Trade Policy and Quality Leadership in Transition Economies*

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October 2002
To appear in *European Economic Review*

Abstract

Trade policy and quality leadership in transition economies are analyzed in a duopoly model of trade and vertical product differentiation. We first show that the incidence of trade liberalization is sensitive to whether firms in transition economies are producers of low or high quality. Second, we find that neither free trade nor the absence of a domestic subsidy are optimal: both a tariff and a subsidy increase price competition and while the former extracts foreign rents the latter results in quality upgrading. Third, there exists a rationale for a government to commit to a socially optimal policy to induce quality leadership by the domestic firm when cost asymmetries are low. Finally, we establish an equivalence result between the effects of long-run exchange rate changes and those of trade policy on price competition (but not on social welfare).

JEL Classification: F12, F13, P31

Keywords: Exchange Rate, Quality Reversal, Optimal Trade Policy, Product Quality, Trade Liberalization.

*We gratefully acknowledge helpful comments from our Editor, K. M. Schmidt, and two anonymous referees. We also thank F. Benaroya, A. Deardorff, J. Cáceres, W. J. Ethier, V. Karamychev, D. Levando, D. Marin and the seminar participants at Carlos III (Madrid), Erasmus (Rotterdam), Licos (Leuven), Linz, Tinbergen Institute (Amsterdam), Zaragoza, and the meeting of the European Trade Study Group (Glasgow) for their constructive remarks. This paper was partly written while the second author was visiting the Center for Economic Studies (CES) at the University of Munich, whose hospitality and financial support are gratefully acknowledged.

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1 Introduction

Some 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 consider our knowledge of trade policy to be applicable to that part of the world. In particular, they would argue that economic reforms should 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 with a *large decline in output* (IMF, 2000), the drop being smaller 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 domestic support (Valdes, 1999). While not questioning the general direction of these reforms, the primary concern of this paper is to examine whether free trade is an adequate policy option and to characterize the nature of the optimal trade policy of CEECs. 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 (World Bank, 1996). 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 and in many cases monopolized.

- 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) finds that there is a quality advantage of imports over exports for the majority of sectors of the Baltic countries. Moreover, 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).

- Transition economies are endowed with a relatively large stock of human capital. Adult illiteracy rates are comparable to those of high-income countries and significantly lower than in

developing countries. Secondary school enrolment rates lie in between developing and developed countries (see the World Bank website at http://www.worldbank.org/data for countries' education indicators).

- 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 (see the World Bank website).

- Nominal 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 during that period to about 300% for the new Russian Ruble in 1998 only.

Though the prominence of these features varies from country to country, the primary common elements of CEECs that we shall allow for in our model are (*i*) an endogenous quality gap between domestic and Western goods, (*ii*) a high degree of industry concentration, (*iii*) a high level of government intervention in economic activity, and (*iv*) large depreciations of their currencies.

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. The quality-differentiated good is supplied by a domestic firm and by imports from a foreign producer. 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 an industrial policy.[1] The instrument considered for trade policy is an *ad valorem* tariff, while industrial policy is implemented through ad valorem taxes or subsidies. In the second stage, firms select the qualities to be produced, and thus incur the fixed costs. Finally, in the third stage, firms indulge in price competition and demand is satisfied. We 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.

In our model a unique risk-dominant subgame perfect equilibrium in pure strategies arises. Such equilibrium is characterized by the existence of a quality differential between the products manufactured by the two distinct firms. Under free trade, high quality is manufactured abroad because the domestic firm is assumed to be less efficient that the foreign one. Starting from free trade, we show that a small tariff on high-quality imports is welfare improving. On the one hand,

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

a tariff reduces both firms' incentives to invest in quality and thus results in quality downgrading of both variants. On the other hand, it fosters competition between firms and enables the domestic government to extract rents from the foreign firm. The net effect is a higher social welfare than free trade, which justifies a role for a trade policy. We also show that the absence of an industrial policy is not optimal either. In contrast to the tariff, a subsidy on low-quality home production increases firms' incentives to invest in quality and thus results in quality upgrading of both variants. In addition, it enhances price competition between firms and therefore leads to an overall welfare gain.

We also address the important question of quality leadership in transition economies: Is the less efficient domestic firm doomed to produce low-quality products, or is it socially optimal for the domestic government to commit to tariffs and subsidies to challenge the quality leadership of the foreign firm? Our analysis shows that such a policy exists and is optimal when the domestic firm's relative cost inefficiency is not too large; otherwise, the domestic government prefers to let high-quality production occur abroad. The first best policy typically consists of a subsidy on domestic production and a tariff on imports. Intuitively, this policy provides the local firm with incentives to upgrade its quality while it reduces the same incentives of the foreign firm. As a result the quality gap is minimized and price competition substantially enhanced. Interestingly, the same results arise if firms compete *à la* Cournot instead.[2]

In addition, the paper offers the following two insights. First, we show that the incidence of trade liberalization is sensitive to whether firms in transition economies are producers of low or of high quality. In the former case, trade liberalization gives rise to (*i*) a reduction in the output of the local firm and (*ii*) an increase in the price of all variants. In the latter case, domestic output can increase instead. Hence, as many local firms in transition economies produce low-quality products, our results offer a different explanation to the price increases and to the collapse of output experienced in those countries. This differs from the alternative interpretations linked to either shortages of materials (Blanchard and Kremer, 1997; Bennett *et al.,* 1999) or to the speed of sectoral reallocation (Castanheira and Roland, 2000). Second, introducing exchange rates in our model we obtain an equivalence result between tariff policies and long-run exchange rate changes

[2]Less developed countries (LDCs) have characteristics similar to those described above for transition economies. However, there are features that distinguish the latter from the former. First, a higher concentration ratio in industry: CEECs were characterized at the start of the transition by "one firm per product," with little concern for product quality. FDI in major CEECs was not substantial to alter this situation. For example, the Russian Federation in 1996 had a FDI stock per capita of $45 against $848 for a comparable group of developing countries at roughly similar levels of economic development (UNCTAD, 1998, Table IX.7). A second important difference is the presence of skilled labor which makes the optimal policy prescription of our paper viable for two reasons. First, relative development costs are smaller than in LDCs which favors a policy that induces quality leadership by the local firm. Second, higher profits together with the availability of a large stock of skilled human capital allow for the adoption of new technologies and the long-run sustainability of quality leadership.

regarding their impact on import prices (like in Feenstra, 1989), the intensity of competition, quantities imported and hedonic prices. In contrast, an important distinction between the two is that an exchange rate depreciation is always welfare deteriorating, as opposed to tariffs which can enhance welfare. We also note that a substantial depreciation can also cause the local firm to leapfrog the foreign competitor in the quality ladder.

There are convincing empirical studies showing that intra-industry trade (IIT) characterized by different levels of quality is a significant proportion of trade. For example, Greenaway *et al.* (1994, 1995) show that over two thirds of all IIT in the UK involves trade of vertically differentiated goods. A great deal of theoretical effort has been spent in explaining how product quality matters. The monopoly problem is discussed in Mussa and Rosen (1978) and Krishna (1987). Oligopoly versions of this model have received substantial attention in both the industrial organization[3] and international trade literature.[4] The papers most closely related to our work are Motta *et al.* (1997), Herguera *et al.* (2002) and Zhou *et al.* (2002). Motta *et al.* (1997) analyze the introduction of trade between two countries that produce different quality levels. They show that the quality leader maintains its position after the opening up to international trade. In contrast, our paper focuses on positive and normative questions such as the impact of ad valorem tariffs and subsidies as well as the nature of the optimal trade and industrial policy. Herguera *et al.* (2002) also study optimal policies in a model similar to ours except that we assume asymmetric development costs across firms, consider ad valorem import tariffs and allow for local subsidies.[5] This is important since when the opportunity cost of public funding is low, a subsidy on local production is more effective in raising national welfare than a tariff on imports; moreover, the optimal policy that induces a quality reversal typically entails subsidization of the domestic industry. Zhou *et al.* (2002) study the implications of an export policy in a typical third-country model. They examine how exporting nations can design profit-shifting policies in the presence of endogenous quality. Their critical assumption is that cost differences between the exporting countries are very large, a framework that is more suitable to analyze strategic trade interactions between LDCs and Western countries. In contrast, our model allows also for small cost asymmetries which gives the government of a transition economy an incentive to select a trade and industrial policy that leads to a reversal in the quality spectrum. Our work should then be seen as complementary to these three papers.[6]

[3] See e.g. Shaked and Sutton (1982, 1983), Gabszewicz and Thisse (1986), Tirole (1988), Ronnen (1991), Motta (1993), Cremer and Thisse (1994), Crampes and Hollander (1995), and Lehmann-Grube (1997).

[4] A large part of this work deals with tariffs and quantitative restrictions like import quotas and VERs (see e.g. Das and Donnenfeld, 1987, 1989; Reitzes, 1992; Ries, 1993; Herguera *et al.* 2000, 2002; and Zhou *et al.*,2002).

[5] It is more and more common for tariffs and subsidies to be specified in *ad valorem* terms, i.e., as a percentage of the selling price. The US International Trade Commission has indeed made suggestions to convert most specific, compound and complex rates of duty to their *ad valorem* equivalents (see http://www.usitc.gov).

