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Abstract

This paper focuses on ignored issues regarding the impact of trade reforms in transition economies. These economies are primarily characterized by a low quality of their products, large depreciations of their currencies, and a high degree of government intervention in economic activity. These elements are embedded in a duopoly model of vertical product differentiation and international trade. First, we show that trade liberalization in transition economies reduces the output of local firms. Second, neither free trade nor zero subsidy is optimal. There exists a rationale for infant-industry protection in that a commitment by the government to use a socially optimal trade and industrial policy can release the domestic firm from low-quality production. Since greater profits are derived from high-quality products, this enables local firms to finance productivity and technology improvements. Third, in terms of social welfare, no equivalence result between the effects of exchange rate changes and the optimal trade policy can be obtained.

JEL Classification: F12, F13, P31

Keywords: Exchange Rates, Hedonic Prices, Leapfrogging, Optimal Trade Policy, Product Quality, Trade Liberalization.

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1 Introduction

Most policymakers at international organizations and elsewhere seem to conduct their analyses of most Central and Eastern European Countries (CEECs) in the same way as any market-oriented economy. They also consider our knowledge of trade policy to be applicable to that part of the world. In particular, they would argue that economic reforms include the opening up of markets, the liberalization of trade and the reduction of support provided to agriculture and industry. Around 1989, most CEECs began to pursue rather liberal agricultural, industrial and trade policies but subsequently were confronted with *inflation and a large decline in output*, the drop being less in sectors where quality and design issues were of less importance (Brenton and Gros, 1997). Thus, not surprisingly, some CEECs in recent years have reintroduced higher levels of support (Valdes, 1999). While not questioning the direction of these reforms, the primary concern of this paper is about the optimal trade policy of CEECs and whether the complete opening up to international trade is an adequate policy option. We will show that the response of firms to trade policy, and the effect of such policy on domestic welfare can differ markedly from that of received theory.

The economic characteristics of an economy in transition have been largely discussed in the literature. Bearing in mind that transition economies emerge from central planning, a (limited) number of stylized facts have inspired our framework of analysis:

- The presence of institutional entry barriers implies that industries are highly concentrated, with just a few producers.
- A limited concern for quality standards has often driven firms in transition economies to supply goods whose quality is inferior to that of Western firms. The data suggest that average unit values of imports over exports vary significantly across transition economies. For example, Lankhuizen (2000) shows a quality advantage of imports over exports for the majority of sectors of the Baltic countries. Average export unit values for the Czech Republic, Hungary, Poland and Slovenia are generally lower than what is observed for Mediterranean countries (Aturupane *et al.*, 1999).
- A heritage of socialist institutions is the separation of research and development activity from production processes. This represents an important obstacle to the diffusion of technological progress. It is therefore not surprising to find little evidence of quality upgrading during the last decade (Aturupane *et al.*, 1999).

- Except for the Baltic countries, the current nominal protection rates reveal high levels of tariff protection, from two to three times those of the U.S. or the European Union.[1]

- Exchange rates in most CEECs fell sharply during the second half of the 1990s but recently stabilized. Rates of depreciation versus the U.S. dollar range between 25% for the Czech Koruna to more than 200% for the Russian Ruble.

While these features vary from country to country and thus there may not be a single theory that characterizes all the above developments, primary common elements of CEECs economies are the existence of (i) a quality gap between their goods and Western goods, (ii) a high level of government intervention in economic activity, and (iii) large depreciations of their currencies in the late nineties.

Our framework of analysis is a duopoly model of vertical product differentiation and international trade. Consumers in the transition economy, henceforth also referred to as the *domestic* economy, have heterogenous preferences for the sole product attribute, quality. We assume that the domestic market is not totally served in equilibrium, i.e., the market size is endogenous in our model. The quality-differentiated good is supplied by a domestic firm and by imports from a foreign producer. We will refer to this producer as the Western firm. In order to meet preferences, firms must incur a fixed cost of quality development. We allow for firms to be asymmetric in regard to their setup technologies and assume that the foreign firm is more efficient than the domestic firm. We study a three-stage game. In the first stage, the government of the transition economy chooses a trade and/or industrial policy. The instrument considered for trade policy is an ad-valorem tariff, while industrial policy is implemented through taxes or subsidies. In the second stage, firms select their qualities to be produced, and thus incur the fixed costs. Finally, in the third stage, firms indulge in price competition and demand is satisfied. Backward induction allows us to solve for a subgame perfect equilibrium. The nature of the game gives a special role to quality which, once set, can only be modified in the long-run.

Our model of international trade incorporates features from the industrial organization literature on vertical product differentiation. In a closed economy, Ronnen (1991) analyzes the incidence of minimum quality standards, while Cremer and Thisse (1994) study the effects of commodity taxation. Extensions to international trade include

[1] See Table 6.6 at the World Bank website (http://www.worldbank.org/data) for countries' average tariffs.

Das and Donnenfeld (1989), Ries (1993) and Herguera *et al.* (2000) who analyze the effects of quantity and quality restrictions, and Reitzes (1992) who studies the impact of tariffs when buyers have different preferences for brands. More closely related to our framework, Motta *et al.* (1997) show that the quality leader maintains its position when two countries producing different quality levels open up to international trade. To the best of our knowledge, neither the effects of tariffs, subsidies and exchange rates nor the choice of the optimal tariff policy has been considered in an international quality-differentiated duopoly setting.

In our model a pure-strategy asymmetric equilibrium arises even if firms have symmetric quality-development costs. Such equilibrium is characterized by the quality gap between the two goods. Free trade is not optimal since higher social welfare can be attained by levying a tariff on high-quality imports. This justifies a role for international trade intervention. In addition, absence of industrial policy[2] is not optimal either since a subsidy on low-quality home production increases welfare as well. First best policy thus typically consists of a subsidy on the low-quality home product and a tariff on high-quality imports.

Furthermore, our analysis allows us to contribute to several important debates. First, the collapse in output of transition economies has been given several interpretations, mostly linked to shortages of materials. In Blanchard and Kremer (1997), transition causes a breakdown of complex chains of production, mainly when a dominant supplier for critical inputs is involved. In Bennett *et al.* (1999), firms respond to material supply bottlenecks by cutting exports disproportionately. In our model, differently, when the firm in the transition economy produces a low-quality product, liberalization of trade gives rise to an implementation paradox: a reduction of tariffs on high-quality imports reduces the output of the local firm. This production decrease may be contrary to what policy makers had initially intended by liberalizing trade.[3] Second, one of the primary factors behind market structure in an industry is productivity and technology improvements (see e.g., Petrakis and Roy, 1999). In most transition economies, the existence of a more centralized system of research and development reduces the relative competitiveness of local firms as the diffusion of know-how is slower than elsewhere. The question is whether low-quality local firms are doomed to produce low-quality products or whether a commitment by the government to use tariffs and

[2] Industrial policy refers to government intervention geared towards strengthening the market position of the domestic firm with respect to foreign competition.

[3] Metzler (1949), in a general equilibrium context, was the first to point out the possibility that a tariff could lower the domestic price of the imported good and therefore reduce competing local production. Here, in contrast, a drop in domestic production follows from trade liberalization.

subsidies for some time may challenge the quality leadership of the foreign firm. In this regard, our results provide a rationale for infant-industry protection: when relative cost inefficiencies of the local firm are not too large, there exists a socially optimal trade and industrial policy that induces leapfrogging. This enables local firms to reap higher profits from high-quality production and to finance future cost-reducing investments. Finally, the empirical literature has suggested a symmetry between the long-run pass-through of tariffs and exchange rates (Feenstra, 1989). This implies that the response of import prices to changes in tariffs can be used to predict the effect of changes in exchange rates and vice versa. Introducing exchange rates in our model, we observe an important distinction between the impact of exchange rates changes and tariff policy in the sense that, an exchange rate depreciation is always welfare deteriorating, as opposed to tariffs, which can enhance welfare. However, equivalence results are obtained in regard to their impact on import prices, the intensity of competition, quantities imported and hedonic prices. In this vein, we also see that a substantial depreciation can cause the local firm to leapfrog the foreign competitor.

Section 2 describes the model formally. Section 3 outlines the firms' optimal decisions and states the existence and uniqueness of industry equilibrium. Section 4 evaluates the incidence of tariffs and home production subsidies and shows the non-optimality of free trade. Section 5 selects the optimal policy. Section 6 examines equivalence results between exchange rates and trade policy. Finally, Section 7 concludes. The Appendix contains some of the proofs to facilitate the reading.

