Strategic Trade Policy and Vertical Product Differentiation: intra-industry trade between developed and developing countries

Michael Kunin
Kresimir Zigic

CERGE-EI

Charles University
Center for Economic Research and Graduate Education
Academy of Sciences of the Czech Republic
Economics Institute

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230

Strategic Trade Policy and Vertical Product Differentiation: intra-industry trade between developed and developing countries*

Michael Kúnin† and Krešimir Žigić‡

Abstract

We analyse the effects of simple strategic trade policy in a duopoly with vertical product differentiation where firms from a developed and less developed country compete in both qualities and prices in the domestic market. The distinction between the developed and developing country firm is captured through the difference in the marginal efficiency in production of quality, where the latter has lower marginal efficiency than the former. We concentrate on the case when the domestic market is in a less developed country and when it possesses the characteristics of a "natural duopoly". That is, the size of the market is such that only two firms can survive in it. We analyse under which conditions welfare maximising trade policy in the form of tariffs can lead to so-called quality reversal, that is, to the situation in which an initially low quality domestic firm will jump up the quality ladder in anticipation of the optimal trade policy. We then contrast our findings with related results concerning quality reversal in the relevant trade literature.

Abstrakt

Analyzujeme důsledky jednoduché strategické obchodní politiky v duopolu s vertikálním rozlišováním produktů, kde si firmy z rozvinuté a rozvojové země konkurují v kvalitě a ceně na domácím trhu. Rozdíl mezi firmou z rozvinuté země a firmou z rozvojové země je zachycen rozdílem v mezní efektivitě při výrobě kvality, přičemž firma z rozvojové země má nižší mezní efektivitu. Soustřeďujeme se na případ, kdy domácí trh je v rozvojové zemi a má vlastnosti přirozeného duopolu. To znamená, že velikost trhu je taková, že na něm mohou přežít jen dvě firmy. Analyzujeme, za jakých podmínek blahobyt maximalizující obchodní politika v podobě cel může vést k takzvanému „obrácení kvality," tedy k situaci, při níž domácí firma, která původně dodávala nižší kvalitu, v anticipaci optimální obchodní politiky začne dodávat vyšší kvalitu než zahraniční firma. Poté porovnáváme naše závěry s obdobnými výsledky vztahujícími se k „obrácení kvality" v relevantní literatuře.

JEL classification: F12; F13; L13

Keywords: Vertical differentiation; Optimal tariff; Quality reversal; Natural duopoly.

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† Charles University and the Academy of Sciences of the Czech Republic, CERGE-EI, Politických vězňů 7, 111 21 Prague 1, Czech Republic; michael.kunin@cerge-ei.cz.

‡ Charles University and the Academy of Sciences of the Czech Republic, CERGE-EI, Politických vězňů 7, 111 21 Prague 1, Czech Republic, and CEPR, London; kresimir.zigic@cerge-ei.cz.

1 Introduction

The concept of vertical product differentiation was until recently practically absent in the considerations of strategic trade theorists, since the prevalent benchmark in the field was oligopoly competition with horizontally differentiated products. Thus, for instance, J. Brander did not have a reason to devote more than two sentences to the effects of trade policy on product quality in his famous survey from the mid-nineties (Brander, 1995). The neglected role of vertical product differentiation seems now to have become history and, according to some authors (Ghosh and Das, 2001), this new focus could lead to a revival of the whole subject of strategic trade policy[1].

The inclusion of vertical product differentiation in the context of strategic trade is not a purely theoretical exercise, but has solid empirical underpinnings. Namely, recent empirical trade literature has managed to distinguish between intra-industry trade (IIT) that is based on horizontal product differentiation ("horizontal IIT") from intra-industry trade based on vertical product differentiation ("vertical IIT"), pointing to the different factors that determine these trade flows. An interesting and somewhat surprising fact is that in general vertical IIT represents a significantly larger share in the total IIT (Greenaway et al., 1994 and 1995). As Schott (2004) has demonstrated, this kind of trade is also consistent with the Heckscher-Ohlin type of specialisation but within products (varieties), where the producers from a capital and skill-intensive country use their advantage to produce vertically superior varieties, that is, varieties that are relatively capital or skill-intensive and possess higher quality. The novelty of his approach is that this specialisation occurs within products rather than, as previously assumed, across products. This also may explain the empirical fact that firms and workers in developed countries not only continue to produce but also to export in industries like apparel and textiles, which are commonly associated with developing countries.

Vertical IIT seems to be a typical pattern in trade between developed countries (DC) and less developed countries (LDC) (Clark and Stanley, 1999). As is clear from the above discussion, trade between DC and LDC is characterised by the different product qualities that they offer in the same market (see Table 3 in Greenaway et al., 1994). Thus, for example, U.S. firms export high-quality (and high-value) products such as hydraulic actuators and high-pressure valve stems and seats to Mexico (U.S. International Trade Commission, 1996) and compete there with the Mexican firms that offer the corresponding product varieties of lower quality. At the same time, Mexican firms export simple low-quality steel and iron valve body housings to the U.S. (U.S. International Trade Commission, 1996), competing with high-quality products of the American firms in the U.S. market.

[1] Ghosh and Das (2001) see the main reason for the current stagnation of the field of strategic trade policy in the neglected role of vertical product differentiation in international trade theory.

The same phenomenon holds (or at least used to hold) for transition countries as well. Thus, for instance, Landesmann and Burgstaller (1997) observe quality differences between Western and Eastern European intra-industry trade. Even more striking, Aturupane et al. (1999) find that vertically differentiated intra-industry trade accounts for 80 to 90 percent of the total intra-industry trade between the EU and advanced Central European transition economies. Similarly, Van Berkum (1999) analyses the pattern of intra-industry trade in agricultural products between the EU and Central European countries, and finds that vertical product differentiation dominates this trade[2]. Finally, Greenaway et al. (1995) show that in the United Kingdom over two thirds of all intra-industry trade is vertically differentiated, which seems to be just a mirror image of the above-described phenomenon.

On the one hand, the motivation for our paper comes from the above-cited empirical evidence which demonstrates that vertical product differentiation is the *differentia specifica* of IIT between DC and LDC firms and, on the other hand, from the lack of appropriate modeling of the above phenomenon. Since the majority of IIT takes place in imperfectly competitive markets, an adequate theoretical analysis has to take into account the strategic interaction among the competing firms, the market structure that comes out of this interaction, as well as the timing and incentives of the government(s) to intervene in such a set-up. The strategic choices in our particular context concern the firms' selection of product qualities on the one side and the appropriate government policy on the other side. Moreover, the very nature of IIT indicates that the domestic (or internal) markets in both DC and LDC may be in the focus of the analysis.