[6] Fershtman *et al.* (1999) have estimated the effect of tax reform in the automobile market in Israel. They argue that the impact of taxation in this type of vertically differentiated market is complex due to the fact that a tax affects

The rest of the paper is organized as follows. Section 2 describes the model formally. Section 3 outlines the firms' optimal decisions and presents the impact of trade liberalization on equilibrium output and prices. Section 4 studies the incidence of import tariffs and domestic production subsidies, shows the non-optimality of free trade and selects the optimal policy. It also discusses the existence and uniqueness of an equilibrium in qualities. Section 5 examines equivalence results between exchange rate changes and trade policy. Finally, Section 6 concludes. The Appendix contains all 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 refer to as the "domestic" and "foreign" country, 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 the set $[0, \overline{\theta}]$, $\overline{\theta} > 0$.

There are two firms competing in the market of the transition economy, a domestic firm and a foreign exporting firm, the latter marked with *.[7] 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.[8] 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 $k \geq 2$, i.e., the cost function exhibits constant elasticity k. Moreover, we assume $C'(q) > 0$, $C''(q) > 0$ for all

not only prices but also the profile and quality of products. We believe that our analysis contributes to a deeper understanding of the implications of government intervention in this type of markets.

[7] The foreign firm may very well be serving its own local market or even other foreign markets. However, we adopt here the typical view that international markets are often segmented and thus the foreign firm's price and quality decisions are only influenced by the conditions existing in the domestic economy. To illustrate, consider for example the market for automobiles. Car producers typically take quality decisions aimed at matching specific regional preferences, such as the desire of air conditioning, automatic gears and control cruise in the US, safety and environmental friendliness in Scandinavian countries, compactness in Japan, etc.

[8] This cost specification 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). The normalization adopted here is without loss of generality provided that the main bulk of costs falls on fixed costs rather than on variable costs. Adding small marginal costs of production makes computations cumbersome and obscures the presentation of the results.

$q > 0$ and $C(0) = 0$.[9] Let e be the expected exchange rate defined as the foreign currency price of domestic currency. We assume that e is fixed over the time horizon during which quality is selected. We assume that $ec \geq c^*$, that is, measured in the same currency, the foreign firm is at least as efficient as the domestic firm in producing any quality level.[10] As we shall see later, 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 strategy of quality differentiation 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 $p_h > p_l$, i.e., a high-quality is sold at a higher price, assumption which will be verified later in equilibrium. Firms' demand functions are obtained 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, the high-quality good is demanded by those consumers such that $\widetilde{\theta} \leq \theta \leq \overline{\theta}$. Likewise the low-quality variant is demanded by those buyers such that $\widehat{\theta} \leq \theta < \widetilde{\theta}$. As θ is uniformly distributed on $[0, \overline{\theta}]$, we derive domestic demands for high- and low-quality goods:

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

Observe that one of these quantities is met by imports from the foreign firm.

We study a three-stage complete information game. First, the government in the transition economy chooses (i) a trade policy, and (ii) a domestic industrial policy.[11] This consists in the announcement of a tariff t on imports and a subsidy s on home production.[12] Given the government policy, the market evolves in the next two stages. In stage 2, firms decide simultaneously on whether to produce low or high quality and then incur the fixed costs of quality development. 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 game the active government acts as a

[9] 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, the cost function must be sufficiently convex to ensure maximization.

[10] There are reasons to assume that the foreign firm is more efficient than the domestic firm. For example, Murphy and Shleifer (1997) argue that countries with higher human capital have a comparative advantage in producing high-quality goods. Section 5 discusses the implications of long-run exchange rate changes that reverse this inequality.

[11] We assume away the possibility of retaliatory trade policies (see e.g. Dixit, 1988; Collie, 1991; Hwang and Schulman, 1993; Bagwell and Staiger, 1999) because when the foreign firm serves several markets, the foreign government finds it very difficult to *target* a retaliation against a particular market, specially so in our setting where subsidies and taxes are retaliatory policy instruments.

[12] Of course we also allow for negative tariffs and negative subsidies: $t > 0$ is a tariff while $t < 0$ indicates subsidization of imports. Similarly $s < 0$ implies taxation of domestic production.

Stackelberg leader by precommiting to a specific tariff-cum-subsidy policy that will not be changed later.[13] Thus, the appropriate solution concept is subgame perfectness. We restrict ourselves to pure-strategy equilibria.

We solve the model by backward induction. We consider first the price competition stage and determine the equilibrium taking (i) any profile of quality choices and (ii) any policy intervention (t, s) as given. We then consider the reduced-form game in qualities and the Nash equilibrium of this subgame determines firms' quality selection, for any given (t, s). Finally, the domestic government chooses the optimal policy (t, s) taking into account the expected exchange rate and firms' cost asymmetries and anticipating the equilibrium of the continuation game. 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 in principle choose to produce a variant whose quality is either lower or higher than that of the foreign firm. Let us consider the former case.[14] Using the pair of demands in (2), taking trade and industrial policy instruments (t, s) and quality choices $(q_h,\ q_l)$ as given, the problem of the domestic firm consists of finding p_l so as to maximize:

$$\pi_l = (1+s)p_l\left(\frac{p_h - p_l}{\overline{\theta}(q_h - q_l)} - \frac{p_l}{\overline{\theta}q_l}\right) - cC(q_l)$$

On the other hand, the rival firm chooses p_h to maximize its profits:[15]

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

[13] A recent literature dealing with time-consistent strategic trade policy has pointed out that optimal trade policy may be sensitive to the different assumptions about government precommitment (see e.g. Goldberg, 1995; Herguera *et al.* 2002; Leahy and Neary, 1999). According to Brander (1995), however, most international trade observers agree in that governments have at their disposal mechanisms to credibly commit to their policy interventions. This is naturally so when governments have a coalitional nature and policies are adopted after multilateral negotiations. In our model, it can easily be seen that in absence of commitment the government would become a revenue maximizer and would extract all the revenues from the foreign firm; this firm, anticipating such undesirable outcome would not enter the domestic market. Thus, absence of commitment would lead to a local monopoly. We will show later that a local monopoly yields a lower social welfare than an international duopoly; therefore, if the government can choose to credibly commit to its policy intervention, it will do so.

[14] In Section 4 we examine the case where the home firm produces high quality instead and conclude that it may be a viable equilibrium under government intervention.

[15] 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.

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 but not directly upon the policy instruments 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, i.e., $p_h/q_h > p_l/q_l$.

Consider now firms' quality selection. In this second stage, firms take (t, s) as given, anticipate the equilibrium prices of the continuation game obtained in (3), and choose their qualities to maximize reduced-form profits. In particular, the domestic firm selects q_l, and the foreign firm q_h, to maximize:

$$\pi_l = (1+s)\frac{\overline{\theta} q_l q_h (q_h - q_l)}{(4q_h - q_l)^2} - cC(q_l) \text{ and } \pi_h^* = e(1-t)\frac{4\overline{\theta} q_h^2 (q_h - q_l)}{(4q_h - q_l)^2} - c^* C(q_h),$$

respectively. First order conditions give the reaction functions in qualities $q_h(q_l)$ and $q_l(q_h)$. They are represented in Figure 1 for a quadratic cost function. Both curves slope upwards, therefore qualities are strategic complements.[16] A candidate subgame perfect equilibrium is given by the intersection of these two curves.

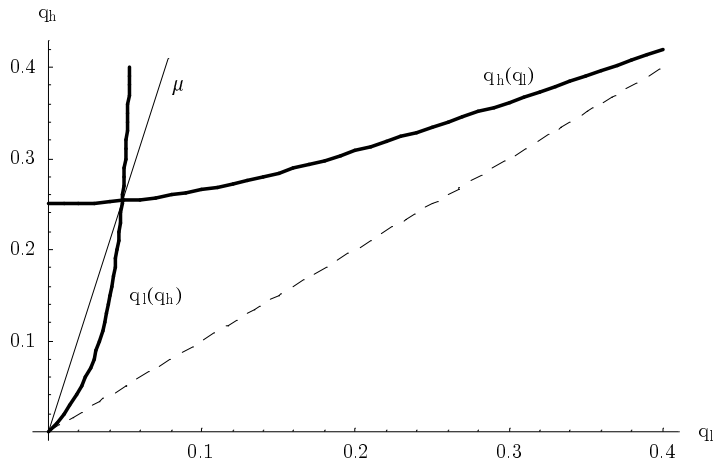

Figure 1: Firms' best response functions in qualities ($c = c^* = e = \overline{\theta} = 1$).