2 The Model

We consider a transition economy in trade relations with the rest of the world, which we shall also call "domestic" and "foreign" countries, respectively. Suppose that a population of measure 1 lives in the transition economy and that preferences of consumer θ are given by the quasi-linear (indirect) utility function:

$$U = \begin{cases} \theta q - p & \text{if he/she buys a unit of a good of quality } q \text{ at price } p \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

Consumers buy at most one unit. Suppose that the consumer-specific quality taste parameter θ is uniformly distributed over $[0, \overline{\theta}]$, $\overline{\theta} > 0$.[4]

There are two firms competing in the market of the transition economy, a domestic

[4] θ can also be interpreted as the reciprocal of the marginal utility of income (Tirole, 1988, p. 96)

firm and a foreign exporting firm, the latter marked with *. We assume that firms must incur a fixed cost of quality development, which is a convex function of quality. Once the quality of the good is determined, production takes place at a common marginal cost that is normalized to zero for both firms.[5] Total costs of firms in their respective currencies are denoted $cC(q)$ and $c^{*}C(q)$, respectively. For mathematical convenience, we assume $C(q)$ to be a homogeneous function of degree $k \geq 2$, $C'(q) > 0$, $C''(q) > 0$, and $C(0) = 0$.[6] Let e be the expected exchange rate defined as the foreign currency price of domestic currency.[7] We assume that $ec \geq c^{*}$, which means that, measured in the same currency, the foreign firm is at least as efficient as the domestic firm in producing any quality level. These development cost asymmetries matter for the selection of an equilibrium in qualities.

The presence of heterogeneity in consumer tastes for quality implies that it is optimal for the two firms to differentiate their goods by choosing different quality levels. The intuition is that a quality differentiation strategy relaxes price competition among the firms. Let us denote low-quality by q_l and high-quality by q_h, $q_h > q_l$. The corresponding prices charged in the transition economy are p_l and p_h and suppose, for a moment, that $p_h \geq p_l$, i.e., a high-quality is sold at a higher price, assumption which will be verified later in equilibrium. Firms' demand functions are as follows. Denote by $\widetilde{\theta}$ the buyer who is indifferent between buying high-quality or low-quality. From (1), $\widetilde{\theta} = (p_h - p_l)/(q_h - q_l)$. Denote by $\widehat{\theta}$ the consumer indifferent between acquiring the low-quality good or nothing, that is, $\widehat{\theta} = p_l/q_l$. Hence, high-quality good is demanded by those consumers such that $\widetilde{\theta} < \theta < \overline{\theta}$. Likewise the low-quality variant is demanded by those buyers such that $\widehat{\theta} < \theta < \widetilde{\theta}$. As θ is uniformly distributed on $[0, \overline{\theta}]$, we derive domestic demands for high- and low-quality goods:

$$D_l(.) = \frac{p_h - p_l}{\overline{\theta}(q_h - q_l)} - \frac{p_l}{\overline{\theta} q_l}, \; D_h(.) = 1 - \frac{p_h - p_l}{\overline{\theta}(q_h - q_l)} \tag{2}$$

One of these quantities is fulfilled by imports from the foreign firm.

We study a three-stage complete information game, i.e., a game where decisions

[5] This specification of costs captures the distinctive features of *pure* vertical differentiation models, where the costs of quality improvements fall primarily on fixed costs and involve only a small or no increase in unit variable costs (see Shaked and Sutton, 1983).

[6] The degree of homogeneity of the cost function is assumed to be greater than or equal to 2 in order to guarantee existence of equilibrium. Given that the revenue functions of the duopolists are convex in own quality, one needs that the cost function is sufficiently convex to ensure maximization.

[7] An increase in e means an appreciation of the transition economy's currency; a decrease in e means a depreciation.

made in an earlier stage are irreversible and fully observable in later stages. First, the government in the transition economy chooses (i) a trade policy on imports, and (ii) an industrial policy with respect to domestic production. This implies the announcement of tax rates (t_l, t_h), one intended for the low-quality good and the other for the high-quality one.[8] Given this tariff-cum-tax policy, the market evolves in the next two stages. In stage 2, firms decide simultaneously on whether to produce low- or high-quality. They then incur the fixed costs of quality development, which are expressed in their own currency. In the third stage, firms select their prices and make their supply decisions. Each firm holds Bertrand (price) conjectures about the decision of the other firm in this third stage. The appropriate solution concept is subgame perfectness.

We solve the model by backward induction. We consider first the price competition stage and determine the equilibrium for (i) any given profile of quality choices, (ii) any pair of tariff rates, and (iii) any expected exchange rate. Then we consider the reduced form game in qualities and the Nash equilibrium of this subgame determines firms' quality selection for any pair of tariff rates and any exchange rate. Finally, the domestic government chooses the optimal policy (t_l, t_h) conditional on any realization of the exchange rate. It is assumed that the exchange rate cannot be determined by the government.

3 Market Equilibrium

We now proceed to derive the equilibrium outcome in stage 3. The domestic firm may choose to produce either a lower or higher quality good than the foreign firm. Consider the former case. Taking the pair of demands in (2), tariff rates (t_l, t_h), quality choices (q_h, q_l) and the expected exchange rate e as given, the problem of the domestic firm when it produces low-quality consists of finding p_l so as to maximize:

$$\pi_l = (1 - t_l)p_l \left(\frac{p_h - p_l}{\bar{\theta}(q_h - q_l)} - \frac{p_l}{\bar{\theta} q_l} \right) - cC(q_l)$$

[8] We concentrate on ad-valorem rates. A positive t implies taxation while $t < 0$ indicates subsidization.

On the other hand, the rival firm chooses p_h to maximize its profits:[9]

$$\pi_h^* = e(1-t_h)p_h\left(1 - \frac{p_h - p_l}{\overline{\theta}(q_h - q_l)}\right) - c^*C(q_h)$$

Solving the pair of reaction functions in prices, we obtain the subgame equilibrium prices of the two variants:

$$p_l = \frac{\overline{\theta}q_l(q_h - q_l)}{4q_h - q_l}, \; p_h = \frac{2\overline{\theta}q_h(q_h - q_l)}{4q_h - q_l} \tag{3}$$

Equilibrium prices depend only upon the two qualities and not directly upon the tariff rates and the exchange rate. The relative price of domestic production p_l/p_h is proportional to relative qualities q_l/q_h while the hedonic price of the high-quality variant is strictly higher than the low-quality one, $p_h/q_h > p_l/q_l$.

Now consider firms' quality selection. In this second stage, firms anticipate the equilibrium prices of the continuation game obtained in (3) and choose their qualities to maximize reduced-form profits. These are obtained by substituting (3) into the expressions for profits above. In particular, the domestic firm selects q_l to maximize:

$$\pi_l = (1-t_l)\frac{\overline{\theta}q_l q_h(q_h - q_l)}{(4q_h - q_l)^2} - cC(q_l)$$

Likewise, the foreign firm chooses the high quality q_h to optimize:

$$\pi_h^* = e(1-t_h)\frac{4\overline{\theta}q_h^2(q_h - q_l)}{(4q_h - q_l)^2} - c^*C(q_h)$$

The first order conditions give the reaction functions in qualities. To simplify expressions define $\mu = q_h/q_l$, with $\mu \geq 1$ since $q_h \geq q_l$. Variable μ is crucial in that it represents the gap in the quality selection of firms. It measures therefore the degree of product differentiation in our model, and thus relates to the extent of price competition. Using the definition of μ and the fact that $C'(\cdot)$ is a homogeneous function of degree $k-1$, the ratio of first order conditions can be written as follows:

$$\frac{ec(1-t_h)}{c^*(1-t_l)} = \frac{\mu^k(4\mu - 7)}{4(4\mu^2 - 3\mu + 2)} \tag{4}$$

[9] In this context, the so-called profits of the foreign firm are expected profits, namely the payoffs after taking the expectation operator with respect to the multiplicative uncertainty caused by the exchange rate.

This expression relates the equilibrium product differentiation μ to the perceived development cost of the home firm relative to the foreign firm, after correcting for tariffs and exchange rate. That is, firms' cost asymmetries in similar currency units can be reduced or reinforced by government intervention via t_l and t_h. For example, a subsidy on the low-quality product ($t_l < 0$) reduces the relative cost of the home firm as effectively perceived in the market of the transition economy. Note that the LHS of (4) is a positive number. Therefore, if an equilibrium exists, it must be the case that $4\mu - 7 > 0$, i.e., $\mu > 7/4 = 1.75$. Note also that the RHS of (4) can be rewritten as the product of μ^{k-1} and $\mu(4\mu - 7)/[4(4\mu^2 - 3\mu + 2)]$, and that these two functions are increasing in μ, and bounded away from zero for all $\mu > 7/4$. Then, the RHS of (4) increases monotonically with μ. This implies that there is a unique real solution to (4) satisfying $\mu > 7/4$. Let us denote such implicit solution as:

$$\mu = F(\overset{+}{c}, \overset{-}{c^*}, \overset{+}{e}, \overset{+}{t_l}, \overset{-}{t_h}, \overset{-}{k}) \tag{5}$$

By differentiating (4) totally, it is easy to see that the quality gap μ is an increasing function of the relative cost of the domestic firm. Further, the signs reported in (5) can be found by looking at the way relative costs relate to its components. A key observation that comes out of this analysis is the similarity between the effects of taxation and long-run exchange rate changes on equilibrium product differentiation. An expected depreciation of the domestic currency (or equivalently an appreciation of the foreign currency, $de < 0$) has an impact similar to that of a tariff on high-quality imports, or to that of a subsidy on low-quality domestic production. We further elaborate on these issues in Section 6.