To the best of our knowledge, there are few theoretical papers that deal with some of the above issues. Some of the first theoretical papers connecting vertical product differentiation and strategic trade are those by Zhou et al. (2000 and 2002), where the authors analyse endogenous quality choice by the firms. However, the stage of action is not the domestic market but rather the standard "third country market" case. Subsequent contributions concentrate on the domestic market, which is arguably a more insightful and more relevant case for the purpose of our analysis. Thus, the already mentioned Ghosh and Das (2001) emphasise competition in the domestic market, in the context where a developed country firm competes with a developing country firm and where the domestic market can be either in the developed or in the developing country. Quality is set exogenously, whereby the developed country firm produces the commodity of high quality and the developing country, of low quality. The authors show that the developing country firm may not survive in the developed country market once the optimal trade policy is applied, but the opposite is not true: the developed country firm always sustains itself in the developing country market under the optimal set of strategic trade policies (tariffs or tariffs *cum* output subsides.) As for the timing of the game, they applied standard

[2]See also Fertő (2002).

sequencing where the governments commit in advance to selected policy instruments.

Moraga-González and Viaene (2004) use a structure very similar to that of Ghosh and Das (2001), with the only difference being that the quality choice is now endogenous, which in turn requires an intermediate stage to be added to the Ghosh and Das' (2001) two-stage game. However, the addition of the endogenous quality choice may have important consequences since the effect of the domestic government's trade and industrial policy (tariffs and subsidies, respectively) may lead to a change in quality leadership. Moreover, Moraga-González and Viaene (2004) confine their analysis to transition economies, identifying the conditions under which the change in quality leadership from developed to transition country firm occurs.

The last relevant paper is Herguera et al. (2002), where the authors also set the stage for the action to be in the domestic, internal market and assume that the quality is chosen endogenously. More importantly, unlike the above-mentioned papers, Herguera et al. (2002) allow for the reverse sequencing of the strategic moves between the firms and the government. However, their analysis relies on the *ex ante* symmetry between the firms and is not carried out in the context of DC versus LDC firms.

We put forward a simple strategic trade duopoly model with vertical product differentiation where the action takes place in the domestic market. The strategic choice considered is the firms' selection of product qualities, and duopoly as a market structure emerges endogenously from the nature of the competition and the size of the market. The trade policy in question is an import tariff and finally, the government sets the tariff only after the firms' quality choice has taken place. Following Neary's (1991) terminology, we, like Herguera et al. (2002) label this set-up an "ex post tariff game". A reason for this reverse sequencing of moves between the firms and the domestic government is that the government may lack credibility with the firms whose behavior it tries to influence, or there may be a time lag between the announcement and the implementation of strategic trade policy (Neary and Leahy, 2000)[3].

All of the literature reviewed above focuses on the exogenously imposed "uncovered" market, i.e., on the situation where the distribution of the consumers with respect to their taste for quality is such that the lowest tail is not served in equilibrium. We, on the other hand, consider both "uncovered" and "covered" market cases and analyse the conditions under which these structures occur in equilibrium. The issue of whether the market is covered or not is endogenous and depends on the size of the market that seems natural to be taken as exogenous. Thus, for instance, the authors from the field of business strategy (Porter, 1990; Linder, 1961), consider market size to be the starting point (parameter) and investigate how it impacts other relevant variables like qualities,

[3]It seems that Carmichael (1987) was the first who referred to empirical evidence showing that in practice the government often sets its policy only after it observes firms' action. See also Gruenspecht (1988) and Neary (1991).

international competitive advantage, and the like. Our main focus is when there is a "covered" market in equilibrium. Following Shaked and Sutton (1982), we label such a market a "natural duopoly." More specifically, we study the impact of the optimal trade policy on the existence of natural duopoly in the case when the domestic firm is from the LDC.

Natural duopoly is an appropriate set-up if, roughly speaking, the taste for quality is predominant in the market in the sense that even the consumer with the lowest valuation for quality prefers to buy a quality good than to buy nothing. Thus, natural duopoly as a market structure would be endogenously determined. That is, the number of firms is not arbitrarily set to two but is the outcome of the given size of the market (determined in turn by the distribution of the consumers' taste for quality) and the nature of the competition that enables only two firms to survive in equilibrium. Lastly, the issue of long-run equilibrium seems to be best addressed in the natural duopoly set-up since a "non-natural duopoly" where the market is not fully covered may not be sustainable in the long run due to the possibility of entry of other firms (to serve this uncovered segment of the market).

Much like Zhou et al. (2000) and Moraga-González and Viaene (2004), we assume that firms differ in quality cost efficiency. This is motivated by different abilities of the firms from the developing world (compared with their developed country counterparts) to elevate the quality level of their products. Namely, the generation of high quality varieties is tightly connected with R&D investment, learning by doing and the level of human capital and, therefore, it seems natural that at the margin an increase in quality would require a higher effort and higher costs on the part of the developing country firm than on the part of the developed country firm.

As for our major results, we show that for the optimal trade policy and for given market size, natural duopoly is the only equilibrium market structure. Furthermore, we clarify and quantify the phenomenon of so called "quality reversal"[4] (see Herguera et al., 2002, and Moraga-González and Viaene, 2004, for the different definitions [concepts] of quality reversal).

First, we show that the key proposition of Herguera et al. (2002), which states that under the *ex post* optimal tariff the foreign firm always produces the low quality good, hinges on their assumption that both firms have identical quality costs. However, the difference in the quality costs is a key distinction between the firms in developed and less developed countries. Thus, we show that the incidence of quality reversals depends on the relative cost efficiency in producing quality and if the difference in these efficiencies is "large enough", we do not observe a switch in the quality ladder. This result resembles

[4]The term "quality reversal" refers to the situation where, say, in free trade the foreign firm from a developed country was initially a high quality provider but due to the implemented trade policy the domestic, developing country firm switches from the low to the high quality producer in the new equilibrium.

the findings of Moraga-González and Viaene (2004), who obtain a similar result in a somewhat different set-up and using a different notion of quality reversal than Herguera et al. (2002). However, unlike Moraga-González and Viaene (2004), we quantify the occurrence of quality reversal and show that duopoly equilibrium in which a domestic, low-quality firm continues to produce the low-quality good (no quality reversal) holds for the majority of the parameter space.

The rest of the paper is organised in the following way: in Section 2, we describe our model, which is solved in Sections 3 to 5. Section 6 concludes. Proofs and figures can be found in the appendices.

2 The model

There are two countries, one domestic and one foreign. Each country has one firm producing a vertically differentiated good for the domestic market. In addition, the domestic government protects the domestic firm by imposing a tariff on imports. Much like Ghosh and Das (2001), Herguera et al. (2002), and Moraga-González and Viaene (2004), we also concentrate on the domestic market.

The "ex *post* tariff game" has three stages. In the first stage, the firms choose their qualities. We denote by $s_1 > 0$ the higher quality and by $s_2 > 0$ the lower quality in the market. In the second stage, the domestic government decides on the tariff so as to maximise domestic welfare that consists of domestic consumer surplus, the domestic firm's profit, and tariff revenues. We denote $t_i \in \mathbb{R}$ the tariff imposed on firm i. In the last stage of the game, the firms compete in prices.