To simplify matters, define $\mu = q_h/q_l$, with $\mu > 1$ since $q_h > q_l$. Variable μ represents the quality gap between the two firms' variants. It measures the degree of product differentiation and thus

[16] For polynomial cost functions with larger degrees of homogeneity k these curves become flatter, but qualities remain strategic complements.

relates to the extent of price competition. The gradient of the ray going through the origin and the equilibrium point in Figure 1 is the quality gap μ. It is clear that $q_h > q_l$ is an equilibrium candidate since the dashed 45 degree line lies to the right of the μ-line. As $C'(\cdot)$ is a homogeneous function of degree $k-1$, the ratio of first order conditions can be written as:

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

This expression implicitly defines the equilibrium product differentiation μ as a function of the home firm's development cost relative to the foreign firm's cost, after correcting for tariff, subsidy and exchange rate. We shall refer to the LHS of (4) as the *relative development cost*.[17]

As the LHS of (4) is a positive number, if an equilibrium exists, it must be the case that $4\mu - 7 > 0$, i.e., $\mu > 7/4$. Note 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 $\mu > 7/4$. Hence, the RHS of (4) increases monotonically with μ. This implies that there is a unique real solution to (4) satisfying $\mu > 7/4$, which is denoted by:

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

The signs reported in (5) are readily found by looking at the way relative development cost relates to its components. Equation (5) implies that firms' cost asymmetries in similar currency units can be lowered or raised by tariffs and subsidies. For example, a subsidy increase on the low-quality product ($ds > 0$), or a tariff increase on high-quality imports ($dt > 0$), reduces the relative development cost of the home firm and thus μ decreases. Another observation that comes out of (5) is the similarity between the impact of a policy intervention and the influence of exchange rate changes on the quality gap. A depreciation (appreciation) of the domestic (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 home production.[18]

From the reaction functions in qualities and by rewriting (2) and (3), we obtain:

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

[17] We note that a subsidy is given here to the units actually produced. The analysis would be qualitatively similar if the subsidy were instead given to the quality-production process of the domestic firm. It would suffice to replace $c/(1+s)$ in (4) by $c(1-s)$ and proceed as below.

[18] Since the RHS of (4) increases exponentially with k, it is readily seen that, for any given relative cost, μ falls sharply as k rises. Most existing models of vertical product differentiation assume that development costs are quadratic ($k = 2$). While larger k values have implications for the quantitative results, it turns out that the qualitative results we derive are insensitive to k.

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

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

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

$$C'(q_h) = e(1 - t)\frac{4\overline{\theta}\mu(4\mu^2 - 3\mu + 2)}{c^*(4\mu - 1)^3}. \tag{10}$$

Equation (5) together with (6) to (10) characterize the stage 2 equilibrium. These equations give rise to a few observations which will be useful later. The quality gap μ is absolutely central to our analysis. For example, a measure of price competition is obtained by taking the ratio of prices in (8), $p_h/p_l = 2\mu$: an increase in μ relaxes price competition and leads to price rises. It is also clear from (8) that both hedonic prices p_h/q_h and p_l/q_l increase in μ, while their ratio is constant. Quantities demanded given by (6), (as well as market size (7)) are negatively related to μ, because a larger quality gap is associated with higher prices and thus lower sales.[19]

Trade Liberalization

We are now ready to switch our attention to a first application of our model, namely, trade liberalization. Many policymakers at international organizations consider trade liberalization as one of the major economic reforms to be adopted by CEECs in transition. Our model however illustrates some potential problems with this policy prescription that arise because quality is endogenous. Assume that an equilibrium exists and consider trade liberalization in the framework above, that is, a reduction of the import tariff t. Then:

[19] There is increasing empirical evidence supporting the features of the model analyzed above. First, a key point obtained in Anderton (1999) is that quality factors in import volumes for both Germany and the UK are very significant. Moreover, low price elasticities are obtained for sectors with a high degree of vertical product differentiation. Second, in a comparative study of clothing exports to Western Europe between 1972 and 1987, Hoen and van Leeuwen (1991) find a gain in competitiveness of Hong-Kong, South Korea and Taiwan compared to Czechoslovakia, Hungary, and Poland. This arises from the substantial upgrading of quality in the former countries relative to the latter resulting from a higher economic development and a greater sophistication of demand in Asian countries. In terms of our model, this can be interpreted by an increase in $\overline{\theta}$. Finally, surveys such as "The Image of European Products" conducted by the Chambre de Commerce et d'Industrie de Paris, or others like the Bozell-Gallup Worldwide Quality Poll, give a direct quality ranking to the goods manufactured in Europe, USA and Japan. Econometric studies using these surveys establish a tight link between quality and innovation (Grozet and Erke-Rousse, 2000), which gives some justification for our quality development cost function.

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) a decline in imports and in domestic output, and (b) an increase in the price of both variants.*

The reason for this result is that trade liberalization helps firms to make more divergent choices on the quality spectrum in order to reduce price competition. Hence, it brings about an increase in the price of and consequently a drop in the demand for both imports and local output. Proposition 1 thus suggests that trade liberalization may have been a contributing factor to the decline in output in some sectors and to the inflation experienced in many CEECs during the nineties.

The decline in output of one sector, as predicted by Proposition 1, is not unusual. Trade liberalization in many international trade models would cause a fall in domestic output of the import-competing sector. However, it is interesting to contrast Proposition 1 with the opposite case where imports are of low quality and the domestic firm produces high quality. Using again the pair of demands in (2), derivations similar to those above yield a different market equilibrium where the quality gap is given by:

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

Note that the only difference between (11) and (4) is the LHS. Under this market structure, equations (6) and (8) are unaltered while qualities are given by the following expressions:

$$C'(q_h) = (1+s)\frac{4\overline{\theta}\mu(4\mu^2-3\mu+2)}{c(4\mu-1)^3} \text{ and } C'(q_l) = e(1-t)\frac{\overline{\theta}\mu^2(4\mu-7)}{c^*(4\mu-1)^3}. \tag{12}$$

It can easily be shown that, in this case, trade liberalization brings about an *increase* in domestic output instead. Hence the incidence of trade liberalization is sensitive to whether the domestic firm produces low or high quality.[20] This contrasting result motivates three distinct questions which will be addressed in the remainder of this paper: (*i*) What are the conditions under which one of the two different equilibria in quality arises? (*ii*) What are the social welfare implications of government intervention? (*iii*) Is there a role for the government to induce a particular assignment in qualities or to exclude the foreign firm from the domestic market altogether?

4 Trade and Industrial Policy

In the first stage of the game, the domestic government chooses a trade and an industrial policy (t, s) to maximize domestic welfare. We assume that tariff revenues net of subsidies are uniformly

[20] As firms in transition economies are often low-quality producers, these results may explain why developed countries may have larger incentives to commit to free trade than transition economies.

distributed among consumers. Therefore, social welfare equals the unweighted sum of domestic consumer surplus, net revenues generated by the tariff-cum-subsidy policy and profits of the domestic firm. It is important to note that like in Lehmann-Grube (1997), production of high quality yields substantially higher profits than low quality. As a result, the expression for social welfare depends on the type of quality produced locally. The next result is crucial in this regard because it characterizes the selection of quality equilibria employing the risk-dominance criterion of Harsanyi and Selten (1988).

Proposition 2 *Given any trade and industrial policy (t, s), in the unique risk-dominant subgame perfect equilibrium: (i) low quality is produced by the domestic firm if $c^* < ec(1-t)/(1+s)$; (ii) high quality is produced by the domestic firm when this inequality is reversed; (iii) when $c^* = ec(1-t)/(1+s)$, the domestic firm may produce either high or low quality.*

The proof is available from the authors upon request.[21] It rests upon the idea that when c^* is sufficiently low compared to $ec(1-t)/(1+s)$, the assignment where the low quality is produced abroad is not a subgame perfect equilibrium because the foreign firm, which is highly efficient, finds it profitable to deviate and jump up over the domestic firm in the quality ladder. However, when firms' cost asymmetries are small, the proof requires a more powerful equilibrium concept, namely, the risk-dominance criterion. This refinement selects away the equilibrium in which the domestic firm produces high quality whenever the foreign firm is more efficient in relative terms.[22]

Given our initial assumption $ec \geq c^*$, Proposition 2 reveals that in the neighborhood of free trade the domestic firm produces low-quality. As a result, social welfare has the following expression:

$$W = CS + tp_h D_h - sp_l D_l + \pi_l \tag{13}$$

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), consumers surplus can be written more conveniently as:

$$CS = \frac{\overline{\theta}\mu^2(4\mu + 5)q_l}{2(4\mu - 1)^2}, \tag{14}$$

[21] It can also be downloaded from http://www.tinbergen.nl/~moraga/transitionwebappendix.pdf.

[22] Motta *et al.* (1997) have also employed this criterion in a related model. Cabrales *et al.* (2000) find that the risk-dominance criterion is supported by the behavior of experimental subjects in 2×2 coordination games similar to ours.

where μ and q_l are given by (5) and (9), respectively. On the other hand, tariff revenues from high-quality imports can be written as:

$$TR_h \equiv tp_h D_h = \frac{t4\overline{\theta}\mu^2(\mu-1)q_l}{(4\mu-1)^2} \tag{15}$$

and home production subsidies as:

$$SC_l \equiv sp_l D_l = \frac{s\overline{\theta}\mu(\mu-1)q_l}{(4\mu-1)^2}.$$

Using (9) and Euler's theorem, reduced-form profits of the domestic firm can be written as:

$$\pi_l = \frac{(1+s)\overline{\theta}\mu q_l}{k(4\mu-1)^3}\left[k(4\mu-1)(\mu-1)-\mu(4\mu-7)\right] \tag{16}$$

Adding these expressions we can write transition economy's welfare as:

$$W = \frac{\overline{\theta}\mu}{(4\mu-1)^2}\left[\frac{4\mu^2+7\mu-2}{2}+4t\mu(\mu-1)-\frac{(1+s)\mu(4\mu-7)}{k(4\mu-1)}\right]q_l \tag{17}$$

Let us denote the first two factors of (17) as $A(\cdot)$. Thus $W = A(\cdot)q_l$.