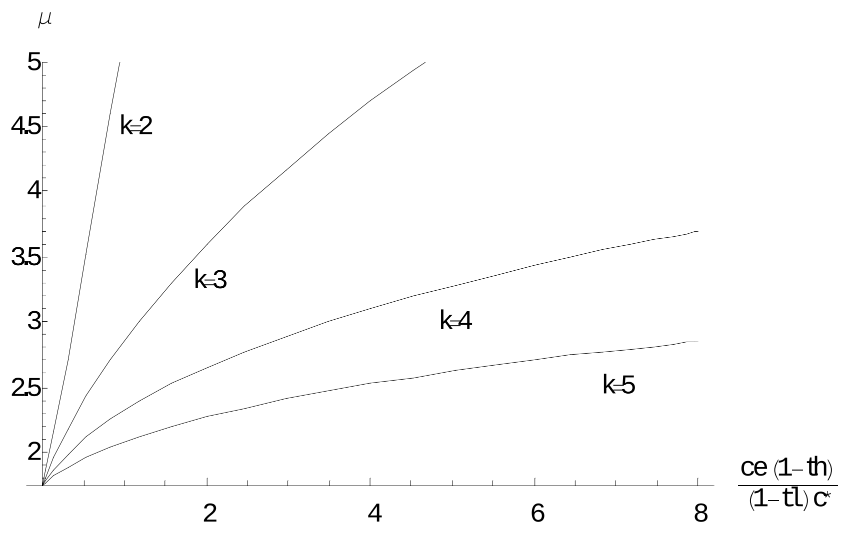

Figure 1: Equilibrium quality gap

The impact of the degree of homogeneity k on the equilibrium quality gap can be seen by observing Figure 1. This graph represents the solution to equation (4) for different values of k. On the horizontal axis we have represented the ratio of relative costs. This figure shows that for any given value of the ratio of relative costs, μ falls as k increases.

Given (5), it is convenient to solve for the market equilibrium in prices and qualities. From the reaction functions in qualities and by rewriting (2) and (3), it obtains:

$$D_l = \frac{\mu}{4\mu - 1}, \; D_h = \frac{2\mu}{4\mu - 1} \tag{6}$$

$$\widehat{\theta} = \frac{\overline{\theta}(\mu - 1)}{(4\mu - 1)} \tag{7}$$

$$p_l = \frac{\overline{\theta}(\mu - 1)q_l}{(4\mu - 1)}, \; p_h = \frac{2\overline{\theta}(\mu - 1)q_h}{(4\mu - 1)} \tag{8}$$

$$C'(q_l) = (1 - t_l)\frac{\overline{\theta}\mu^2(4\mu - 7)}{c(4\mu - 1)^3} \tag{9}$$

$$C'(q_h) = e(1 - t_h)\frac{4\overline{\theta}\mu(4\mu^2 - 3\mu + 2)}{c^*(4\mu - 1)^3} \tag{10}$$

where μ is the solution to equation (4). Equations (6) to (10) characterize the stage 2 equilibrium. They give rise to a few observations which will be useful later. Quantities demanded given by (6) are negatively related to μ. Market size is obtained by looking at the position of the marginal consumer who is indifferent between acquiring the low-quality variant or nothing, i.e., from (7). As $\widehat{\theta}$ is increasing in μ, the number of consumers served (i.e., the market size) is negatively related to μ. A measure of price competition is obtained by taking the ratio of prices in (8), $p_h/p_l = 2\mu$. A decrease in the quality gap intensifies price competition and price convergence is observed.

Policy makers at international organizations consider trade liberalization as one of the major economic reforms to be adopted by CEECs in transition. To illustrate some problems with this policy prescription consider trade liberalization in our framework, that is, consider a reduction of the import tariff t_h :

Proposition 1 *Independently of initial conditions and as long as the firm in the transition economy is a low-quality producer, trade liberalization causes a decline in its output.*

Proof: From (6), we obtain the partial derivative of D_l with respect to t_h :

$$\frac{\partial D_l}{\partial t_h} = \frac{-1}{(4\mu - 1)^2} \frac{\partial \mu}{\partial t_h}$$

Since $\partial \mu / \partial t_h < 0$ (see equation (5)), we have $\partial D_l / \partial t_h > 0$. Hence, a decrease in t_h decreases output of the local firm. Note that as μ is monotonic in t_h and D_l in μ, this is also true for large changes in t_h. ■

Trade liberalization brings about an output drop presumably contrary to what policymakers of CEECs had intended. There are three further remarks in line here. First, trade liberalization leads to a decrease in imports D_h, and a decrease in the number of consumers being served. Second, the impact of trade liberalization on social welfare, as we will see later, depends on the initial tariff rate t_h. As it might be expected, welfare will decrease (increase) if t_h is lower (higher) than the optimal import tariff rate. Third, it can be shown from (4), (8), (9) and (10) that prices of both variants increase as t_h decreases. A direct implication of this observation is that trade liberalization may have been a factor contributing to the inflation experienced in many CEECs.

So far we have assumed that the domestic firm is a low-quality producer. However, the steps taken above could be repeated assuming instead that high-quality is produced domestically, while imports are of low-quality. Does Proposition 1 apply to that case as well? To show that the answer to such question is negative consider the following thought experiment. Assume for a moment that the active government is located abroad where high-quality products are manufactured and low-quality products are imported. This situation is the mirror image of the model assumed so far and is thus representative of Western economies facing low-quality imports from transition economies. Then:

Proposition 2 *If the domestic firm produces high-quality and imports are of low-quality, trade liberalization brings about an increase in domestic output.*

Proof: Undertaking the same steps as above but considering that low-quality is produced abroad, one can see that the equilibrium product differentiation would be given by the solution to

$$\frac{c^*(1-t_h)}{ec(1-t_l)} = \frac{\mu^k(4\mu-7)}{4(4\mu^2-3\mu+2)}. \tag{11}$$

Note that the expressions for D_h and D_l remain like in (6). Hence:

$$\frac{\partial D_h}{\partial t_l} = \frac{-2}{(4\mu-1)^2}\frac{\partial \mu}{\partial t_l}.$$

Since $\partial\mu/\partial t_l > 0$ in (11), a decrease in t_l increases D_h and thus output of the high-quality domestic firm increases. As μ is monotonic in t_l and D_h in μ, this is also true for large changes in t_l. ■

Propositions 1 and 2 provide opposite predictions regarding the output effect of trade liberalization. These effects are thus sensitive to whether countries are producers of high- or low-quality. While Western economies may have large incentives to commit to free trade, transition economies in contrast may not. These results could also explain some of the differences in tariff schedules between CEECs and industrialized countries. Moreover, they clearly indicate that the current knowledge of trade policy is not directly applicable to CEECs.

Selection of equilibria

We are now ready to address a central theoretical question in the model: When will the market equilibrium be such that the domestic firm produces low-quality and the foreign firm high-quality? Further, when will this market equilibrium be unique? These are actually two distinct questions, since it turns out that the market equilibrium is not unique for all parameter values. We state below a result which considers large relative cost differences among the two firms. This result shows that an equilibrium where the domestic firm produces high-quality never exists provided that such firm is sufficiently inefficient. Later, we numerically evaluate the Harsany-Selten risk-dominance criterion and see that such criterion selects away the equilibrium where the domestic firm produces high-quality for all (small and large) relative cost differences.

As already indicated, there may be two equilibrium quality spectra in our (sub)game. In the first one, the high-quality good is produced by the foreign firm. We refer to this situation as Assignment 1. In this case, the equilibrium product differentiation is given by the solution to (4). Denote the solution to this equation as μ_1. The equilibrium under Assignment 1 is then characterized as follows:

Assignment 1: Domestic firm produces the low-quality good while foreign firm produces the high-quality good:

$$q_l = C'^{-1}\left[(1-t_l)\frac{\overline{\theta}\mu_1^2(4\mu_1-7)}{c\,(4\mu_1-1)^3}\right],\; q_h^* = C'^{-1}\left[e(1-t_h)\frac{4\overline{\theta}\mu_1(4\mu_1^2-3\mu_1+2)}{c^*\,(4\mu_1-1)^3}\right].$$

There is an alternative quality spectrum where the high-quality good is produced by the domestic firm instead. Refer to this situation as Assignment 2. In this case, the equilibrium product differentiation is given by the solution to (11). Denote such a solution as μ_2. Then, under Assignment 2, the equilibrium is characterized as follows:

Assignment 2: Domestic firm produces the high-quality good while foreign firm manufactures the low-quality good

$$q_h = C'^{-1}\left[(1-t_h)\frac{4\overline{\theta}\mu_2(4\mu_2^2-3\mu_2+2)}{c\,(4\mu_2-1)^3}\right],\; q_l^* = C'^{-1}\left[e(1-t_l)\frac{\overline{\theta}\mu_2^2(4\mu_2-7)}{c^*\,(4\mu_2-1)^3}\right].$$

These two proposed equilibrium configurations are not feasible for all parameter constellations. Actually, the next result states that whenever c^* is sufficiently low, the assignment where the low-quality is produced in the foreign economy is not a stable equilibrium because the foreign firm (which is relatively more efficient) finds it profitable to deviate and leapfrog the domestic firm.