The consumers in the domestic market differ in their taste parameter θ, which is distributed with unit density over the interval $\left[\underline{\theta}, \bar{\theta}\right]$, where $0 \leq \underline{\theta} < \bar{\theta}$. Each consumer may either buy exactly one unit of the good from one of the firms, or buy nothing (which is equivalent to the assumption that a third modification of the good, with quality zero, is available for free), and the utility of a consumer with quality parameter θ is given by

$$U = \begin{cases} \theta s_i - p_i, & \text{if a unit of the good of quality } s_i \text{ is bought at price } p_i; \\ 0, & \text{otherwise.} \end{cases} \tag{1}$$

In the last stage, the firms produce at zero costs. In the first stage, however, the firms incur fixed costs of quality choice, $C(s_i) = a_i s_i^2/2$, where $a_i > 0$. The firm with the lower a_i is more cost-efficient, and in the setting of a DC firm competing with a LDC firm the former one is likely to have the lower a_i.

For the sake of exposition, we write $\Theta = \underline{\theta}/\bar{\theta}$ and $S = s_2/s_1$; note that both Θ and S lie within $[0, 1)$. The game is solved by backward induction.

3 The third stage: price equilibrium

At this stage, qualities s_1 and s_2 are fixed, and the tariffs t_1 and t_2 are given. Note that the tariff imposed on the domestic firm equals zero, i.e., $t_1 = 0$ if the domestic firm is the high-quality one, and $t_2 = 0$ if the domestic firm is the low-quality one[5].

Given the prices p_1 and p_2, according to (1) the consumer indifferent between the firms is characterised by the taste parameter value

$$\theta = \theta_{12} = \frac{p_1 - p_2}{s_1 - s_2},$$

and the consumer indifferent between firm i and not buying at all is characterised by

$$\theta = \theta_{i0} = p_i/s_i.$$

Firm i's demand function D_i is the measure of consumers who buy from firm i. The demand functions depend on where the indifferent consumers θ_{12}, θ_{10}, and θ_{20} are located with respect to each other and to the consumers with the highest and the lowest quality sensitivities in the market, $\bar{\theta}$ and $\underline{\theta}$. The complete demand functions and the market structures which can occur at different prices (p_1, p_2) are presented in Appendix A.

It should be noted that a necessary condition for the low-quality firm to survive in the market is that the price-quality ratio (hedonic price) is lower for the low-quality firm, $p_2/s_2 < p_1/s_1$.

As for the market structures that can occur, the most prominent are:

- *Monopoly of the high-quality firm*, when all consumers buy from firm 1 so that $D_1 = \bar{\theta} - \underline{\theta}$ and $D_2 = 0$.

- *Duopoly*, when each firm has a positive market share, i.e. $\underline{\theta} < \theta_{12} < \bar{\theta}$. Then $D_1 = \bar{\theta} - \theta_{12}$ and $D_2 = \theta_{12} - \max\{\underline{\theta}, \theta_{20}\}$. Three subcases are distinguished according to the position of θ_{20} with respect to $\underline{\theta}$.

  1. If $\theta_{20} < \underline{\theta}$, i.e., if the consumer with the lowest quality sensitivity strictly prefers buying from the low-quality firm to not buying, then $D_2 = \theta_{12} - \underline{\theta}$ and the situation will be referred to henceforth as *over-covered market*, for even the consumer with the lowest quality sensitivity obtains a positive utility.

  2. If $\theta_{20} = \underline{\theta}$, i.e., if the consumer with the smallest quality sensitivity is indifferent between buying from the low-quality firm and not buying, then $D_2 = \theta_{12} - \underline{\theta} = \theta_{12} - \theta_{20}$ and we will henceforth call this situation *exactly covered market*.

[5]Following Herguera et al. (2002), we constrain our trade policy to the choice of a single instrument, a tariff, noting that $t_1 = 0$ or $t_2 = 0$ is not necessarily the optimal policy. Namely, besides imposing a tariff on the foreign firm, it may be welfare improving to subsidise or tax the domestic firm (Ghosh and Das, 2001). However, we assume that this is not a feasible option.

3. If $\theta_{20} > \underline{\theta}$, i.e., if the consumer with the smallest quality sensitivity strictly prefers not buying to buying from the low-quality firm, then $D_2 = \theta_{12} - \theta_{20}$ and the situation will be referred to as *non-covered market*, for there are consumers who are not served by either firm.

Further on, *covered market* will refer to either over-covered market or exactly covered market.

The third stage profit of firm i ($i = 1, 2$) equals

$$\Pi_i = (p_i - t_i)D_i.$$

Prices are chosen non-cooperatively, and each firm maximises its profit taking the rival's price as given.

A complete mathematical treatment of this price competition game for arbitrary tariffs and qualities is provided by Kúnin (2003). The equilibirum market structures that can occur when one of the tariffs, which is the tariff on the domestic firm, is set to zero, along with the corresponding conditions on the other tariff and qualities, are presented in Appendix B. In particular, equilibrium prices, third stage profits and conditions for the outcome to be duopoly are the following.

If the domestic firm produces high quality ($t_1 = 0$) and the equilibrium market structure is duopoly with an over-covered market then the equilibrium prices and profits are

$$p_1 = \frac{(2\bar{\theta} - \underline{\theta})(s_1 - s_2) + t_2}{3}, \quad p_2 = \frac{(\bar{\theta} - 2\underline{\theta})(s_1 - s_2) + 2t_2}{3},$$

$$\Pi_1 = \frac{\Big((2\bar{\theta} - \underline{\theta})(s_1 - s_2) + t_2\Big)^2}{9(s_1 - s_2)}, \quad \Pi_2 = \frac{\Big((\bar{\theta} - 2\underline{\theta})(s_1 - s_2) - t_2\Big)^2}{9(s_1 - s_2)}.$$

If the domestic firm produces high quality and the equilibrium market structure is duopoly with an exactly covered market then the equilibrium prices and profits are[6]

$$p_1 = \Big(\bar{\theta}(s_1 - s_2) + \underline{\theta}s_2\Big)/2, \quad p_2 = \underline{\theta}s_2,$$

$$\Pi_1 = \frac{\Big(\bar{\theta}(s_1 - s_2) + \underline{\theta}s_2\Big)^2}{4(s_1 - s_2)}, \quad \Pi_2 = \frac{(\underline{\theta}s_2 - t_2)\Big((\bar{\theta} - 2\underline{\theta})s_1 + (\underline{\theta} - \bar{\theta})s_2\Big)}{2(s_1 - s_2)}.$$

If the domestic firm produces high quality and the equilibrium market structure is duopoly with a non-covered market then the equilibrium prices and profits are

$$p_1 = \frac{s_1\Big(2\bar{\theta}(s_1 - s_2) + t_2\Big)}{4s_1 - s_2}, \quad p_2 = \frac{s_2\bar{\theta}(s_1 - s_2) + 2s_1t_2}{4s_1 - s_2},$$

