left[\frac{p(H)}{v(H)}\right]^{1-\sigma} \right\}^{\frac{1}{1-\sigma}} \tag{35}$$

and prices depend on the parameters and on the wage rate in the following way:

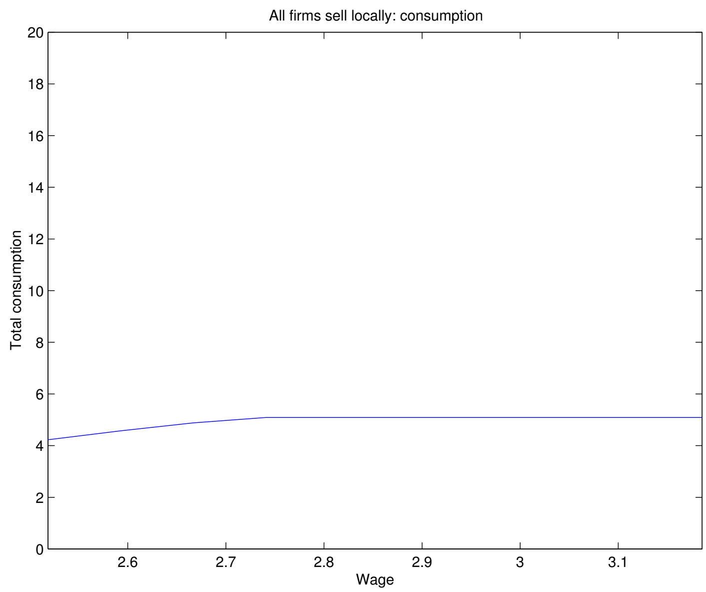
$$p(L) = \begin{cases} p_L(L) & , \quad \text{if } p_M \leq p_L(L) \\ p_M & , \quad \text{if } p_M \in (p_L(L), p_H(L)] \\ p_H(L) & , \quad \text{if } p_M > p_H(L) \end{cases}$$

$$p(H) = \begin{cases} p_L(H) & , \quad \text{if } p_M \leq p_L(H) \\ p_M & , \quad \text{if } p_M \in (p_L(H), p_H(H)] \\ p_H(H) & , \quad \text{if } p_M > p_H(H) \end{cases}$$

Proof of Lemma 10. If both 'bad' and 'good' firms just sell to the local market, equilibrium in the intermediate goods market requires that they price at $p(L) = \tilde{p}(L)$ and $p(H) = \tilde{p}(H)$. This means $\bar{y}(L) = x(L|p(L))$ and $\bar{y}(H) = x(H|p(H))$ and substituting the corresponding expressions for local demand into the condition for labor market equilibrium, which requires $\bar{y}(H) = \frac{1-f-u\bar{y}(L)}{1-u}$, yields the above expression for $y(1)$, which in equilibrium is equal to the consumption level. The several possible cases of price determination depend upon the fact that the prices that assure equilibrium on the intermediate good markets must also be optimal for the corresponding firms, and optimal prices depend on where p_M falls with respect to the various price thresholds. Substituting the appropriate prices yields the consumption level corresponding to a given wage in each candidate equilibrium. To check that this is indeed an equilibrium, though, one still has to verify that firms make non-negative profits, that $\forall m \in [0,1)$, $\hat{\pi}(m) \geq \bar{\pi}(m)$ and that the final good market is in equilibrium, i.e., that $y(1) = \frac{E}{P}$, where $E = w + u\pi(L) + (1-u)\pi(H)$. If we start from our basic parametrization, $a = 0.1$, $\beta_L = 0.3$, $\beta_H = 1$, $\sigma = 4$, $f = 0.1$, $p^* = 10$, numerical investigation of these conditions shows that no equilibrium exists for $\tau = 0$. For $\tau = 0.1$, the next graph shows the wages for which an equilibrium exists as a function of u.



One sees that there exists a value of u for which a continuum of equilibria exist (the vertical part of the curve). Such equilibria are characterized by the fact that $p_M \in (p_H(L), p_L(H)]$ and therefore $p(L) = p_H(L),\ p(H) = p_L(H)$: this implies that the consumption level is the same in each of these equilibria. The decreasing part of the curve corresponds to equilibria where $p_M \in (p_L(L), p_H(L)]$ and therefore $p(L) = p_M,\ p(H) = p_L(H)$, so that the consumption level depends on the wage. Notice, though, that in the range of u corresponding to the downward sloping part of the curve the equilibrium is unique, in the sense that for every u there exists a unique equilibrium such that all firms serve the local market only. With this in mind, the next graph shows equilibrium consumption as a function of equilibrium wage. ■



Comparative statics for 'survive and survive' equilibria. Raising trade tariffs has the effect of shifting to the right the range of u for which such an equilibrium exists and of diminishing equilibrium consumption, but does not change the qualitative analysis. If local firms become less heterogeneous, in the sense that the local quality gap narrows down, for instance with $\beta_L = 0.6$ and $\beta_H = 0.7$, for each $u \in (0.1, 0.9)$ there exists a unique 'survive and survive' equilibrium.

Static equilibria in the case of FDI. It is easy to show that each of the four equilibria discussed in Lemmas 7 to 10 exists for some parameter values. The proof follows exactly the same lines, with a few minor changes. Rather than carrying it out completely, we just point here at the few modifications one has to introduce in the formulation of Lemmas 7 to 10 to adapt them to the new hypothesis on FDI.

- In 'export and die' equilibria, aggregate income is $E = w + T$, P is still determined by equation (26), and equation (25) has to be replaced by

$$c = \frac{w}{P - u\tau(1+\tau)^{-\sigma}(1+a)^{1-\sigma}P^{\sigma-1}}. \tag{36}$$

- In 'export and survive' equilibria, aggregate income is $E = w + u\pi(L)$, and equations (27) to (31) are replaced by

$$c = \frac{1-uf}{P-u[p(L)-w]p(L)^{-\sigma}[v(L)P]^{\sigma-1}}, \quad \text{where} \tag{37}$$

$$P = \left\{u\left[\frac{p(L)}{v(L)}\right]^{1-\sigma} + (1-u)\left[(1+\tau)(1+a)\right]^{\sigma-1}\right\}^{\frac{1}{1-\sigma}}, \tag{38}$$

$$p(L) = \begin{cases} p_L(L) & , \text{ if } p_M \leq p_L(L) \\ p_M & , \text{ if } p_M \in (p_L(L), p_H(L)] \\ p_H(L) & , \text{ if } p_M > p_H(L) \end{cases}. \tag{39}$$

- In 'survive and die' equilibria, aggregate income is $E = w + T$, P is still given by equation (33), and equation (32) is replaced by

$$c = \frac{w}{P - u\tau(1+\tau)^{-\sigma}(1+a)^{1-\sigma}P^{\sigma-1}}. \tag{40}$$

- In 'survive and survive' equilibria, aggregate income is $E = w + u\pi(L)$, but apart from that the equations in Lemma 10 still describe equilibrium consumption and prices.

With these specifications, quantities and prices are analytically specified for each of the four type of candidate equilibria. Following the same numerical procedures we adopted above, we can show that in each case there are parameters for which the candidate equilibria are indeed equilibria.

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