There is frequent discussion about the options for reforming CEECs' trade regime. Some transition economies have argued that foreign trade should be liberalized more slowly than internal markets to lessen the decline in output (see Proposition 1). These countries maintain therefore high import tariffs and low domestic prices through a system of subsidies and administrative controls. In contrast, most international organizations claim that trade controls tend to be relatively ineffective at protecting firms or raising tariff revenues (World Bank, 1996, p.32). The subsequent propositions shed some light into this important debate by showing that a trade policy can be designed to foster price competition between firms and therefore to contribute to welfare.

4.1 Positive Analysis of Trade and Industrial Policy

Starting from the benchmark case of free trade and absence of industrial policy ($s = t = 0$) the implications of a small tariff on high-quality imports are described in the following result:

Proposition 3 *A small tariff on high-quality imports leads to (a) a quality downgrade of both variants, (b) a decline of both variants' prices and hedonic prices, (c) an increase in the quantities sold and in the number of consumers being served, (d) a fall in domestic profits, (e) a decrease in consumers surplus, and (f) an increase in social welfare.*

Figure 2 provides the main intuition for this result. A tariff on high-quality imports shifts downwards the best response function of the foreign firm (from $q_h(q_l)$ to $q_h(q_l;t)$). Since both firms' reaction functions are strictly increasing, a tariff results in *quality downgrading* of both variants. Therefore, a tariff on imports undermines both firms' incentives to invest in quality. Interestingly, as shown in (5), the high quality falls more than the low quality, and thus the quality gap falls. As a result, a tariff on high-quality imports enhances price competition between firms.

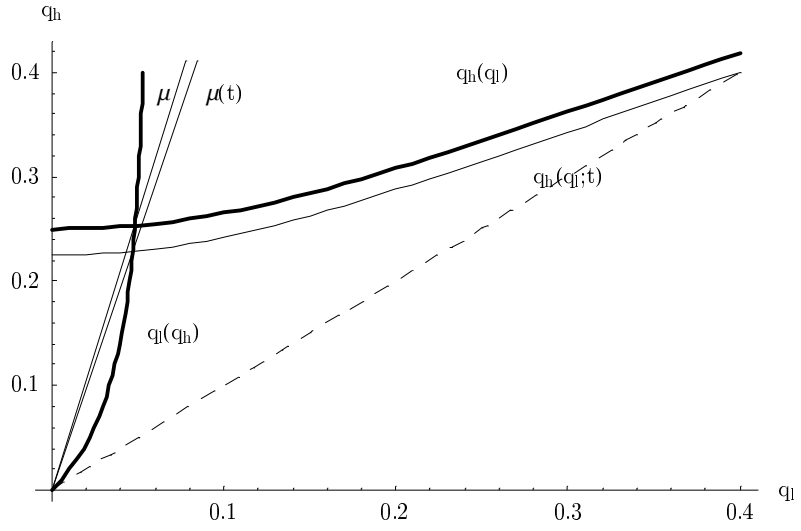

Figure 2: A tariff on high-quality imports.

To study whether a tariff is socially desirable, let us look at the three separate components of the welfare function in (13). First, it turns out that consumer surplus falls because the detrimental effects of quality downgrading offset the beneficial effects associated with tougher competition. Second, domestic profits also decrease due to the increased price competitiveness. Finally, tariff revenues are shifted from the high-quality producer abroad to the local government. This rent-shifting effect of the tariff turns out to dominate and more than offset the fall in both consumer surplus and domestic profits. As a result, an import tariff is socially desirable.[23]

We now evaluate the incidence of a small subsidy on low-quality domestic production. Again starting from free trade and no subsidy, we obtain the following result:

[23] It is interesting to compare this result to previous work under monopoly. Using our demand and cost specifications in Brander and Spencer (1984) would yield the result that a tariff against a foreign producer leaves imports and consumer surplus unchanged. Thus, it is unambiguously welfare improving because enough rent is extracted from the foreign seller. When quality is endogenous, like in Krishna (1987) and Das and Donnenfeld (1987), a tariff reduces quality, leaves imports unchanged and thus reduces consumer surplus. Our analysis here yields the insight that the case for a tariff against a foreign monopolist when quality is endogenous is reinforced in our duopoly framework because the tariff fosters price competition between the firms.

Proposition 4 *A small subsidy on low-quality home production leads to: (a) a quality upgrade of both variants, (b) a decline of both variants' hedonic prices (c) an increase in 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.*

Figure 3 shows that a subsidy on low-quality production shifts the best response function of the domestic firm to the right (from $q_l(q_h)$ to $q_l(q_h; s)$). Since both firms' reaction functions are strictly increasing, the subsidy results in *quality upgrading* of both variants. Thus, in contrast to the case of a tariff on imports, a subsidy on local production raises both firms' incentives to invest in quality. Interestingly, the low quality rises more than the high quality and thus the quality gap between the variants declines. Hence, a subsidy is also a mechanism that enhances price competition between firms.

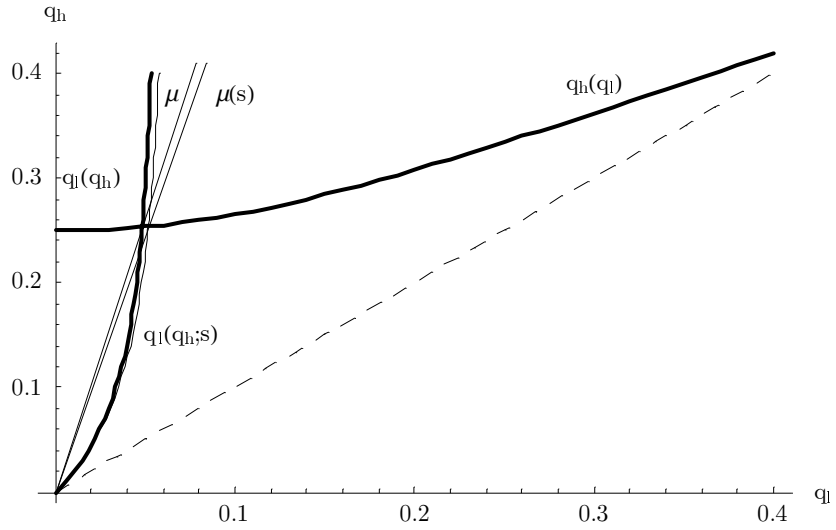

Figure 3: A subsidy on low-quality domestic production.

As to the welfare implications of the subsidy, it is clear that it enhances welfare because the subsidy (i) raises the quality of both variants and (ii) fosters price competition between firms. This in turn implies that goods of superior quality are bought by more customers at lower hedonic prices, yielding a welfare gain sufficiently large to offset subsidization expenses.

In summary, Propositions 3 and 4 indicate that the absence of government intervention in the form of free trade or zero subsidy is not an optimal policy prescription. A small tariff results in quality downgrading but improves welfare because enough income is taken away from the foreign firm to compensate for the reduction in both consumer surplus and domestic profits. In contrast, a subsidy on local production raises welfare because it results in quality upgrading and intensifies price competition. As a consequence, if the opportunity cost of public funding is low, a tariff on foreign production seems to be less appealing than a subsidy on local production because it

deteriorates qualities. Of course, the attractiveness of commercial policy compared to industrial policy increases as the opportunity cost of public funding rises.

4.2 Optimal Policy

Having shown the non-optimality of free trade, we now examine the nature of the optimal trade and industrial policy (t, s). In particular, we ask whether local firms are doomed to produce low-quality products or whether it is optimal for the active government to commit to a policy that challenges the quality leadership of the foreign firm. Recall from Proposition 2 that trade and industrial policies have a bearing on the relative development cost of the domestic firm, and therefore on the equilibrium market structure. Indeed for any e, c^* and c such that $ec \geq c^*$ there exist many pairs (t, s) such that this inequality is reversed, thus inducing *a quality reversal*. This outcome is attractive because high-quality production generates substantially higher profits.[24] However, such a policy may require too large subsidies and thus have negative consequences for social welfare.