[6]In this particular case, the equilibrium prices do not depend on the tariff t_2. This happens because an exactly covered market implies $p_2 = \underline{\theta}s_2$. Then p_1 as the best reaction to p_2 does not depend on t_2 because each firm's profit function (and, hence, its reaction function/correspondence) does not depend on the tariff imposed on the other firm.

$$\Pi_1 = \frac{s_1^2\Big(2\bar\theta(s_1 - s_2) + t_2\Big)^2}{(s_1 - s_2)(4s_1 - s_2)^2}, \quad \Pi_2 = \frac{s_1\Big(\bar\theta s_2(s_1 - s_2) - t_2(2s_1 - s_2)\Big)^2}{s_2(s_1 - s_2)(4s_1 - s_2)^2}.$$

If the domestic firm produces low quality ($t_2 = 0$) and the equilibrium market structure is duopoly with an over-covered market then the equilibrium prices and profits are

$$p_1 = \frac{(2\bar\theta - \underline{\theta})(s_1 - s_2) + 2t_1}{3}, \quad p_2 = \frac{(\bar\theta - 2\underline{\theta})(s_1 - s_2) + t_1}{3},$$

$$\Pi_1 = \frac{\Big((2\bar\theta - \underline{\theta})(s_1 - s_2) - t_1\Big)^2}{9(s_1 - s_2)}, \quad \Pi_2 = \frac{\Big((\bar\theta - 2\underline{\theta})(s_1 - s_2) + t_1\Big)^2}{9(s_1 - s_2)}.$$

If the domestic firm produces low quality and the equilibrium market structure is duopoly with an exactly covered market then the equilibrium prices and profits are

$$p_1 = \Big(\bar\theta(s_1 - s_2) + \underline{\theta}s_2 + t_1\Big)/2, \quad p_2 = \underline{\theta}s_2,$$

$$\Pi_1 = \frac{\Big(\bar\theta(s_1 - s_2) + \underline{\theta}s_2 - t_1\Big)^2}{4(s_1 - s_2)}, \quad \Pi_2 = \frac{\underline{\theta}s_2\Big((\bar\theta - 2\underline{\theta})s_1 + (\underline{\theta} - \bar\theta)s_2 + t_1\Big)}{2(s_1 - s_2)}.$$

Finally, if the domestic firm produces low quality and the equilibrium market structure is duopoly with a non-covered market then the equilibrium prices and profits are

$$p_1 = \frac{2s_1\Big(\bar\theta(s_1 - s_2) + t_1\Big)}{4s_1 - s_2}, \quad p_2 = \frac{s_2\Big(\bar\theta(s_1 - s_2) + t_1\Big)}{4s_1 - s_2},$$

$$\Pi_1 = \frac{\Big(2\bar\theta s_1(s_1 - s_2) - t_1(2s_1 - s_2)\Big)^2}{(s_1 - s_2)(4s_1 - s_2)^2}, \quad \Pi_2 = \frac{s_1 s_2\Big(\bar\theta(s_1 - s_2) + t_1\Big)^2}{(s_1 - s_2)(4s_1 - s_2)^2}.$$

4 The second stage: tariff choice

At this stage, the domestic government chooses the import tariff taking qualities s_1 and s_2 as given. The government's objective function is the domestic welfare W_i, which includes three components, namely, the domestic consumer surplus CS, the profit of the domestic firm Π_i, and the tariff revenue $t_j D_j$.

The consumer surplus is defined as $CS = CS_1 + CS_2$, where CS_i is the surplus of the consumers who buy from firm i, $CS_i = \int_{Q_i}(\theta s_i - p_i)d\theta$. In the last integral, $Q_i \subseteq \left[\underline{\theta}, \bar\theta\right]$ denotes the set of quality parameters θ such that the consumers in Q_i buy from firm i. In particular, if there is a duopoly and the market is either over-covered or exactly covered, then the domestic consumer surplus equals

$$CS = \int_{\theta_{12}}^{\bar\theta}(\theta s_1 - p_1)d\theta + \int_{\underline{\theta}}^{\theta_{12}}(\theta s_2 - p_2)d\theta.$$

If the welfare is maximised at a tariff leading to monopoly with a covered market, then such a tariff is often not unique. The reason is that there is a range of tariffs that yield the same total welfare but different distributions of welfare.[7] In such cases, it is assumed that the government selects *the minimal non-negative* tariff among the set of optimal tariffs.

The derivation and the values of the optimal tariffs as well as the corresponding firms' profits can be found in Appendix C. The equilibrium market structure (after welfare maximisation) is determined by $\Theta = \underline{\theta}/\bar{\theta}$ and $S = s_2/s_1$.

A useful benchmark for analysing the outcomes under optimal trade policy is free trade, i.e. $t_1 = t_2 = 0$. In this case, the market structures occurring for given $\Theta, S \in [0, 1)$ are shown in Figure 2. Under free trade, the outcome is monopoly when the market is relatively homogeneous ($\Theta \geq 1/2$) and duopoly otherwise, for any qualities. If $\Theta \in [1/4, 1/2)$, i.e. when the market is sufficiently heterogeneous to sustain just two firms, then the outcome is duopoly with a covered market for any S, which is often referred to as *natural duopoly* (Shaked and Sutton, 1982).

4.1 High-quality domestic firm

If the domestic firm produces the high-quality good, then the possible equilibrium market structures are duopoly with a non-covered market, duopoly with an exactly covered market, and monopoly of the high-quality firm with a covered market (see Appendix C). These market structures are shown in Figure 3.

The outcome of the second stage is monopoly in two cases. First, if $\Theta \geq 1/2$ then there is monopoly under free trade so that no trade policy is needed to ensure that the high-quality domestic firm becomes a monopolist and $t_2 = 0$. Second, when $(1 - S)/(2 - S) \leq \Theta < 1/2$, then the low-quality foreign firm is driven out of the market by the optimal tariff of $t_2 = (\bar{\theta} - 2\underline{\theta})(s_1 - s_2)$, which is the minimal tariff leading to monopoly.

A comparison of Figures 2 and 3 shows that trade policy when the domestic firm produces the high-quality good shifts the market structure away from duopoly with a covered market. There are two equilibrium market structures under free trade which correspond to duopoly with a covered market; one of them, duopoly with an over-covered market, is not possible under trade policy, and the set of Θ and S for the other one, duopoly with an exactly covered market, is much smaller under trade policy than under free trade. In addition, trade policy shifts the market structure towards monopoly in the following sense: under free trade, the outcome is never monopoly when $\Theta < 1/2$, but the

[7] This happens when for some optimal tariff the market structure is monopoly with an *over-covered* market. The monopolist sets its price at the highest level Such that it is not profitable for the other firm to enter due to the tariff. Then a small increase in the tariff allows the monopolist to further increase its price while the market stays over-covered, which leads to a redistribution of welfare in favour of the monopolist.