Proposition 3 *For any parameter constellation* (c, e, t_h, t_l, k), *there exists some parameter* $\overline{c}^*$ *such that for all* $c^* < \overline{c}^*$ *the assignment in which the domestic firm produces low-quality is part of a subgame perfect equilibrium. Moreover, there exists some* $\underline{c}^*$ *such that for all* $c^* < \underline{c}^*$ *the assignment in which the domestic firm produces high-quality is not part of a subgame perfect equilibrium.*

Proof: See Appendix.

When cost differences are not sufficiently large the equilibrium where the foreign firm produces low-quality also exists. However, the risk dominance criterion of Harsany and Selten (1988) enables us to rule out equilibrium 2 as a plausible prediction of our game. To illustrate that, let us apply this refinement of Nash equilibrium to the game at hand. Both foreign and domestic firms face the choice of equilibrium given by Assignment 1 versus equilibrium characterized by Assignment 2. Let us represent firms' choices between both assignments by the following matrix:

Foreign firm

		A_1^*	A_2^*
Domestic firm	A_1	π_l, π_h^*	π_l^{12}, π_h^{*12}
	A_2	π_l^{21}, π_h^{*21}	π_h, π_l^*

where π_l^{12} and π_h^{*12} denote the payoffs to the low-quality domestic firm and to the high-quality foreign firm, respectively, when the former chooses to produce the low-quality given by Assignment 1 and the latter chooses to produce the low-quality given by Assignment 2. π_l^{21} and π_h^{*21} are similarly interpreted.

When cost differences are small, $\{A_1, A_1^*\}$ and $\{A_2, A_2^*\}$ are both equilibria of the subgame with corresponding firms payoffs (π_l, π_h^*) and (π_h, π_l^*), respectively. Let $G_{11} = \pi_l - \pi_l^{21}$ be the gains the domestic firm obtains by predicting correctly that the foreign firm will select Assignment 1. Likewise, $G_{12} = \pi_h - \pi_l^{12}$ denotes the gains the domestic firm derives by forecasting correctly that the foreign firm will select Assignment 2. For the foreign firm we have $G_{21} = \pi_h^* - \pi_h^{*12}$ and $G_{22} = \pi_l^* - \pi_h^{*21}$. It is said that Assignment 1 risk-dominates Assignment 2 whenever $G_{11}G_{21} > G_{12}G_{22}$.

Figure 2 illustrates this inequality by representing $G_{11}G_{21}$ and $G_{12}G_{22}$ for different values of relative costs. Here we assume that tariff rates are zero and cost functions are quadratic. It can be seen that the inequality above is satisfied and therefore the unique equilibrium remaining is Assignment 1. We have conducted a number of simulations with different tax rates and cost functions and the criterion always selects away Assignment 2.

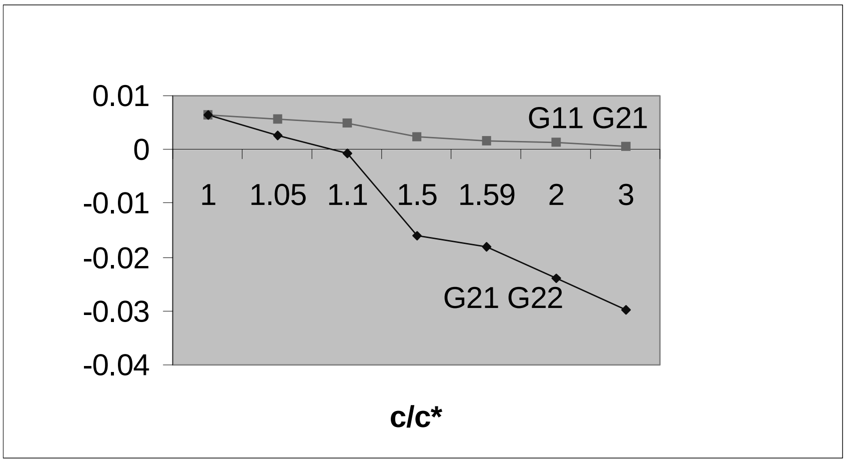

Figure 2: Harsany-Selten criterion

4 Trade and industrial policy

Finally, in the first stage of the game, the domestic government chooses the optimal policy that maximizes domestic social welfare. We assume that tax revenues are uniformly distributed among consumers. Therefore social welfare equals the unweighted sum of domestic consumer surplus, revenues generated by the tax schedule and profits of the domestic firm:

$$W = CS + t_h p_h D_h + t_l p_l D_l + \pi \tag{12}$$

Consumers surplus is given by:

$$CS = \int_{\frac{p_h - p_l}{q_h - q_l}}^{\overline{\theta}} (xq_h - p_h)dx + \int_{p_l/q_l}^{\frac{p_h - p_l}{q_h - q_l}} (xq_l - p_l)dx$$

Employing (8), (9) and (10) and undertaking some algebraic computations, consumers surplus can be written more conveniently as:

$$CS = \frac{\overline{\theta}\mu^2(4\mu + 5)q_l}{2(4\mu - 1)^2} \tag{13}$$

where μ is the solution to equation (4) and q_l is given by (9). On the other hand, tariff revenues are given by:

$$TR_h = \frac{t_h 4\overline{\theta}\mu^2(\mu - 1)q_l}{(4\mu - 1)^2} \tag{14}$$

Tax proceeds (or subsidization costs) obtained from home production are:

$$TR_l = \frac{t_l\overline{\theta}\mu(\mu - 1)q_l}{(4\mu - 1)^2}$$

Likewise, reduced-form profits of the domestic firm are (see Appendix):

$$\pi_l = \frac{(1 - t_l)\overline{\theta}\mu q_l}{k(4\mu - 1)^3}\left[k(4\mu - 1)(\mu - 1) - \mu(4\mu - 7)\right] \tag{15}$$

Using these expressions we can write the social welfare function of the transition economy as:

$$W = \frac{\overline{\theta}\mu}{(4\mu - 1)^2}\left[\frac{4\mu^2 + 7\mu - 2}{2} + 4t_h\mu(\mu - 1) - \frac{(1 - t_l)\mu(4\mu - 7)}{k(4\mu - 1)}\right] q_l \tag{16}$$

where q_l is given by (9).

Using (16) we can examine the effects of trade and industrial policy in our model. In the next section, we shall study the optimal policies. Let us first consider the impact of an industrial policy. Starting from free trade ($t_h = 0$), we study the effects of a subsidy on home production (that is $dt_l < 0$):

Proposition 4 *Starting from free trade a small subsidy on the low-quality home production leads to: (a) an upgrade in the quality of both variants, (b) a decrease in the hedonic prices of both variants (c) an increase in the quantities sold and in the number of consumers being served, (d) an increase in domestic firm's profits, (e) an increase in consumer surplus, and (f) an increase in social welfare.*

Proof: See Appendix.

Subsidization is welfare improving because it enhances price competition between the two firms. As the quality of the domestic good raises, the foreign firm is forced to raise its quality as well, in an attempt to relax price competition. While both qualities increase, the quality gap is reduced (see (4)), which strengthens price competition. This in turn implies that goods of superior quality are offered at lower hedonic prices, leading to a welfare gain.

To examine the impact of tariff protection, let us start from free trade, i.e. where $t_h = 0$ and no industrial policy, i.e. $t_l = 0$ and consider the case of an import tariff (that is, $dt_h > 0$).

Proposition 5 *A small tariff on high-quality imports leads to (a) a decrease in the quality of both variants, (b) a decrease in prices and hedonic prices of both variants, (c) an increase in the quantities sold and in the number of consumers being served, (d) a decrease in domestic profits, (e) a fall in consumers surplus, and (f) an increase in social welfare.*

Proof: See Appendix.

Tariff protection in the form of an ad-valorem tax increases welfare but at the cost of reducing the qualities of both variants. A tariff on foreign production reduces the foreign quality, which forces the local firm to cut quality too. The drop in qualities is such that the quality gap between the goods fall (see (4)), which increases price competition. This effect, which results in lower hedonic prices mitigates the negative impact that the policy has on qualities. In any case, the policy would result in a welfare loss but tariff revenues accruing from high-quality production are large enough to make the policy measure attractive from a welfare standpoint. Note further that a tariff on high-quality imports leads to two unexpected outcomes: (1) imports increase and (2) the domestic firm is harmed.

What Propositions 4 and 5 indicate is that the absence of government intervention in the form of free trade or zero subsidy is not an optimal policy prescription. A subsidy raises welfare essentially because it intensifies price competition. A small tariff is welfare enhancing because income is taken away from the foreign firm, which more than compensates for the reduction in consumer surplus and domestic profits caused by the policy.

5 Optimal policy

The results of Propositions 4 and 5 clearly indicate that the activist government has incentives to introduce a trade and industrial policy. In this section, we will shed some light on the optimal policy intervention.