Quality Reversal Induced by Policy

For any e, c^* and c, let us define $W_1(t, s)$ as the social welfare under any policy mix (t, s) such that low quality is manufactured locally. We refer to this situation as Assignment 1 in qualities. Denote by (t_1, s_1) the maximizer of $W_1(t, s)$, that is, $(t_1, s_1) = \arg\max W_1(t, s)$ s.t. $c^* \leq ec(1-t)/(1+s)$. Likewise, let us define $W_2(t, s)$ as the social welfare such that high quality is manufactured locally instead. We refer to this situation as Assignment 2. Denote by (t_2, s_2) the maximizer of $W_2(t, s)$, i.e., $(t_2, s_2) = \arg\max W_2(t, s)$ s.t. $c^* \geq ec(1-t)/(1+s)$. Hence $W_i(t_i, s_i)$ is the maximum level of welfare attained under Assignment i, $i = 1, 2$. Then:

Proposition 5 *[A] Consider the set of policy interventions such that the firm in the transition economy manufactures low quality. Then the best policy mix (t_1, s_1) involves (i) a positive tariff on high-quality imports and (ii) a subsidy (tax) on low-quality domestic production if firms' cost asymmetries are large (small).*
[B] Consider the set of policy interventions such that the firm in the transition economy manufactures high quality. Then the best policy mix (t_2, s_2) involves (i) a tariff (subsidy) on low-quality imports if firms' cost asymmetries are large (small) and (ii) a subsidy on high-quality domestic production.
[C] The optimal policy is (t_1, s_1) if and only if $W_1(t_1, s_1) > W_2(t_2, s_2)$. Otherwise, the optimal policy is (t_2, s_2).

[24] Higher profits from high-quality production could potentially finance future adoption of new technologies and cost-reducing investments (see Petrakis and Roy, 1999). High levels of human capital in transition economies can make this quality configuration sustainable in the long-run without government support.

Interestingly, when firms' cost asymmetries are substantial, the nature of the best policy mix is insensitive to whether low quality is produced locally or abroad, namely, domestic production is subsidized and imports are subject to a tariff. This policy clearly pursues the minimization of the quality gap to foster price competition as much as possible. In contrast, when firms' cost differences are small, then low-quality domestic production may be taxed or low quality imports may be subsidized. This arises because small cost asymmetries restrict substantially the government's choice set.

Figure 4 depicts the optimal levels of welfare under the two possible quality assignments for different values of ec/c^* and quadratic cost functions ($k = 2$). The curves $W_1(t_1, s_1)$ and $W_2(t_2, s_2)$ represent the optimal welfare levels when low and high quality is produced at home, respectively. Upon the observation of these two curves, it is clear that $W_2(t_2, s_2)$ lies above $W_1(t_1, s_1)$ when cost asymmetries ec/c^* lie to the left of point A in the graph. In this region of parameters, the activist government finds it beneficial to introduce a trade and industrial policy (t_2, s_2) that induces a quality reversal (relative to free trade). In contrast, to the right of point A, $W_1(t_1, s_1)$ lies above $W_2(t_2, s_2)$ and it is therefore not optimal to induce a quality reversal. This would require subsidies that are too large so that a higher level of welfare is attained by letting high quality be produced abroad.

Figure 4 also reproduces the welfare levels attained under free trade W_{FT} and under a prohibitive tariff W_M, i.e., a tariff that makes exports unprofitable for the foreign firm (Herguera *et al.*, 2002).[25] Comparing these two curves with the bold-kinked curve representing the optimal welfare level for any relative development cost, it is clear that welfare under the optimal policy is higher than W_{FT} and W_M. Interestingly, free trade dominates the autarky outcome for all cost asymmetries to the right of point A.[26]

[25] Under a prohibitive tariff, domestic demand is $D(p, q) = 1 - p/\overline{\theta}q$. It can be seen that social welfare is maximized when the local firm receives a subsidy $s = 1/2$ when costs are quadratic. This yields a welfare level of $W_M = 9\overline{\theta}^2/128c_1$.

[26] Remarkably, the qualitative nature of these results is robust to a change in the nature of competition. Under Cournot competition, the policy prescription is the same as that of Proposition 5 except for the fact that low-quality imports are always subject to a tariff. Moreover, the optimal policy also induces a quality leadership of the domestic firm provided that cost asymmetries are small.

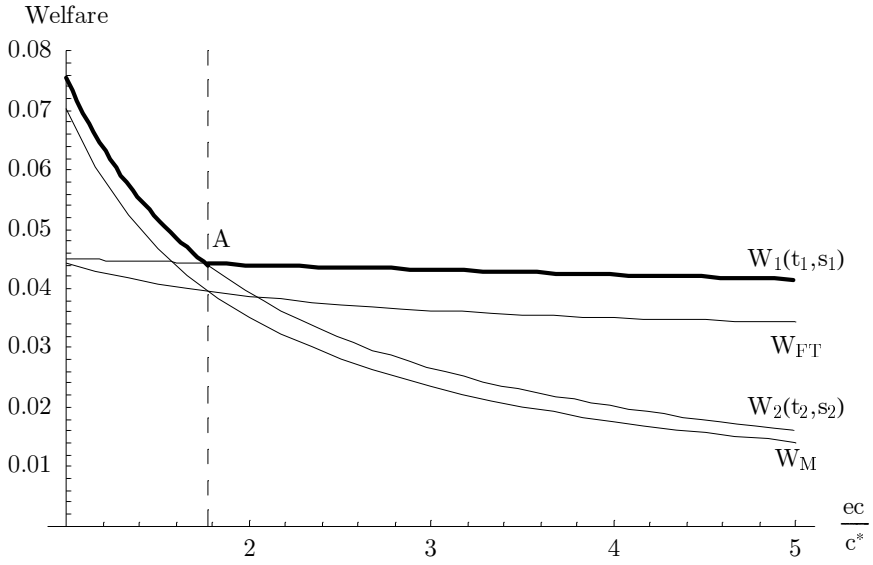

Figure 4: Welfare under free trade, prohibitive tariffs, and the two quality spectra.

Similar graphs can be obtained for levels of quality under the optimal policy. These figures reveal that low quality under the optimal policy is always above the low-quality level under free trade. In contrast, high quality under the optimal policy is typically below that under free trade. This suggests that, in absence of government intervention, the low-quality firm's incentives to invest are socially insufficient while those of the high-quality firm are typically excessive, thus yielding a too large quality gap.

5 Exchange Rate Movements

Earlier in the paper we have identified similarities between trade and industrial policies and expected long-run exchange rate changes. Central to the comparison is (5), which shows 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 imports, or of a subsidy on domestic production. A major difference is, however, that exchange rate changes do not affect government revenues. 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 whose proof is straightforward and thus omitted.

Proposition 6 *Starting from free trade, for any c and c^*, there exists an expected exchange rate e such that the quality gap and thus price competition are equal to those under the optimal trade policy. Quantities imported and hedonic prices are the same too.*

This result suggests that since most CEECs have experienced large depreciations of their currencies, this has contributed to reduce product differentiation among firms and foster price competition.

Note however that there exist differences between trade policies and exchange rate changes. First, credibility (time-consistency) issues may matter in the former while not in the latter. Second, from a welfare perspective there is a major drawback when a small depreciation of the currency occurs:

Proposition 7 *Irrespective of the quality produced by the domestic firm, a small expected depreciation of the transition economy's currency leads to a decrease in social welfare.*

An intuitive reasoning can be given for this result. Consider for example the case of high-quality imports. We can refer to (5) and Proposition 3 to argue that a depreciation of the expected exchange rate of the transition economy leads to an increase in the quantities sold and to an increase in the size of the market. However, the drawbacks are (i) that the domestic firm is harmed because of lower profits and (ii) that consumer surplus decreases because the quality of both variants fall. As there is no effect on government revenues, social welfare unambiguously falls. The same can be argued for the case of low-quality imports.

Finally, note that *large* depreciations of the exchange rate may lead to a quality reversal like trade and industrial policies do. Indeed, for any initial level of cost asymmetries, there may be a long-run expected exchange rate $\widehat{e}$ such that $\widehat{e}c < c^*$, which according to Proposition 2 would lead the domestic firm to leapfrog the foreign competitor in the quality ladder.[27] Depending on initial conditions, this might increase welfare because high-quality production yields substantially higher profits.

6 Conclusion and Discussion

This paper has considered trade and industrial policy in transition economies from a positive and a normative point of view in a partial equilibrium framework. The discerning features of these economies which have been emphasized in our model include the existence of a local monopoly in autarky, a quality gap between Western goods and those manufactured in CEECs, the presence of a high level of government intervention in economic activity, and the observed large depreciations of their currencies.

Our framework of analysis has been a duopoly model of vertical differentiation and international trade. We have shown that (i) 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.

[27] These observations further imply that the import demand function has an inverted "v" shape in relation to the exchange rate. A quality reversal gives rise to a discontinuity at some $\overline{e}$, where $\overline{e}$ satisfies $c\overline{e}(1-t)/(c^*(1+s)) = 1$. For any expected exchange rate below this value, imports are of low quality and increasing in the exchange rate. In contrast, for any expected exchange rate above $\overline{e}$, imports are of high quality and respond negatively to any further exchange rate appreciation.

(*ii*) The domestic government can raise home welfare either by imposing a tariff on high-quality imports or by subsidizing home low-quality production, which proves the non-optimality of free trade. Interestingly, one of the attractive features common to these interventions is that they enhance price competition between firms. (*iii*) Output effects of trade liberalization are sensitive to whether local firms produce high-quality or low-quality goods. Moreover, trade liberalization may have been a contributing factor to the decline in output and to price rises experienced by many CEECs in the 1990s. Whether social welfare improves with trade liberalization depends on initial conditions. (*iv*) Optimal government intervention via tariffs and subsidies induces the firm in the transition economy to leapfrog the foreign competitor's quality, provided that cost differences are not excessive; otherwise, high-quality production occurs abroad. (*v*) Finally, 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 usually leads to social welfare losses.