The other reason for such a redistribution to occur is the special consumer utility structure $U = \theta s - p$. With this utility, the consumer surplus loss caused by a price increase (provided that the consumer does not switch to the other firm or to buying nothing) is *exactly* offset by the firm's gain.

impact of optimal trade policy is such that for any positive Θ the outcome is monopoly if the qualities are sufficiently close, i.e. if S is sufficiently close to unity (see Figure 3).

4.2 Low-quality domestic firm

If the domestic firm produces the low-quality good, then the possible equilibrium market structures are duopoly with a non-covered market, duopoly with an exactly covered market, duopoly with an over-covered market, and monopoly of the high-quality (in this case, foreign) firm with an over-covered market (see Appendix C).

In particular, if $2(1-S)/3 < \Theta < 2/3$ then the optimal tariff is $t_1 = (\bar{\theta}-\underline{\theta})(s_1-s_2)$ and the outcome is duopoly with an over-covered market, and if $(2/3)(1-S)/(2-S) \leq \Theta \leq 2(1-S)/3$ then the optimal tariff is $t_1 = \bar{\theta}(s_1 - s_2)/3 + \underline{\theta}s_2$ and the outcome is duopoly with an exactly covered market. The market structures occurring under the optimal tariff when the domestic firm produces the low quality are shown in Figure 4.

A comparison of Figures 2 and 4 shows that trade policy when the domestic firm produces the low-quality good shifts the market structure towards duopoly since the range of Θ such that the outcome is monopoly is $[1/2, 1]$ under free trade and $[2/3, 1]$ under trade policy. The range of Θ such that the outcome is duopoly with a covered market for any S expands and shifts from $[1/4, 1/2]$ under free trade to $[1/3, 2/3]$ under trade policy.

5 The first stage: quality choice

At this stage, the firms simultaneously choose qualities s_1 and s_2 to maximise their profits net of quality costs $C_i(s_i) = a_i s_i^2/2$. Let $k_i = a_i/\bar{\theta}^2$, and let $K = k_2/k_1 = a_2/a_1$. The value of K can be interpreted as a measure of relative technological advance of firm 1 with respect to firm 2 for if quality s costs firm 1 $C_1(s)$ then the same quality s costs firm 2 $C_2(s) = KC_1(s)$.

It turns out that the outcome of the first stage and of the entire game is determined by Θ, which reflects consumer heterogeneity, and K.

The following approach is used to find quality equilibria. First, a pair of qualities (s_1, s_2) is found such that it would be an equilibrium *if it were* a priori *fixed which firm produces which quality*. Then this pair of qualities, called a *candidate equilibrium*, is checked for being an equilibrium, i.e. it is checked whether either firm is better off deviating in such a way that the high-quality firm becomes the low-quality one and vice versa.

More formally, a candidate equilibrium is a pair of qualities (s_1, s_2) such that (i) given s_2, the value s_1 maximises firm 1's profit subject to firm 1 being high-quality, $s_1 > s_2$; (ii) given s_1, the value s_2 maximises firm 2's profit subject to firm 2 being low-quality,

$s_1 > s_2$; (iii) both firms' profits are non-negative at (s_1, s_2). The last requirement is added since each firm can secure a non-negative profit in the entire game by entering as low-quality and choosing the quality of $s_i = 0$. Thus, in a candidate equilibrium, firm 1 is bound to produce higher quality.

A candidate equilibrium (s_1, s_2) is an equilibrium of the whole game when (i) and (ii) hold when the constraint $s_1 > s_2$ is *not* imposed. This means that firm 1 cannot strictly increase its profit by switching to be the low-quality firm, and firm 2 cannot strictly increase its profit by switching to be the high-quality firm. In more formal language, there does not exist $s_2' > s_1$ such that $\Pi_2^H(s_1, s_2') > \Pi_2^L(s_1, s_2)$, and nor does there exist $s_1' < s_2$ such that $\Pi_1^L(s_1', s_2) > \Pi_1^H(s_1, s_2)$, where Π_i^H and Π_i^L are firm i's profit functions when it produces high and low quality, respectively.

5.1 Quality reversals

It is a well-established fact that if there is no trade policy and the firms are identical, then the game has more than one equilibrium. Indeed, if (s_1, s_2) is an equilibrium of the whole game with $t_1 = t_2 = 0$ and $K = 1$ then so is (s_2, s_1). If the technologies possessed by the firms differ and/or trade policy is used, then often there are still two candidate equilibria, one with the domestic firm being high-quality and one with the domestic firm being low-quality.

However, unlike the case of free trade with identical firms, one of the candidate equilibria often turns out not to be an equilibrium of the entire game. A simple case, which does not have to involve trade policy, is that if the technological margin between the firms is sufficiently wide then the candidate equilibrium with the less advanced firm producing the high-quality good is not sustainable. A more interesting case arises when under free trade there is an equilibrium of the whole game wherein the domestic firm is high-quality or low-quality, but under the optimal trade policy the candidate equilibrium with the same position of the domestic firm is not an equilibrium of the whole game.

Herguera et al. (2002) refer to this last situation as a (policy-induced) *quality reversal*. They find that if $\Theta = 0$ and $K = 1$ (when there are two equilibria under free trade) then the candidate equilibrium under the optimal trade policy where the domestic firm produces the low-quality good is not an equilibrium of the whole game for the domestic firm's optimal response to the foreign firm's quality in the candidate equilibrium is to choose an even higher quality.

A slightly different (and, roughly speaking, complementary) definition of a quality reversal is employed by Moraga-González and Viaene (2004). In their model $\Theta = 0$ but the firms are allowed to differ in their quality cost efficiency, i.e. K can differ from 1. They show that even if there are two equilibria under free trade, then the one with the less efficient firm producing high quality is risk dominated. However, trade policy can reverse this result, i.e. the equilibrium with the less efficient domestic firm producing high quality becomes risk dominant. Thus, they define a quality reversal as the situation when, due to trade policy, the less efficient firm produces high quality in the risk dominant equilibrium.

5.2 Natural duopoly

A situation of particular interest is natural duopoly with a domestic low-quality firm. We assume that the model parameters are such that the market in question is a natural duopoly in the sense of Shaked and Sutton (1982), i.e., the consumer with the lowest quality sensitivity $\underline{\theta}$ prefers buying from one of the firms to not buying at all, and both firms are in the market in equilibrium. In other words, the distribution of tastes (or incomes) across consumers has to be heterogeneous enough in order to have more than one top-quality firm serving the whole market but, on the other hand, tastes should not be overly dispersed to enable more than two firms to survive in the market (Gabszewicz, 1985).

As is shown in the previous section and in Appendix C, if the domestic firm is low-quality, then after the application of the optimal tariff the equilibrium structure is duopoly with covered market when $(2/3)(1-S)/(2-S) \leq \Theta < 2/3$. We restrict our attention to the case $\Theta \in [1/3, 2/3)$, for then the outcome of the entire game is duopoly with covered market regardless of quality choices $s_1 > s_2$. In particular, the market is exactly covered when $S \leq 1 - 3\Theta/2$ and over-covered otherwise.