Differentiating (16) with respect to t_h and t_l and rearranging terms we obtain:

$$\frac{dW}{dt_h} = \frac{W}{1-t_h}\left[\frac{(1-t_h)}{A}\frac{4\overline{\theta}\mu^2(\mu-1)}{(4\mu-1)^2} - \alpha\beta\right] \tag{17}$$

$$\frac{dW}{dt_l} = \frac{W}{1-t_l}\left[\frac{(1-t_l)}{A}\frac{\overline{\theta}\mu^2(4\mu-7)}{k(4\mu-1)^3} + \alpha\beta - \frac{1}{k-1}\right] \tag{18}$$

where $\alpha = (d\mu/dr)(r/\mu)$, with $r = ec(1-t_h)/c^*(1-t_l)$, and $\beta = (dW/d\mu)(\mu/W)$.[10] Here α represents the elasticity of the quality gap μ with respect to the relative costs given in (4), which is positive. β represents the elasticity of social welfare with respect to the quality gap μ. This elasticity is also positive. The explicit values of α and β are cumbersome and therefore omitted.

Proposition 6 *As long as the firm in the transition economy is a producer of low-quality, the optimal policy mix involves: (i) a tariff ($t_h > 0$) on high-quality imports, and (ii) a subsidy ($t_l < 0$) on low-quality production provided that ec/c^* is sufficiently large. Otherwise, domestic production is also taxed.*

Proof: See Appendix.

This proposition can be given the following interpretation. When development costs asymmetries are very large, the quality gap and price difference between variants of the

[10] Equations (17) and (18) are presented in a very compact way. There are a series of steps that we omit here to save on space.

product is large. The tariff-cum-subsidy policy aims then at reducing this quality gap and so at fostering price competition. In contrast, when development costs asymmetries are small, the quality gap is minimal in that case but social welfare can still be increased by raising government revenues and applying a tariff-cum-tax policy.

Numerical simulations

We are now ready to address a central question of transition economies. Are local firms doomed to produce low-quality products or it is possible that a commitment by the government to use a socially optimal trade and industrial policy can challenge the quality leadership of the foreign firm? The latter would allow the domestic firm to derive higher profits and finance productivity and technology improvements.

Our purpose is to numerically compute the equilibria of the game under the two possible quality configurations of our model, that is, first when the domestic firm produces a low-quality product and second, when it leapfrogs the foreign firm and produces a high-quality variant. Figure 3 represents the levels of welfare under these two situations. We have normalized $\overline{\theta} = 1$ and taken $C(q) = q^2/2$ as the cost function. The curve labelled "low-quality" shows the welfare levels achieved under the optimal policy when the low-quality is produced by the domestic firm . Note that the optimal policy is restricted in the sense that $c(1 - t_h)/ec^*(1 - t_l) = 1$ and this is so because an unrestricted solution to equations (17) and (18) would be such that $ec(1 - t_h)/c^*(1 - t_l) < 1$, which, according to the risk-dominance criterion, would imply that higher-quality goods are produced in the home country. If this were so, a policy intended for Assignment 1 would be welfare deteriorating because in equilibrium what would arise is Assignment 2 rather than 1. The policy thus must be restricted. The curve labelled "high-quality" shows the welfare levels achieved under the optimal policy when high-quality production occurs in the domestic country. Upon the observation of these two curves, it is clear that the domestic government prefers that high-quality goods be produced at home when firms' cost asymmetries are small. The reason is that the profits from high-quality production are substantially much larger than from low-quality production. It thus turns out that the active government finds it beneficial to introduce a tariff-cum-subsidy policy that induces the domestic country to produce a higher quality as long as countries cost asymmetries are not too large. The government, by heavily subsidizing home production, confers a sufficiently great cost advantage to the domestic firm so as to induce Assignment 2 as the equilibrium prevailing in the market. For very large cost differences subsidizing home production is too costly so that a higher level of welfare is attained under assignment 1, i.e., by letting high-quality production to occur abroad.

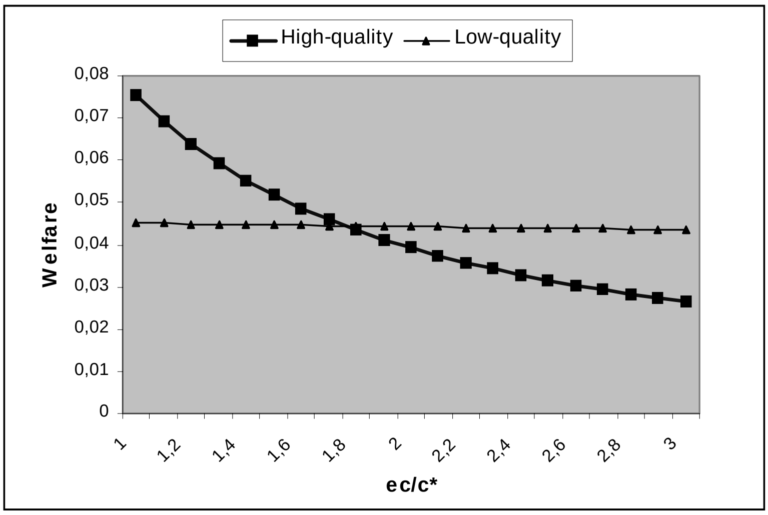

Figure 3: Trade policy and leapfrogging

6 Exchange rate movements

The preceding sections have identified similarities between trade and industrial policies and the effects of expected exchange rate depreciations. Central to the comparison are equations (4) and (5), which show that an expected depreciation of the currency brings about changes in product differentiation and price competition which are similar to those of a tariff on high-quality imports, or of a subsidy on low-quality domestic production. However, a major difference is that exchange rate changes do not affect government budget balance directly. In the remainder of this section we formalize the role of expected exchange rate changes on the market equilibrium. We start by noting an equivalence result:

Proposition 7 *There exists a value of the exchange rate which generates the same degree of price competition which arises from the optimal trade policy. Quantities imported and hedonic prices will then be the same too.*

Proof: See Appendix.

This proposition states that, starting from free trade, the effects of an optimal trade policy which aims at decreasing the extent of product differentiation can be duplicated by a depreciation of the transition economy's currency. As most CEECs have experienced large depreciation of their currencies, this has contributed to reduce product differentiation among firms and to foster price competition. Moreover, other things being equal, a substantial depreciation can cause the local firm to leapfrog the foreign competitor.

As Figure 4 shows, the import demand function has an inverted v shape in relation to the exchange rate. Leapfrogging gives rise to a discontinuity at the point where relative costs are equal ($\overline{e}$). For any expected exchange rate below such value, imports are of low-quality and increasing in the exchange rate. In contrast, for any expected exchange rate above such value, imports are of high-quality and, unexpectedly, respond negatively to any further exchange rate appreciation.

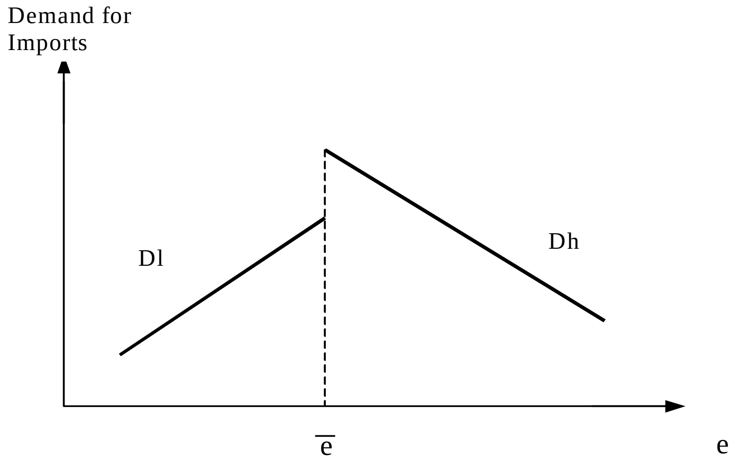

Figure 4: Import Demand Function

From a welfare perspective, however, there is a major drawback when a depreciation occurs:

Proposition 8 *Irrespective of the quality produced by the domestic firm, a depreciation of the transition economy's currency gives rise to a decrease in social welfare.*

Proof: See Appendix.

An intuitive reasoning can be given to this result. Consider the case of high-quality imports. By Proposition 5, we know that an expected depreciation of the exchange rate of the transition economy gives rise to an increase in the quantities sold and to an increase in the number of consumers willing to purchase the good. Nevertheless, the domestic firm is harmed because its profits fall and consumer surplus also decreases because the quality of both variants decrease (more than their respective prices). As there is no effect on government revenues, social welfare falls.

7 Discussion

This paper has considered the optimal trade and industrial policy of transition economies. Discerning features of these economies which have been emphasized in our model include the existence of a quality gap between Western goods and those products manufactured in CEECs, the presence of a high level of government intervention in economic activity, and the occurrence of large depreciations of their currencies. The paper started with the question whether our knowledge of trade policy is directly applicable to transition economies.