Our results have been derived in the context of a duopolistic market structure. We have thus ignored the possibility of entry resulting from government intervention in the domestic market. A multi-firm framework could be analyzed along the lines of this paper, but at the cost of increased complexity. A taxonomy of cases would arise because of the distinct firms' development costs and their attempts to leapfrog each other's quality. The risk-dominance criterion could still be applied numerically on a bilateral comparison of firms. Social welfare would be affected by the relative number of local firms and the optimal trade policy would become sensitive to the position of these firms on the quality spectrum. Presumably, the beneficial effects of trade liberalization would be enhanced if entry were allowed.

An interesting extension of our model would be one which allows for the foreign government to retaliate. It can be shown that, if the domestic government is inactive, unilateral trade policy of the foreign country would consist of taxing its own firm (like in Zhou *et al.* (2002)). However, such a policy cannot be optimal if cost asymmetries are small and the domestic government is also active, because it would help the local government in its attempt to induce quality leadership of its firm. This would substantially lower the profits of the foreign firm and thus the welfare of the foreign country. Therefore, we expect the foreign government to confer a subsidy to its firm in order to discourage the domestic firm to become a quality leader.

A second interesting extension would be to allow for foreign direct investments, which seem to be crucial for the economic development of some transition economies. A first possibility is that, under a privatization program, the incumbent firm is acquired by the foreign competitor. The domestic country would then be confronted with a two-plant foreign monopolist and we expect the optimal policy to be similar to Krishna (1987). Another possibility is that the local firm is acquired by a third foreign firm. This would only affect the first stage of the game in that domestic profits

in (16) would now be repatriated abroad and therefore drop from the expression for domestic social welfare (see Moraga-González and Viaene, 2001).

7 Appendix

Proof of Proposition 1: (a) From (6), we obtain $\partial D_l/\partial t = -(\partial \mu/\partial t)/(4\mu-1)^2$. From (5), it follows that $\partial \mu/\partial t < 0$. Therefore $\partial D_l/\partial t > 0$. Since $D_h = 2D_l$, then $dD_h/dt > 0$. (b) Notice that $dp_l/dt = q_l(\partial p_l/\partial \mu)(\partial \mu/\partial t) + (p_l/ql)(dq_l/dt)$. It is readily seen that $\partial p_l/\partial \mu > 0$. Note also that the RHS of (9) increases with μ. Since $C(\cdot)$ is convex, then we have $\partial q_l/\partial \mu > 0$ and therefore $(dq_l/dt) = (\partial q_l/\partial \mu)(\partial \mu/\partial t) < 0$. Therefore $dp_l/dt < 0$. One shows similarly that $dp_h/dt < 0$. ■

Proof of Proposition 3: Note that $\partial \mu/\partial t < 0$. (a) Notice that the RHS of (9) increases with μ. Since $C(\cdot)$ is convex, $\partial q_l/\partial \mu > 0$ and therefore $(dq_l/dt) = (\partial q_l/\partial \mu)(\partial \mu/\partial t) < 0$. Since $q_h = \mu q_l$, it follows that $dq_h/dt < 0$. (b) As noted in the proof of Proposition 1, prices fall with the tariff. Since $\partial(p_h/q_h)/\partial \mu > 0$, it follows that $d(p_h/q_h)/dt < 0$. One shows similarly that $d(p_l/q_l)/dt > 0$. (c) Once again, this follows from Proposition 1. (d) The profits of the domestic firm in the absence of industrial policy can be written as $\pi_l = \overline{\theta} q_l F(\mu) - cC(q_l)$ where $F(\mu) = \mu(\mu-1)/(4\mu-1)^2$. We need to find the sign of

$$\frac{d\pi_l}{dt} = \overline{\theta} q_l F'(\mu)\frac{\partial \mu}{\partial t} + \left[\overline{\theta} F(\mu) - cC'(q_l)\right]\frac{dq_l}{dt} \tag{18}$$

Using (9), $\overline{\theta} F(\mu) - cC'(q_l) = \overline{\theta}\mu F'(\mu)$ where $F'(\mu) = (2\mu+1)/(4\mu-1)^3$. Therefore (18) reduces to

$$\frac{d\pi_l}{dt} = \overline{\theta} F'(\mu)\left[q_l\frac{\partial \mu}{\partial t} + \mu\frac{dq_l}{dt}\right] = \overline{\theta} F'(\mu)\frac{dq_h}{dt} < 0,$$

where the inequality follows from (a). (e) Using (14) we can compute

$$\frac{dCS}{dt} = \frac{\partial CS}{\partial \mu}\frac{\partial \mu}{\partial t} + \frac{\partial CS}{\partial q_l}\frac{dq_l}{dt}.$$

Note that $\partial CS/\partial \mu = \overline{\theta}\mu\left[\mu(8\mu-6)-5\right]q_l/(4\mu-1)^3 > 0$ and that $\partial CS/\partial q_l > 0$. Then, using the results above we obtain that $dCS/dt < 0$. (f) Finally, social welfare equals $W = CS + TR_h + \pi_l$. Now, notice that $d\pi_l/dt < 0$ and $dCS/dt < 0$ as shown in (d) and (e) respectively. Then welfare can only rise whenever import tariff proceeds are large enough. We need to compare the relative magnitude of these two forces working in opposite directions. Notice that, as shown in (a), q_l falls with t, and therefore $C(q_l)$ does so too. Therefore, to prove the result it is enough to show that

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

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

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

Observe that $dq_h/dt = \partial q_h/\partial t + (\partial q_h/\partial\mu)(\partial\mu/\partial t)$. Using the Euler's theorem and equations (4) and (10) we can obtain the following derivatives:

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

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

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

or

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

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 4: Note first that applying the implicit function theorem to equation (4) we have that $\partial\mu/\partial s < 0$. (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 thus $dq_h/ds = (\partial q_h/\partial\mu)(\partial\mu/\partial s) > 0$.Since $q_l = q_h/\mu$,it follows that $dq_l/ds > 0$. (b) Using (8) we have that $p_h/q_h = 2\overline{\theta}(\mu-1)/(4\mu-1)$. Since $\partial(p_h/q_h)/\partial\mu = 6\overline{\theta}/(4\mu-1)^2 > 0$,then $d(p_h/q_h)/ds < 0$. One shows similarly that $d(p_l/q_l)/ds < 0$. (c) Using (6), we have

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

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

$$\frac{d\pi_l}{ds} = \overline{\theta}q_l F(\mu) + (1+s)\overline{\theta}q_l F'(\mu)\frac{\partial\mu}{\partial s} + \left[(1+s)\overline{\theta}F(\mu) - cC'(q_l)\right]\frac{dq_l}{ds} \tag{19}$$

Now we can use (9) to state that $(1+s)\overline{\theta}F(\mu) - cC'(q_l) = (1+s)\overline{\theta}\mu F'(\mu)$ where $F'(\mu) = (2\mu + 1)/(4\mu-1)^3$. Therefore equation (19) reduces to

$$\begin{aligned}\frac{d\pi_l}{ds} &= \overline{\theta}q_l F(\mu) + (1+s)\overline{\theta}F'(\mu)\left[q_l\frac{\partial\mu}{\partial s} + \mu\frac{dq_l}{ds}\right] \\ &= \overline{\theta}q_l F(\mu) + (1+s)\overline{\theta}F'(\mu)\frac{dq_h}{ds} > 0,\end{aligned}$$

where the inequality follows from (a). Likewise, one can prove that gross profits $\widetilde{\pi}_l = \pi_l + s\overline{\theta}q_h F(\mu)/\mu$ by noting that $F(\mu)/\mu$ declines with μ.
(e) From (14) consumer surplus can be written as

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

Then, $dCS/ds = (\partial CS/\partial\mu)(\partial\mu/\partial s) + (\partial CS/\partial q_h)(dq_h/ds)$. 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 $dCS/ds > 0$. (f) Finally, social welfare equals $W = CS - SC_l + \pi_l = CS + \widetilde{\pi}_l$. Now, since $d\widetilde{\pi}_l/ds > 0$ and $dCS/ds > 0$ as shown above, it follows that $dW/ds > 0$. The proof is now complete. ■

Proof of Proposition 5: Note that social welfare is given by (17) provided that the domestic firm manufactures a low-quality good. The active government must find (t,s) to maximize (17) subject to the constraint that $c/(1+s) \geq c^*/(e(1-t))$. If welfare attains a maximum at an interior point, then the first order conditions that must be satisfied can be rearranged in the following manner:

$$\frac{dW}{dt} = \frac{W}{1-t}\left[\frac{(1-t)}{A}\frac{4\overline{\theta}\mu^2(\mu-1)}{(4\mu-1)^2} - \alpha\beta\right] \tag{20}$$

$$\frac{dW}{ds} = \frac{-W}{1+s}\left[\frac{(1+s)}{A}\frac{\overline{\theta}\mu^2(4\mu-7)}{k(4\mu-1)^3} + \alpha\beta - \frac{1}{k-1}\right] \tag{21}$$

where $\alpha = (d\mu/dr)(r/\mu)$, with $r = ec(1-t)/c^*(1+s)$, and $\beta = (dW/d\mu)(\mu/W)$.[28] Here α represents the elasticity of the quality gap μ with respect to the relative development cost 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.