The first-stage profit of the high-quality firm (divided by a positive constant $\bar{\theta}^2$) equals

$$\Pi_1 = (s_1 - s_2)/9 - k_1 s_1^2/2$$

in both "exactly covered" and "over-covered" cases. The first-stage profit of the low-quality firm (also divided by $\bar{\theta}^2$) equals

$$\Pi_2 = \Theta(2 - 3\Theta)s_2/3 - k_2 s_2^2/2$$

when the market is exactly covered and

$$\Pi_2^+ = (2 - 3\Theta)^2(s_1 - s_2)/9 - k_2 s_2^2/2$$

when the market is over-covered. It is immediately seen that firm 2's profit under an over-covered market strictly decreases in its own quality, $\partial\Pi_2^+/\partial s_2 < 0$, so that the market cannot be over-covered in equilibrium. This yields two options for firm 2's profit maximisation, given s_1. Namely, it can be maximised at a quality corresponding to the interior of the area when the outcome is an exactly covered market, which implies $S < 1 - 3\Theta/2$ (see Figure 3), or at a quality corresponding to the boundary of this area, which means $S = 1 - 3\Theta/2$. The former situation is further referred to an *interior equilibrium* and the latter one is referred to as a *boundary equilibrium* (though, strictly speaking, they are both *candidate* equilibria).

Proposition 1 *Let* $\Theta \in [1/3, 2/3]$*. Then for any* k_1 *and* k_2 *there exists a unique candidate equilibrium* (s_1, s_2) *such that the domestic firm produces low quality. In addition, the pair* (s_1, s_2) *corresponds to an interior equilibrium when* $K > 6\Theta$ *and to a boundary equilibrium when* $K \leq 6\Theta$*.*

The proof of Proposition 1 can be found in Appendix D. If $K > 6\Theta$, then the candidate equilibrium in Proposition 1 is

$$s_1 = 1/(9k_1), \quad s_2 = \Theta(2 - 3\Theta)/(3k_2),$$

with the firms' first stage profits equal to

$$\Pi_1 = (K - 6\Theta(2 - 3\Theta))/(162k_2), \quad \Pi_2 = \Theta^2(2 - 3\Theta)^2/(18k_2).$$

The corresponding values for $K \leq 6\Theta$ are

$$s_1 = 1/(9k_1), \quad s_2 = (2 - 3\Theta)/(18k_1),$$

$$\Pi_1 = (3\Theta - 1)/(162k_1), \quad \Pi_2 = (12\Theta - K)(2 - 3\Theta)^2/(648k_1).$$

The intuition beyond the threshold $K = 6\Theta$ is that if K is low, then quality is (relatively) cheap for firm 2 so that its profit increases in its own quality until the market structure changes to duopoly with over-covered market, which results in a boundary equilibrium. If K is high, then quality is expensive for firm 2 so that its profit starts to decline before the market structure changes, so that there is an interior equilibrium.

5.3 Quality reversals in natural duopoly

In the set-up of natural duopoly with the domestic firm producing low quality, a quality reversal as defined by Herguera et al. (2002) occurs when the candidate equilibrium derived in Proposition 1 is not an equilibrium of the entire game. A quality reversal as defined by Moraga-González and Viaene (2004) happens when the firm with the higher a_i produces high quality in equilibrium.

If the domestic firm in response to $s_1 = 1/(9k_1)$ chooses higher quality, it becomes the high-quality firm, and the outcome may be either monopoly of the domestic firm (for smaller differences in qualities) or duopoly, which in its turn can have either exactly covered or over-covered market.

Proposition 2 *If the degree of consumer heterogeneity* Θ *and the relative cost efficiency of the high-quality firm* K *are such that* $1/3 \leq \Theta \leq 2/3$ *and* $K \geq R(\Theta)$*, where* $1 \leq R(\Theta) < 2$ *for all applicable* Θ*, then in the candidate equilibrium in Proposition 1 there is no quality reversal by the domestic firm. In other words, the candidate equilibrium in Proposition 1 is an equilibrium of the entire game.*

The proof of Proposition 2 and the explicit form of $R(\Theta)$ can be found in Appendix E. The graph of $R(\Theta)$ is depicted in Figure 5. For $\Theta < 1/2$, $R(\Theta)$ is strictly decreasing, and for $\Theta \geq 1/2$, $R(\Theta) < 1.1$.

Note that if the firms possess the same level of technology, $K = 1$, then due to the trade policy there is always a quality reversal. However, if the consumers are neither too homogeneous nor too heterogeneous ($1/3 \leq \Theta \leq 2/3$), then the minimal relative quality cost efficiency of the foreign firm guaranteeing no quality reversal, $K = R(\Theta)$, is not significantly greater than unity. Even for lower values of Θ (close to 1/3) there is no quality reversal when the foreign firm is at least twice as efficient as the domestic firm (the exact bound is $K \geq R(1/3) = 28/15$.) For higher values of Θ (above 1/2) even a ten percent difference in quality cost efficiency suffices for no quality reversal[8].

Again, put in the context where the action takes place in the developing country market, the duopoly where the foreign firm (coming from the developed country) offers the high-quality good and the domestic, developing country firm offers the low-quality good is sustainable provided that the relative quality cost efficiency in favour of the developed country firm exceeds a certain threshold level and that the consumer heterogeneity is sufficiently "narrow". This relatively narrow range between the upper and lower bound of consumer tastes seems to picture very well some of the developing country markets where only a fraction of the people ("elite") may form the narrow market for, say, very expensive quality goods like cars.

6 Conclusion

The focus of our analysis is the interaction of strategic trade policy in the form of a tariff and competition in qualities and prices in the context of developed versus less developed country firms. Following the recent debate about the sequencing of the moves between the domestic government and domestic firm, we opt for the setup in which the government acts only after the strategic choice of the firms has been completed. The conspicuous effect of trade policy in this set-up is that it may affect the market structure as well as induce a firm's leap-frogging from low to high quality production and vice versa. The latter phenomenon is known under the name "quality reversal".

[8] Another kind of a quality reversal that may happen is the reversal by the foreign firm to a lower quality than that of the domestic firm.

It is possible to show that there is a quality reversal by the foreign firm in the following cases. For boundary equilibria, a reversal takes place when $\Theta < \Theta_r$, where $\Theta_r \approx 0.334335$. For interior equilibria, a reversal takes place when $K < 6\Theta(2-3\Theta)/(2-3\Theta_r)$.

Note that this kind of a quality reversal occurs for a very small range of parameters only. Perhaps, this fact is the reason why such quality reversals were overlooked in the relevant literature. The intuition is that if Θ is small ($\Theta \approx 1/3$) and so is K, then the market is large so that the products are less differentiated, which along with trade policy leads to lower profits for the foreign firm.