Our framework of analysis was a duopoly model of vertical differentiation and international trade. We have seen that a pure-strategy asymmetric equilibrium arises whenever consumers have heterogeneous tastes in quality. In absence of government intervention, the least efficient firm located in the transition economy produces a low-quality variant and imports are of high-quality. Domestic government can raise welfare by taxing the foreign high-quality firm or by subsidizing home production, which proves the non-optimality of free trade. Trade liberalization would result in an output drop of the firm in the transition economy and in an increase in all prices. Further, it has been shown that government intervention via tariffs and subsidies can induce the firm in transition economies to leapfrog high-quality imports. Finally, we have shown that there exists a partial equivalence result between an exchange rate depreciation and the government's optimal policy. This equivalence is however not complete because the former leads to social welfare losses while the latter is socially optimal.

An interesting extension of our model would be one which allows for foreign direct investments, which seem to be crucial for the economic development of some transition economies. A foreign acquisition of the local firm would only affect the first stage of the game in that domestic profits in (15) would now be repatriated abroad and therefore drop from the expression for domestic social welfare. In contrast, the market equilibrium would remain qualitatively unaffected.

There is a recent literature dealing with time-consistent strategic trade policy. The main contribution of this work is to show that optimal trade policy may be sensitive to the timing of policy moves (see e.g. Leahy and Neary, 1996). In contrast, our setting implicitly assumes that the activist government can credibly commit to its policy choice before firms make price and quality decisions. We have also assumed away the possibility that the foreign country engages into retaliatory trade policies (see e.g. Collie, 1991), or argues that government actions are inconsistent with the country's bid to join the World Trade Organization (see e.g. Bagwell and Staiger, 1999). Alternative models could therefore be used to study questions similar to those raised in our model assuming a non-committal government or possible retaliatory policies.

8 Appendix

Proof of Proposition 3: We first show that the foreign firm finds it beneficial to leapfrog the domestic firm whenever c^* is relatively low compared to $ec(1-t_h)/(1-t_l)$. In the context of Assignment 2, consider the foreign firm contemplating to leapfrog the rival's quality choice. Then, the foreign firm would choose q to maximize deviating profits

$$\widehat{\pi}_h^* = e(1-t_h)\frac{4\overline{\theta}q^2(q-q_h)}{(4q-q_h)^2} - c^*C(q)$$

The first order condition is:

$$e(1-t_h)\frac{4\overline{\theta}q(4q^2-3qq_h+2q_h^2)}{(4q-q_h)^3} - c^*C'(q) = 0$$

Let us define $q = \lambda q_h$ where $\lambda \geq 1$. Then, we can write:

$$C'(q) = e(1-t_h)\frac{4\overline{\theta}\lambda(4\lambda^2-3\lambda+2)}{c^*(4\lambda-1)^3} = C'(\lambda q_h) = \lambda^{k-1}(1-t_h)\frac{4\overline{\theta}\mu_2(4\mu_2^2-3\mu_2+2)}{c\,(4\mu_2-1)^3}$$

From this relationship, we can obtain:

$$\frac{c^*}{ec} = \frac{\lambda(4\lambda^2-3\lambda+2)}{\lambda^{k-1}(4\lambda-1)^3}\frac{(4\mu_2-1)^3}{\mu_2(4\mu_2^2-3\mu_2+2)}$$

Using equation (11) we can substitute c^*/ec to obtain:

$$\frac{(1-t_l)}{(1-t_h)}\frac{\mu_2^{k+1}(4\mu_2-7)}{4\,(4\mu_2-1)^3} = \frac{(4\lambda^2-3\lambda+2)}{\lambda^{k-2}(4\lambda-1)^3} \qquad (19)$$

Refer to the solution to this equation as λ_2. Note that the LHS of (19) increases with μ_2, while its RHS decreases with λ. Thus, μ_2 and λ_2 are inversely related.

We are now ready to compare deviating profits

$$\begin{aligned}\widehat{\pi}_h^* &= e(1-t_h)\frac{4\overline{\theta}\lambda_2^2(\lambda_2-1)}{(4\lambda_2-1)^2}q_h - c^*C(q) \\ &= e(1-t_h)\frac{4\overline{\theta}\lambda_2^2(\lambda_2-1)}{(4\lambda_2-1)^2}\mu_2 q_l - c^*C(\lambda_2\mu_2 q_l)\end{aligned}$$

with equilibrium benefits

$$\pi_l^* = e(1-t_l)\frac{\overline{\theta}\mu_2(\mu_2-1)}{(4\mu_2-1)^2}q_l - c^*C(q_l).$$

The foreign firm would deviate whenever $\widehat{\pi}_h^* \geq \pi_l^*$, i.e., if and only if

$$e\overline{\theta}\left[(1-t_h)\frac{4\lambda_2^2(\lambda_2-1)}{(4\lambda_2-1)^2}\mu_2 - (1-t_l)\frac{\mu_2\,(\mu_2-1)}{(4\mu_2-1)^2}\right] \geq \frac{(\lambda_2^k\mu_2^k-1)c^*C(q_l)}{q_l}. \tag{20}$$

Now, using Euler's theorem, we note that

$$\frac{C(q_l)}{q_l} = \frac{C'(q_l)}{k} = \frac{e(1-t_l)\overline{\theta}\mu_2^2(4\mu_2-7)}{kc^*(4\mu_2-1)^3},$$

Then we can rewrite (20) as follows:

$$\frac{(1-t_h)}{(1-t_l)}\frac{4\lambda_2^2(\lambda_2-1)}{(4\lambda_2-1)^2} - \frac{(\mu_2-1)}{(4\mu_2-1)^2} \geq (\lambda_2^k\mu_2^k-1)\frac{\mu_2(4\mu_2-7)}{k(4\mu_2-1)^3}$$

Or,

$$\frac{(1-t_h)}{(1-t_l)}\frac{4\lambda_2^2(\lambda_2-1)}{(4\lambda_2-1)^2} - \lambda_2^k\frac{\mu_2^{k+1}(4\mu_2-7)}{(4\mu_2-1)^3} \geq \frac{1}{(4\mu_2-1)^2}\left[(\mu_2-1) - \frac{\mu_2(4\mu_2-7)}{k(4\mu_2-1)}\right]$$

We can use (19) to substitute $\lambda_2^k\mu_2^k$ to obtain:

$$\begin{aligned}&\frac{(1-t_h)}{(1-t_l)}\frac{4\lambda_2^2}{(4\lambda_2-1)^2}\left[(\lambda_2-1) - \frac{(4\lambda_2^2-3\lambda_2+2)}{k(4\lambda_2-1)}\right] \\ \geq\ &\frac{1}{(4\mu_2-1)^2}\left[(\mu_2-1) - \frac{\mu_2(4\mu_2-7)}{k(4\mu_2-1)}\right]\end{aligned}$$

Note now that the LHS of this expression in an increasing function of λ_2, while its RHS decreases with μ_2. Notice also that the LHS varies at a higher rate than the RHS. Since, as c^* falls, λ_2 increases while μ_2 decreases, it is clear that there exists some sufficiently low $\underline{c}^*$ such that for any lower c^* the above inequality holds. As a result, the foreign firm would find it beneficial to deviate and leapfrog the domestic firm.

We show now that, in contrast, Assignment 1 is indeed an equilibrium when c^* is sufficiently low. To prove this, let us first see that both firms' profits at the proposed equilibrium are non-negative. Later we will check that no firm has an incentive to deviate from it, i.e. that no firm has an incentive to leapfrog its rival's choice. Equilibrium profits for the low-quality firm under Assignment 1 can be written as (using Euler's theorem):

$$\pi_l = (1-t_l)\frac{\overline{\theta}\mu_1(\mu_1-1)}{(4\mu_1-1)^2}q_l - \frac{cq_lC'(q_l)}{k}$$

We can use the first order condition (9) to obtain

$$\pi_l = \frac{(1-t_l)\overline{\theta}\mu_1 q_l}{k(4\mu_1-1)^3}\left[k(4\mu_1-1)(\mu_1-1)-\mu_1(4\mu_1-7)\right] > 0 \text{ for all } k>1 \qquad (21)$$

whenever $q_l > 0$. But in a proposed equilibrium $\mu_1 > 0$ and thus q_l and q_h are also positive. One proves that profits of the high-quality firm are positive similarly.