Suppose for the moment that the constraint of the program is not binding, i.e., $c/(1+s) > c^*/(e(1-t))$. The best interior trade and industrial policy provided that foreign firm produces high quality is a pair (t,s) solving the first order conditions (20) and (21), along with equations (4), (9)

[28] Equations (20) and (21) are presented in a compact way. There is a series of steps that we omit here to save on space.

and (10). We can isolate $\alpha\beta$ from (20) and (21) to obtain:

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

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

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

Therefore

$$t = \frac{\left[8(k-1)\mu(\mu-1) - 4\mu^2 - 7\mu + 2\right]}{8k\mu(\mu-1)} + \frac{2(1+s)(4\mu-7)}{8k(\mu-1)(4\mu-1)}. \tag{22}$$

This equation gives a relationship between t and s at an interior equilibrium. It further shows that the best trade policy when high quality is produced abroad is a *positive* tariff, irrespective of whether local production is subsidized or taxed.[29] This stems from the fact that a tariff on foreign production enables the domestic government to extract rents from the foreign firm that are sufficient to offset the negative effects associated to quality downgrading. Since in an interior equilibrium $1 + s < ec(1-t)/c^*$, low quality production is taxed whenever cost asymmetries are low, while it will typically be subsidized when cost differences are high.

It may very well happen that the solution to the system of equations (4), (9), (10), (20) and (21) violates the constraint $c/(1+s) \geq c^*/(e(1-t))$. If this is so, such constraint should be binding and it is readily seen that when cost asymmetries are large then domestic production will be surely subsidized. We note that for the quadratic cost case ($k = 2$) of Figure 4, the restriction is indeed binding. Let (t_1, s_1) be the solution to such program; then $W_1(t_1, s_1)$ denotes the welfare level attained under the best trade and industrial policy provided high-quality production occurs abroad.

The same steps as before can be taken to study the best policy mix among the set of policy interventions such that high-quality production occurs domestically. For this purpose government must choose (t, s) to optimize $W = CS - sp_hD_h + tp_lD_l + \pi_h$ subject to the constraint that $c/(1+s) \leq c^*/(e(1-t))$. We do not report details of these computations here since they do not add further insights. The calculations reveal that in an interior equilibrium, imports face a tariff when k is large; otherwise a subsidy is in place. For the quadratic cost case, we find that the constraint

[29] Note that $s \geq -1$. Moreover, it can be seen that if the constraint is not binding then μ is a number greater than 5 and thus the first summand of (22) is positive.

is generally binding. In such a case, when cost asymmetries are low, imports face a subsidy and thus local production is also subsidized. When cost differences are large, imports face a tariff and domestic production a subsidy. Let (t_2, s_2) be the solution to this second program and $W_2(t_2, s_2)$ the corresponding welfare level when home firm produces high quality. The optimal policy is obviously given by the solution to the overall program, that is, (t_1, s_1) if and only if $W_1(t_1, s_1) > W_2(t_2, s_2)$; otherwise (t_2, s_2). We illustrate this solution by means of the bold curve in Figure 4 in the main body of the paper. ■

Proof of Proposition 7: Let us first consider the case where the low-quality variant is produced at the domestic country. Assuming $t = s = 0$, social welfare is the sum of consumer surplus in (14) and domestic firm's profits in (16) $W = \overline{\theta}\Gamma(\mu)q_l/2$ 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 (14) and the profits derived from high-quality production $W = \overline{\theta}\Psi(\mu)q_h/2$ 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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Supplementary Appendix
(not for publication)

to **Trade Policy and Quality Leadership in Transition Economies**

by José Luis Moraga-González and Jean-Marie Viaene

In this note, we provide the proof of Proposition 2. Recall that for any given government intervention (t, s), there may potentially be two pure-strategy quality equilibria in our continuation game. In the first equilibrium, high quality is produced abroad while in the second it is produced locally. We refer to the first situation as Assignment 1 (A1) and to the second as Assignment 2 (A2).

Consider first the assignment in qualities A1. In this case, the quality gap is given by the solution to (4). Let us denote the solution to this equation as μ_1. The equilibrium qualities are in this case obtained from (9) and (10):

$$q_l = C'^{-1}\left[(1+s)\frac{\overline{\theta}\mu_1^2(4\mu_1-7)}{c\,(4\mu_1-1)^3}\right],\ q_h^* = C'^{-1}\left[e(1-t)\frac{4\overline{\theta}\mu_1(4\mu_1^2-3\mu_1+2)}{c^*\,(4\mu_1-1)^3}\right].$$

Consider now the alternative quality spectrum defined by Assignment 2. In this case the equilibrium product differentiation would be given by the solution to (11). Denote the solution to this equation as μ_2. Then, under A2, equilibrium qualities are:

$$q_h = C'^{-1}\left[(1-t)\frac{4\overline{\theta}\mu_2(4\mu_2^2-3\mu_2+2)}{c\,(4\mu_2-1)^3}\right],\ q_l^* = C'^{-1}\left[e(1+s)\frac{\overline{\theta}\mu_2^2(4\mu_2-7)}{c^*\,(4\mu_2-1)^3}\right].$$

The result reads as follows:

Proposition 2: *Given any trade and industrial policy (t, s), in the unique risk-dominant equilibrium: (i) low quality is produced by the domestic firm if and only if $c^* < ec(1-t)/(1+s)$, (ii) high quality is produced by the domestic firm when this inequality is reversed, and (iii) when $c^* = ec(1-t)/(1+s)$, the domestic firm may produce either high or low quality.*

Proof: We first prove a partial result given in Lemma 1 below. This result states that the domestic firm produces low quality in the unique subgame perfect equilibrium provided that cost differences are sufficiently large. For small cost differences, a more powerful equilibrium refinement is needed. In this case, we employ the risk-dominance criterion of Harsany and Selten (1988). Applying analytically this refinement to our game proves to be quite difficult since equilibrium profits cannot be computed explicitly. As a result, we have chosen to apply the refinement numerically for several polynomial specifications of the cost function.

Lemma 1 *For any government intervention (t, s) and any other parameters, there exists $\widehat{c}^*$ such that for all $c^* < \widehat{c}^*$ the unique quality configuration which is part of a subgame perfect equilibrium is such that low quality is produced by the domestic firm.*

Proof: Consider that the foreign firm produces low quality instead. We shall show that this firm finds it beneficial to leapfrog the domestic firm whenever $c^*/e(1-t)$ is sufficiently low compared to $c/(1+s)$. Consider the foreign firm contemplating to leapfrog rival's quality choice. Then, this firm would choose q to maximize its deviating profits. These are given by:

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

The first order condition is:

$$e(1-t)\frac{4\overline{\theta}q(4q^2-3qq_h+2q_h^2)}{(4q-q_h)^3} - c^*C'(q) = 0 \tag{23}$$

Let us define $q = \lambda q_h$ where $\lambda \geq 1$. Then, from (23) we can write:

$$C'(q) = e(1-t)\frac{4\overline{\theta}\lambda(4\lambda^2-3\lambda+2)}{c^*(4\lambda-1)^3} = C'(\lambda q_h) = \lambda^{k-1}(1+s)\frac{4\overline{\theta}\mu_2(4\mu_2^2-3\mu_2+2)}{c\,(4\mu_2-1)^3}$$

From this relationship, we can obtain:

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

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

$$\frac{\mu_2^{k+1}(4\mu_2-7)}{4\,(4\mu_2-1)^3} = \frac{(4\lambda^2-3\lambda+2)}{\lambda^{k-2}(4\lambda-1)^3} \tag{24}$$

Refer to the solution of this equation as λ_2. Note that the LHS of (24) 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 foreign firm's deviating profits given by

$$\widehat{\pi}_h^* = e(1-t)\frac{4\overline{\theta}\lambda_2^2(\lambda_2-1)}{(4\lambda_2-1)^2}q_h - c^*C(q),$$

or

$$\widehat{\pi}_h^* = e(1-t)\frac{4\overline{\theta}\lambda_2^2(\lambda_2-1)}{(4\lambda_2-1)^2}\mu_2 q_l - c^*C(\lambda_2\mu_2 q_l)$$

with equilibrium benefits given by

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

The foreign firm finds it profitable to deviate from the proposed equilibrium whenever $\widehat{\pi}_h^* \geq \pi_l^*$, i.e., if and only if

$$e(1-t)\overline{\theta}\left[\frac{4\lambda_2^2(\lambda_2-1)}{(4\lambda_2-1)^2}\mu_2 - \frac{\mu_2\,(\mu_2-1)}{(4\mu_2-1)^2}\right] \geq \frac{(\lambda_2^k\mu_2^k-1)c^*C(q_l)}{q_l}. \tag{25}$$

Now, using Euler's theorem, we note that

$$\frac{C(q_l)}{q_l} = \frac{C'(q_l)}{k} = \frac{e(1-t)\overline{\theta}\mu_2^2(4\mu_2-7)}{kc^*(4\mu_2-1)^3},$$

Then we can rewrite (25) as follows:

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

Or,

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

We can use (24) to substitute $\lambda_2^k\mu_2^k$ in the equation above. This yields:

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

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's rate of increase is greater than the RHS's rate of decrease. Since λ_2 increases while μ_2 decreases as c^* falls, it is clear that there exists some sufficiently low $\overline{c}^*$ such that for all $c^* < \overline{c}^*$ the above inequality holds and thus the foreign firm would find it beneficial to deviate and leapfrog the domestic firm.