We concentrate on the case when the domestic market is in the less developed country and possesses the characteristics of "natural duopoly" in the Shaked and Sutton (1982) sense. That is, the size of the market is such that given the optimal tariff only two firms can survive in it. We show that compared to free trade, the optimal trade policy in this set-up enables duopoly to be a viable and dominant market structure for the larger size of the market, where the size of the market is measured in relative terms as the ratio of the lowest to highest consumer's preference for the quality.

As for the quality reversal, we demonstrate that trade policy has somewhat limited ability to induce it. Namely, the lag in quality cost efficiency of the less developed country firm vis-à-vis the developed country firm should be relatively small (less than double) for quality reversal to be the best response for the initially low-quality, domestic firm. We also discuss and compare our findings with other relevant results from trade literature that tackle the issue of quality reversal.

As for future research, the model developed and the results derived above enable us to extend our analysis to some other important issues like, for instance, the equilibrium of the whole game when the high-quality firm is the domestic one. Having this in hand, we can then study the social welfare implications of trade liberalisation in both DC and LDC. Thus, for instance, one of the policy conclusions that our analysis seems to provide is that trade liberalisation in the less developed country might lead to major social welfare costs and undesired effects such as the establishment of foreign firms' monopolies. In the less drastic case, trade liberalisation may cause the policy induced domestic high-quality producers to re-switch to low quality production once the tariff barriers would be removed. However, the exact outcome of trade liberalisation is an empirical issue that would depend upon the specific relative inefficiency in quality costs of a specific less developed country firm compared to its developed country counterpart and upon the specific change in the key parameters that would determine the size of the market after the liberalisation.

References

Aturupane, C., S. Djankov, and B. Hoekman (1999), "Horizontal and Vertical Intra-Industry Trade between Eastern Europe and the European Union," *Weltwirtschaftliches Archiv* 135, 63-81.

Brander, J. (1995), "Strategic Trade Policy," in Grossman, G. M. and K. Rogoff (eds.), *The Handbook of International Economics, vol. 3*, Amsterdam: North-Holland.

Carmichael, C. M. (1987), "The Control of Export Credit Subsidies and its Welfare Consequences," *Journal of International Economics* 23, 1-9.

Clark, P. D., and D. L. Stanley (1999), "Determinants of Intra-Industry Trade between Developing Countries and the United States," *Journal of Development Economics* 24, 79-95.

Fertő, I. (2002), "Intra-Industry Trade in Agri-Food Products between Hungary and the EU," *Global Development Network Project*, mimeo.

Gabszewicz, J. J. (1985), Comment in Arrow, K. J. and Honkapohja, S. (eds.) *Frontiers of Economics*, Oxford: Basil Blackwell.

Ghosh, S., and S. P. Das (2001), "Strategic Trade Policy and Sustainability," mimeo, Indian Statistical Institute, 1-22.

Greenaway, D., R. C. Hine, and C. R. Milner (1994), "Country-Specific Factors and the Pattern of Horizontal and Vertical Intra-Industry Trade in the UK," *Weltwirtschaftliches Archiv* 131, 70-100.

Greenaway, D., R. C. Hine, and C. R. Milner (1995), "Horizontal and Vertical Intra-Industry Trade: A Cross-Industry Analysis for the United Kingdom," *Economic Journal* 105, 1505-1518.

Gruenspecht, H. K. (1988), "Export Subsides for Differentiated Products," *Journal of International Economics* 24, 331-344.

Herguera, I., P. Kujal, and E. Petrakis (2002), "Tariffs, Quality Reversal and Exit in Vertically Differentiated Industries," *Journal of International Economics* 58, 476-492.

Kúnin, M. (2003), "A Complete Mathematical Derivation of Price Equilibria under Vertical Differentiation in a Simple Model with Two Firms and Tariffs," *CERGE-EI Discussion Paper Series* 2003-108.

Landesmann, M. and J. Burgstaller (1997), "Vertical Product Differentiation in EU Markets: The Relative Position of East European Producers," *WIIW Research Reports* 234a.

Linder, S. (1961), *An Essay on Trade and Transformation*, New York: John Wiley.

Moraga-González, J. L. and J. M. Viaene (2004), "Trade Policy and Quality Leadership in Transition Economies," *European Economic Review*, forthcoming.

Neary, J. P. (1991), "Export Subsidies and Price Competition" in Helpman, E. and A. Razin (eds.), *International Trade and Trade Policy*, Cambridge, Mass.: MIT Press.

Neary, J. P. and D. Leahy (2000), "Strategic Trade and Industrial Policy towards Dynamic Oligopolies," *Economic Journal* 110, 484-508.

Porter, M. E. (1990), *The Competitive Advantage of Nations*, London: MacMillan.

Schott, P. (2004), "Across-Product versus Within-Product Specialization in International Trade," *Quarterly Journal of Economics*, forthcoming.

Shaked, A. and J. Sutton (1982), "Natural Oligopolies," *Econometrica* 51, 1469-1483.

U.S. International Trade Commission (1996), "Production Sharing: Use of U.S. Components and Materials in Foreign Assembly Operations, 1991 -1994," *USITC Publication* 2966.

Van Berkum, S. (1999), "Patterns of Intra-Industry Trade and Foreign Direct Investment in Agro-Food Products: Implications for East-West Integration," *MOCT-MOST* 9, 255-271.

Zhou, D., B. J. Spencer, and I. Vertinsky (2000), "Strategic Trade Policy with Endogenous Choice of Quality and Asymmetric Costs," *NBER Working Paper Series* 7536.

Zhou, D., B. J. Spencer, and I. Vertinsky (2002), "Strategic Trade Policy with Endogenous Choice of Quality and Asymmetric Costs," *Journal of International Economics* 56, 205-232.

APPENDIX

A Market structures and demand functions

In the model set up in Section 2, the demand facing firm i, D_i equals the measure of consumers that prefer firm i to both the other firm and to not buying at all. The consumer indifferent between the two firms is characterised by

$$\theta = \theta_{12} = (p_1 - p_2)/(s_1 - s_2).$$

If $\theta > \theta_{12}$, then the consumer prefers the product of firm 1 to that of firm 2; if $\theta < \theta_{12}$, then the consumer prefers the product of firm 2 to that of firm 1. The consumer indifferent between firm i's good and the zero good is characterised by $\theta_{i0} = p_i/s_i$. A consumer will prefer buying from firm i to not buying at all when $\theta > \theta_{i0}$.