Let us see now that no firm would leapfrog rivals' choices under Assignment 1 whenever c^* is sufficiently low. Consider the case of "upward" leapfrogging first, that is suppose firm at domestic country deviates by leapfrogging its rival. In such a case, domestic firm would select $q \geq q_h$ to maximize deviating profits:

$$\widetilde{\pi}_h = (1-t_h)\frac{4\overline{\theta}q^2(q-q_h)}{(4q-q_h)^2} - cC(q)$$

The first order condition is:

$$(1-t_h)\frac{4\overline{\theta}q(4q^2-3qq_h+2q_h^2)}{(4q-q_h)^3} - cC'(q) = 0$$

Define $v \geq 1$ such that $q = vq_h$. Then, we can write:

$$C'(q) = (1-t_h)\frac{4\overline{\theta}v(4v^2-3v+2)}{c(4v-1)^3} = C'(vq_h) = v^{k-1}e(1-t_h)\frac{4\overline{\theta}\mu_1(4\mu_1^2-3\mu_1+2)}{c^*\left(4\mu_1-1\right)^3}$$

From this equality, we obtain that in the optimal deviation v must satisfy:

$$\frac{ec}{c^*} = \frac{v(4v^2 - 3v + 2)}{v^{k-1}(4v-1)^3} \frac{(4\mu_1 - 1)^3}{\mu_1(4\mu_1^2 - 3\mu_1 + 2)} \tag{22}$$

Using equation (4), we can substitute ec/c^* to rewrite (22) as:

$$\frac{v(4v^2 - 3v + 2)}{v^{k-1}(4v-1)^3} = \frac{1-t_l}{1-t_h} \frac{\mu_1^{k+1}(4\mu_1 - 7)}{4\,(4\mu_1 - 1)^3} \tag{23}$$

Denote the solution to this equation as v_1 and notice that v_1 and μ_1 are inversely related since the LHS of (23) decreases in v and its RHS increases in μ_1. We can now compare deviating profits $\widetilde{\pi}_h$ with those at the proposed equilibrium π_l. Domestic firm does not deviate whenever $\widetilde{\pi}_h \leq \pi_l$. Equilibrium profits are given by (21) while deviating profits can be written as:

$$\widetilde{\pi}_h = (1-t_h)\frac{4\overline{\theta}q^2(q-q_h)}{(4q-q_h)^2} - cC(q) = (1-t_h)\frac{4\overline{\theta}v_1^2(v_1-1)}{(4v_1-1)^2}q_h - v_1^k\mu_1^k C(q_l)$$

We can use equation (23) and the Euler theorem to write $\widetilde{\pi}_h$ as:

$$\widetilde{\pi}_h = \frac{(1-t_h)4\overline{\theta}v_1^2}{k(4v_1-1)^3}\mu_1 q_l \left[k(4v_1-1)(v_1-1) - (4v_1^2 - 3v_1 + 2)\right]$$

Now, equations (22) and (23) imply that as c^* falls, v_1 falls and μ_1 increases. As a result, by simple inspection of $\widetilde{\pi}_h$ and π_l one concludes that Assignment 1 is a stable equilibrium for sufficiently low foreign investment cost. The case of "downward" leapfrogging can be ruled out similarly. This completes the proof that Assignment 1 is the only possible equilibrium for large cost differences.

Proof of Proposition 4: Note first that applying the implicit function theorem to equation (4) we have that $\partial\mu/\partial t_l > 0$.
(a) Notice that the RHS of (10) decreases with μ. Since $C(\cdot)$ is convex, then we have $\partial q_h/\partial\mu < 0$ and

$$\frac{dq_h}{dt_l} = \frac{\partial q_h}{\partial\mu}\frac{\partial\mu}{\partial t_l} < 0.$$

Since $q_l = q_h/\mu$, it follows that $dq_l/dt_l < 0$.

(b) Using (8) we have that $p_h/q_h = 2\overline{\theta}(\mu-1)/(4\mu-1)$. Since

$$\frac{\partial(p_h/q_h)}{\partial\mu} = \frac{6\overline{\theta}}{(4\mu-1)^2} > 0,$$

then $d(p_h/q_h)/dt_l > 0$. One shows similarly that $d(p_l/q_l)/dt_l > 0$.
(c) Using (6), we have

$$\frac{dD_l}{dt_l} = \frac{\partial D_l}{\partial\mu}\frac{\partial\mu}{\partial t_l} = \frac{-1}{(4\mu-1)^2}\frac{\partial\mu}{\partial t_l} < 0.$$

Since $D_h = 2D_l$, then $dD_h/dt_l < 0$.
(d) The profits of the domestic firm can be written as $\pi_l = (1-t_l)\overline{\theta}q_lF(\mu) - cC(q_l)$ where $F(\mu) = \mu(\mu-1)/(4\mu-1)^2$. We need to find the sign of

$$\frac{d\pi_l}{dt_l} = -\overline{\theta}q_lF(\mu) + (1-t_l)\overline{\theta}q_lF'(\mu)\frac{\partial\mu}{\partial t_l} + \left[(1-t_l)\overline{\theta}F(\mu) - cC'(q_l)\right]\frac{dq_l}{dt_l} \qquad (24)$$

Now we can use (9) to state that $(1-t_l)\overline{\theta}F(\mu) - cC'(q_l) = (1-t_l)\overline{\theta}\mu F'(\mu)$ where $F'(\mu) = (2\mu+1)/(4\mu-1)^3$. Therefore equation (24) reduces to

$$\begin{aligned}\frac{d\pi_l}{dt_l} &= -\overline{\theta}q_lF(\mu) + (1-t_l)\overline{\theta}F'(\mu)\left[q_l\frac{\partial\mu}{\partial t_l} + \mu\frac{dq_l}{dt_l}\right] \\ &= -\overline{\theta}q_lF(\mu) + (1-t_l)\overline{\theta}F'(\mu)\frac{dq_h}{dt_l} < 0,\end{aligned}$$

where the inequality follows from (a). One can prove that gross profits, that is, $\widetilde{\pi}_l = \pi_l - t_l\overline{\theta}q_lF(\mu)$, also increase after the introduction of a small subsidy. Indeed,

$$\left.\frac{d\widetilde{\pi}_l}{dt_l}\right|_{t_l=0} = \left.\frac{d\pi_l}{dt_l}\right|_{t_l=0} - \overline{\theta}q_lF(\mu) < 0.$$

(e) From (13) consumer surplus can be written as

$$CS = \frac{\overline{\theta}\mu(4\mu+5)}{2(4\mu-1)^2}q_h.$$

Then,

$$\frac{dCS}{dt_l} = \frac{\partial CS}{\partial\mu}\frac{\partial\mu}{\partial t_l} + \frac{\partial CS}{\partial q_h}\frac{dq_h}{dt_l}$$

Note that $\partial CS/\partial\mu = -\overline{\theta}(28\mu+5)q_h/(4\mu-1)^3 < 0$ and that $\partial CS/\partial q_h > 0$. Then,

using the results above we obtain that $dCS/dt_l < 0$.
(f) Finally, social welfare equals $W = CS + \pi_l + TR_l$. It is convenient to express social welfare using domestic firm's gross profits $\widetilde{\pi}_l$ as $W = CS + \widetilde{\pi}_l$. Now, since $d\widetilde{\pi}_l/dt_l < 0$ and $dCS/dt_l < 0$ as shown in (d) and (e) respectively, it follows that $dW/dt_l < 0$. This completes the proof. ■

Proof of Proposition 5: Note first that applying the implicit function theorem to equation (4) we have that $\partial\mu/\partial t_h < 0$.
(a) Notice that the RHS of (9) increases with μ. Since $C(\cdot)$ is convex, then we have $\partial q_l/\partial\mu > 0$ and therefore

$$\frac{dq_l}{dt_h} = \frac{\partial q_l}{\partial\mu}\frac{\partial\mu}{\partial t_h} < 0.$$

Since $q_h = \mu q_l$, it follows that $dq_h/dt_h < 0$.
(b) As observed earlier $\partial(p_h/q_h)/\partial\mu > 0$ and thus $d(p_h/q_h)/dt_h < 0$. One shows similarly that $d(p_l/q_l)/dt_h > 0$. This shows that hedonic prices fall after the tariff. To show that prices fall notice that $\partial p_h/\partial\mu > 0$ and $\partial p_l/\partial\mu > 0$. Using (a), it follows that $dp_h/dt_h < 0$ and $dp_l/dt_h < 0$.
(c) Using (6), we have

$$\frac{dD_l}{dt_h} = \frac{\partial D_l}{\partial\mu}\frac{\partial\mu}{\partial t_h} = \frac{-1}{(4\mu-1)^2}\frac{\partial\mu}{\partial t_h} > 0.$$

Since $D_h = 2D_l$, then $dD_h/dt_h > 0$.
(d) The profits of the domestic firm can be written as $\pi_l = (1-t_l)\overline{\theta}q_l F(\mu) - cC(q_l)$ where $F(\mu) = \mu(\mu-1)/(4\mu-1)^2$. We need to find the sign of

$$\frac{d\pi_l}{dt_h} = (1-t_l)\overline{\theta}q_l F'(\mu)\frac{\partial\mu}{\partial t_h} + \left[(1-t_l)\overline{\theta}F(\mu) - cC'(q_l)\right]\frac{dq_l}{dt_h} \tag{25}$$

Now we can use (9) to state that $(1-t_l)\overline{\theta}F(\mu) - cC'(q_l) = (1-t_l)\overline{\theta}\mu F'(\mu)$ where $F'(\mu) = (2\mu+1)/(4\mu-1)^3$. Therefore equation (25) reduces to

$$\frac{d\pi_l}{dt_h} = (1-t_l)\overline{\theta}F'(\mu)\left[q_l\frac{\partial\mu}{\partial t_h} + \mu\frac{dq_l}{dt_h}\right] = (1-t_l)\overline{\theta}F'(\mu)\frac{dq_h}{dt_h} < 0,$$

where the inequality follows from (a).