We now show that the quality configuration where low quality is produced locally is an equilibrium provided that c^* is sufficiently low. We first check that both firms' profits at the proposed equilibrium are non-negative. We then prove that no firm has an incentive to leapfrog its rival's choice. Equilibrium profits of the low-quality firm under Assignment 1 can be written as (using

Euler's theorem):

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

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

$$\pi_l = \frac{(1+s)\overline{\theta}\mu_1 q_l}{k(4\mu_1-1)^3}\left[k(4\mu_1-1)(\mu_1-1)-\mu_1(4\mu_1-7)\right]. \tag{26}$$

The expression in (26) is positive provided that $q_l > 0$. But in a proposed equilibrium $\mu_1 > 0$ and thus q_l and q_h are also positive. One can prove that profits of the high-quality firm are also positive analogously.

We now check that, under Assignment 1, no firm has an incentive to leapfrog its rival's choice whenever c^* is sufficiently low. Consider the case of upward leapfrogging first, i.e., suppose the domestic firm deviates by leapfrogging its rival's quality. In such a case, the home firm would select $q \geq q_h$ to maximize its deviating profits. These are given by:

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

The first order condition is:

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

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

$$C'(q) = (1+s)\frac{4\overline{\theta}v(4v^2-3v+2)}{c(4v-1)^3} = C'(vq_h) = v^{k-1}e(1-t)\frac{4\overline{\theta}\mu_1(4\mu_1^2-3\mu_1+2)}{c^*\left(4\mu_1-1\right)^3}$$

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

$$\frac{(1-t)\,ec}{(1+s)\,c^*} = \frac{v(4v^2-3v+2)}{v^{k-1}(4v-1)^3}\frac{(4\mu_1-1)^3}{\mu_1(4\mu_1^2-3\mu_1+2)} \tag{27}$$

Using equation (4), we can substitute ec/c^* to rewrite (27) as:

$$\frac{v(4v^2-3v+2)}{v^{k-1}(4v-1)^3} = \frac{\mu_1^{k+1}(4\mu_1-7)}{4\left(4\mu_1-1\right)^3} \tag{28}$$

Denote the solution to this equation as v_1 and notice that v_1 and μ_1 are inversely related since the LHS of (28) decreases with v while its RHS increases with 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 (26) while deviating profits can be written as:

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

We can use equation (28) and Euler's theorem to write $\widetilde{\pi}_h$ as:

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

From (27) and (28), it follows that v_1 falls while μ_1 increases as c^* falls. As a result, simple inspection of $\widetilde{\pi}_h$ and π_l reveals that there exists $\underline{c}^*$ such that for all $c^* < \underline{c}^*$ Assignment 1 is an equilibrium of the continuation game. The case of downward leapfrogging is readily ruled out by observing that low-quality production yields lower profits that high-quality production, ceteris paribus. The arguments above imply that there exists $\widehat{c}^* = \min\{\underline{c}^*, \overline{c}^*\}$ such that for all $c^* < \widehat{c}^*$ Assignment 1 constitutes the unique quality configuration that can be part of a subgame perfect equilibrium. The proof of Lemma 1 is now complete.

In what follows we apply the Harsanyi-Selten criterion to our setting. This refinement rules out the equilibrium where high quality is produced domestically whenever $c^* < ec(1-t)/(1+s)$. The refinement works as follows in our setting. Both firms face the choice between the equilibrium given by Assignment 1 ($A1$) and the one given by Assignment 2 ($A2$). These choices can be represented in 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^*

The payoffs π_l^{12} and π_h^{*12} denote the profits 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 good given by Assignment 2. The payoffs π_l^{21} and π_h^{*21} are interpreted similarly.

As indicated above, when cost differences are small, $\{A_1, A_1^*\}$ and $\{A_2, A_2^*\}$ are both equilibria of the subgame; these equilibria yield 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. Similarly, 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 $G_{11}G_{21} > G_{12}G_{22}$.

Unfortunately, applying theoretically this refinement to our game is very difficult because the maximizers of $\pi_l, \pi_h^*, \pi_l^*, \pi_h, \pi_h^{*12}, \pi_l^{12}, \pi_l^{21}$ and π_h^{*21} cannot be obtained explicitly. Thus, we have chosen to simulate our model using polynomial cost functions of various degrees. Figure 5 depicts the gains G_{11}, G_{21}, G_{12} and G_{22} as a function of the effective relative costs $ec(1-t)/(c^*(1+s))$, for a quadratic cost of quality function.

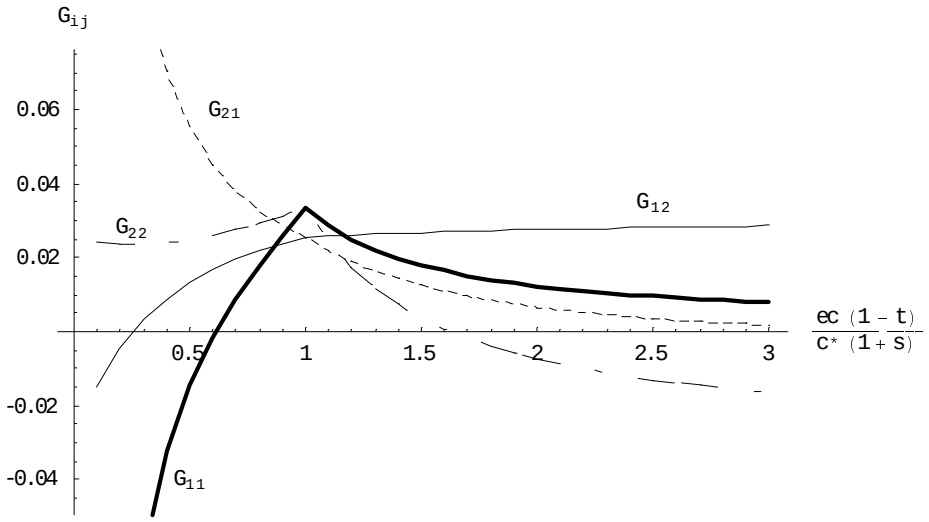

Figure 5

Inequality $G_{11}G_{21} > G_{12}G_{22}$ can be evaluated by observing Figure 6. This graph shows $G_{11}G_{21}$ and $G_{12}G_{22}$ as a function of relative costs. It can be seen that $G_{11}G_{21} > G_{12}G_{22}$ if and only if relative costs are greater than 1. This implies that Assignment 2 is ruled out whenever the domestic firm is (relatively) less efficient than the foreign firm. This, together with Lemma 1 proves part (i) of Proposition 2. If the domestic firm is (relatively) more efficient than the domestic firm, Assignment 1 is selected away (part ii). The criterion has no bite if the two firms are equally efficient (part iii). We have conducted a number of simulations with different polynomial cost functions and the selection criterion does not change.

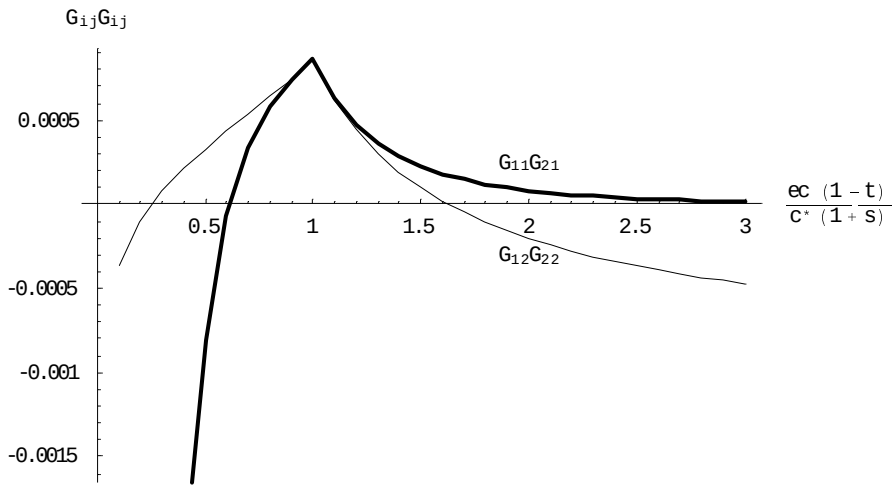

Figure 6: Harsanyi-Selten criterion.