(e) Using (13) we can compute

$$\frac{dCS}{dt_h} = \frac{\partial CS}{\partial \mu}\frac{\partial \mu}{\partial t_h} + \frac{\partial CS}{\partial q_l}\frac{dq_l}{dt_h}.$$

Note that $\partial CS/\partial \mu = \overline{\theta}\mu(\mu(8\mu-6)-5)q_l/\left(4\mu-1\right)^3 > 0$ and that $\partial CS/\partial q_l > 0$. Then, using the results above we obtain that $dCS/dt_h < 0$.

(f) Finally, social welfare equals $W = CS + \pi_l + TR_h$. Now, notice that $d\pi_l/dt_h < 0$ and $dCS/dt_h < 0$ as shown in (d) and (e) respectively. Then welfare can only increase whenever the proceeds obtained from import tariffs are large enough. We need to compare the strength of these two opposite forces. Notice that, as shown in (a), as t_h increases q_l falls, and thus $C(q_l)$. Therefore, to prove the result it is enough to show that

$$\left.\frac{dTR_h}{dt_h}\right|_{t_h=0} + \left.\frac{d(CS+R_l)}{dt_h}\right|_{t_h=0} > 0$$

where R_l denotes the revenues of the domestic firm. Now, observe that $dTR_h/dt_h|_{t_h=0} = 4\overline{\theta}\mu(\mu-1)q_h/(4\mu-1)^2 > 0$, and that $CS + R_l = \overline{\theta}(2+\mu)q_h/2(4\mu-1)$. Therefore

$$\left.\frac{d(CS+R_l)}{dt_h}\right|_{t_h=0} = -\frac{9\overline{\theta}q_h}{2(4\mu-1)^2}\frac{\partial \mu}{\partial t_h} + \frac{\overline{\theta}(2+\mu)}{2(4\mu-1)}\frac{dq_h}{dt_h}$$

Observe that

$$\frac{dq_h}{dt_h} = \frac{\partial q_h}{\partial t_h} + \frac{\partial q_h}{\partial \mu}\frac{\partial \mu}{\partial t_h}.$$

Using the Euler's theorem and equations (4) and (10) we can obtain the following derivatives:

$$\begin{aligned}
\frac{\partial q_h}{\partial \mu} &= -\frac{2(5\mu+1)q_h}{(k-1)\mu(4\mu-1)(4\mu^2-3\mu+2)} < 0 \\
\frac{\partial q_h}{\partial t_h} &= -\frac{q_h}{(k-1)(1-t_h)} < 0
\end{aligned}$$

Then, taking into account the signs of these derivatives, to prove the claim it is enough to show that

$$\left.\frac{dTR_h}{dt_h}\right|_{t_h=0} = \frac{4\overline{\theta}\mu(\mu-1)q_h}{(4\mu-1)^2} > \frac{\overline{\theta}(2+\mu)}{2(4\mu-1)}\left.\frac{\partial q_h}{\partial t_h}\right|_{t_h=0},$$

that is

$$\frac{4\overline{\theta}\mu(\mu-1)q_h}{(4\mu-1)^2} > \frac{\overline{\theta}(2+\mu)}{2(4\mu-1)}\frac{q_h}{(k-1)}$$

Since, for a given μ, the RHS of this equation decreases with k, it is enough to show that the inequality holds for the minimum k, i.e. $k = 2$. It obtains that it must be the case $4\mu^2 - 7\mu - 6 > 0$, which is true for any solution to (4). ■

Proof of Proposition 6: The optimal policy is a triple (t_l, t_h, μ) such that (4) and the first order conditions (17) and (18) hold. We can isolate $\alpha\beta$ from (17) and (18) to obtain:

$$(1-t_h)k(k-1)4\overline{\theta}\mu^2(\mu-1)(4\mu-1) = A(\cdot)k(4\mu-1)^3 - (1-t_l)(k-1)\overline{\theta}\mu^2(4\mu-7)$$

Using the expression for $A(\cdot)$ above, this equation reduces to:

$$\begin{aligned} 8k\mu(\mu-1)(4\mu-1)t_h &= (4\mu-1)\left[8(k-1)\mu(\mu-1) - 4\mu^2 - 7\mu + 2\right] \\ &\quad +2k\mu(4\mu-7)(1-t_l) \end{aligned}$$

Therefore

$$t_h = \frac{[8(k-1)\mu(\mu-1) - 4\mu^2 - 7\mu + 2]}{8k\mu(\mu-1)} + \frac{2(1-t_l)(4\mu-7)}{8k(\mu-1)(4\mu-1)} \tag{26}$$

This equation gives the relationship between t_h and t_l. It further shows that the optimal trade policy involves a positive tariff on the foreign high-quality imports, i.e., $t_h > 0$, irrespective of whether home production is taxed or subsidized.

According to the risk dominance criterion, the home firm keeps on producing low-quality if and only if:

$$r = \frac{ec(1-t_h)}{c^*(1-t_l)} \geq 1 \tag{27}$$

The simulations we have conducted show that $r < 1$ under the optimal policy given by the solution to (17) and (18). This is therefore contradictory with the assumption made at the start that the domestic firm produces low-quality. The optimal policy must therefore be such that (27) is binding, i.e., $r = 1$, or, in other words $t_h = 1 - c^*(1-t_l)/ec$.

Inserting this constraint into (26), and arranging terms one obtains:

$$(1-t_l)\left[2\left(4\mu-7\right)+\frac{c^*}{ec}8k(\mu-1)(4\mu-1)\right]=(4\mu-1)(\mu(12\mu-1)-2). \tag{28}$$

We are now ready to state that when cost asymmetries are low, i.e. $c^*/ec \simeq 1$, then domestic production is also taxed because $t_h > 0$ and $t_l \simeq t_h$ as it follows from (27). Equation (28), however, shows that for c^*/ec sufficiently low, $t_l < 0$. ■

Proof of Proposition 7: Consider the case where the home firm produces low-quality products. Starting from a free trade situation ($t_h = t_l = 0$) and a normalized level of the expected exchange rate $e = 1$, this implies $c \geq c^*$. Then there exists a new level of the expected exchange rate $\widehat{e}$ such that

$$\widehat{e}=\frac{1-t_h}{1-t_l} \tag{29}$$

and

$$\frac{\widehat{e}c}{c^*}=\frac{\left(1-t_h\right)c}{\left(1-t_l\right)c^*}=1$$

where (t_h, t_l) are the optimal policy rates. Hence, $\widehat{e} \leq 1$ (that is, a depreciation) if and only if $t_h \geq t_l > 0$ and $t_h > 0 > t_l$. Under (29) the quality gap μ will be the same. Hence, D_l, D_h, p_l/q_l, and p_h/q_h will also be similar. ■

Proof of Proposition 8: Let us first consider the case where the low-quality variant is produced at the domestic country. Assuming $t_h = t_l = 0$, social welfare is the sum of consumer surplus in (13) and domestic firm's profits in (15):

$$W=\frac{\overline{\theta}}{2}\Gamma(\mu)q_l$$

where $\Gamma(\mu) = \left[16\mu^4 + 24\mu^3 - 15\mu^2 + 2\mu - 8\mu^3/k + 14\mu^2/k\right]/(4\mu-1)^3 > 0$. We need to compute

$$\frac{dW}{de}=\frac{\overline{\theta}}{2}\left[\Gamma(\mu)\frac{\partial q_l}{\partial\mu}+q_l\frac{\partial\Gamma(\mu)}{\partial\mu}\right]\frac{\partial\mu}{\partial e}$$

Since $\partial q_l/\partial\mu > 0$, $\partial\Gamma(\mu)/\partial\mu > 0$, using (5) we conclude that and $dW/de > 0$.

Consider now the case where the domestic firm produces high-quality. Social welfare is now computed by adding consumers surplus in (13) and the profits derived from high-quality production:

$$W = \frac{\overline{\theta}}{2}\Psi(\mu)q_h$$

where $\Psi(\mu) = \left[48\mu^3 - 32\mu^3/k - 24\mu^2 + 24\mu^2/k + 3\mu - 16\mu/k\right]/(4\mu - 1)^3 > 0$. Partial differentiation yields

$$\frac{dW}{de} = \frac{\overline{\theta}}{2}\left[\Psi(\mu)\frac{\partial q_h}{\partial \mu} + q_h\frac{\partial \Psi(\mu)}{\partial \mu}\right]\frac{\partial \mu}{\partial e}.$$

From the equilibrium condition corresponding to this case in (11), we obtain that $\partial\mu/\partial e < 0$. Notice also $\partial q_h/\partial\mu < 0$ and that $\partial\Psi(\mu)/\partial\mu < 0$. We conclude that $dW/\partial e > 0$. Therefore, a devaluation ($de < 0$) gives rise to a decrease in welfare in both cases. ■

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