The demand functions depend on the mutual ordering of the values θ_{12}, θ_{10}, θ_{20} as well as $\underline{\theta}$ and $\bar{\theta}$. As far as the first three values are concerned (i.e., the positions of the indifferent consumers), the following can be shown to hold.

$$\begin{aligned}
p_2/p_1 < s_2/s_1 &\iff \theta_{20} < \theta_{10} < \theta_{12}, \\
p_2/p_1 = s_2/s_1 &\iff \theta_{20} = \theta_{10} = \theta_{12}, \\
p_2/p_1 > s_2/s_1 &\iff \theta_{20} > \theta_{10} > \theta_{12}.
\end{aligned}$$

Thus, if $p_2/p_1 \geq s_1/s_2$, then firm 2 is out of the market (every consumer either buys from firm 1 or buys nothing) so that $D_2 = 0$, and firm 1's demand depends on the position of θ_{10} with respect to $\left[\underline{\theta}, \bar{\theta}\right]$, namely

$$p_2/p_1 \geq S \Longrightarrow D_1 = \begin{cases} \bar{\theta} - \underline{\theta}, & \theta_{10} \leq \underline{\theta}, & \text{(M1)} \\ \bar{\theta} - \theta_{10}, & \underline{\theta} < \theta_{10} \leq \bar{\theta}, & \text{(m1)} \\ 0, & \theta_{10} > \bar{\theta}. & \text{(z)} \end{cases}$$

If $p_2/p_1 < S$, then a consumer with quality sensitivity θ prefers firm 1's product when $\theta > \theta_{12}$, prefers firm 2's product when $\theta_{20} < \theta < \theta_{12}$, and prefers the zero good when $\theta < \theta_{20}$. Therefore, the following cases are possible (since the demand functions are continuous, the situations when there is an equality between some two values are skipped.)

Case	D_1	D_2	Notation
$\theta_{20} < \theta_{12} < \underline{\theta} < \bar{\theta}$	$\bar{\theta} - \underline{\theta}$	0	(M1)
$\theta_{20} < \underline{\theta} < \theta_{12} < \bar{\theta}$	$\bar{\theta} - \theta_{12}$	$\theta_{12} - \underline{\theta}$	(D)
$\theta_{20} < \underline{\theta} < \bar{\theta} < \theta_{12}$	0	$\bar{\theta} - \underline{\theta}$	(M2)
$\underline{\theta} < \theta_{20} < \theta_{12} < \bar{\theta}$	$\bar{\theta} - \theta_{12}$	$\theta_{12} - \theta_{20}$	(d)
$\underline{\theta} < \theta_{20} < \bar{\theta} < \theta_{12}$	0	$\bar{\theta} - \theta_{20}$	(m2)
$\underline{\theta} < \bar{\theta} < \theta_{20} < \theta_{12}$	0	0	(z)

From the above it follows that there are seven different structures. In three cases, *the market is covered*, i.e., all consumers with $\theta \in \left[\underline{\theta}, \bar{\theta}\right]$ are served by one of the firms. These cases are (Mi), when firm i serves the whole market as a monopoly, and (D), when the market is divided between the firms. In other three cases, *the market is partially covered* (it can be also said that the marked is *not covered*), i.e., there are consumers in the market who choose the zero good. These cases are (mi), when firm i serves all consumers who do not choose the zero good (so that it is a monopoly), and (d), when the market is divided between the firms and there are consumers who choose the zero good. In the last case (z), all consumers in the market choose the zero good.

The conditions on prices under which these structures can occur can be rewritten as

Structure	Conditions
(M1)	$0 \le p_1 < \underline{\theta} s_1$, $p_2 \ge 0$, $p_1 - p_2 < \underline{\theta}(s_1 - s_2)$
(M2)	$0 \le p_2 < \underline{\theta} s_2$, $p_1 - p_2 > \bar{\theta}(s_1 - s_2)$
(D)	$0 \le p_2 < \underline{\theta} s_2$, $\underline{\theta}(s_1 - s_2) < p_1 - p_2 < \bar{\theta}(s_1 - s_2)$
(m1)	$p_2/p_1 > s_2/s_1$, $\underline{\theta} s_1 < p_1 < \bar{\theta} s_1$
(m2)	$\underline{\theta} s_2 < p_2 < \bar{\theta} s_2$, $p_1 - p_2 > \bar{\theta}(s_1 - s_2)$
(d)	$p_2 > \underline{\theta} s_2$, $p_1 - p_2 < \bar{\theta}(s_1 - s_2)$, $p_2/p_1 < s_2/s_1$
(z)	$p_1 > \bar{\theta} s_1$, $p_2 > \bar{\theta} s_2$

The sets of prices (p_1, p_2) at which these market structures happen are depicted in Figure 1.

If there is an equality between some of the values θ_{ij}, $\underline{\theta}$, $\bar{\theta}$, then the resulting market structure is a boundary case of some structures listed above. An important case is *exactly covered market*, when the least quality-sensitive consumer is exactly indifferent between buying from the firm offering the better deal and not buying at all. The case of particular importance (the thick line in Figure 1) is duopoly with exactly covered market denoted (D/d), which is the borderline case between (D) and (d). It happens when $\theta_{20} = \underline{\theta}$ and $\underline{\theta} < \theta_{12} < \bar{\theta}$ (i.e., $p_2 = \underline{\theta} s_2$ and $\underline{\theta} s_1 < p_1 < \bar{\theta}(s_1 - s_2) + \underline{\theta} s_2$.)

Another special boundary structure is *constrained monopoly*, which takes place on one of the (Mi/D) and (mi/d) boundaries. If this case occurs in equilibrium, then there is monopoly, but the monopolist's price is less than the price it would charge were it a single firm initially. If the "constrained" monopolist increases its price, then the main reason for its profit to fall will be that then the other firm becomes sustainable.

B Price equilibria

High-quality domestic firm

Let $t_1 = 0$, i.e., let the high-quality firm be domestic. Then the following equilibria can occur according to Kúnin (2003).

Singular case **(M1/D)**, constrained monopoly of the high-quality firm with covered market, occurs when $t_2 < 0$, and $\Theta \geq 1/2$. The low-quality firm is out of the market, the price charged by the high-quality firm is $p_1 = \underline{\theta}(s_1 - s_2)$, and its last stage profit equals $\Pi_1 = (\bar{\theta} - \underline{\theta})\underline{\theta}(s_1 - s_2)$.

Regular case **(M1/D)**, constrained monopoly of the high-quality firm with over-covered market, occurs when

$$t_2 < \underline{\theta}s_2,\ t_2 \geq 0,\ t_2 \geq (\bar{\theta} - 2\underline{\theta})(s_1 - s_2),$$

which implies $\Theta > (s_1 - s_2)/(2s_1 - s_2)$. The first constraint always binds, and the second one is stronger than the last one iff $\Theta > 1/2$. The monopoly price is $p_1 = \underline{\theta}(s_1 - s_2) + t_2$, and the monopoly profit equals $\Pi_1 = (\bar{\theta} - \underline{\theta})(\underline{\theta}(s_1 - s_2) + t_2)$.

Case **(m1/d)**, constrained monopoly of the high-quality firm with non-covered market, occurs when

$$t_2 < \bar{\theta}s_2/2,\ t_2 \geq \underline{\theta}s_2,\ t_2 \geq \bar{\theta}s_2(s_1 - s_2)/(2s_1 - s_2),$$

which implies $\Theta < 1/2$. The first constraint always binds, and the second one is stronger than the last one iff $\Theta \geq (s_1 - s_2)/(2s_1 - s_2)$. The monopoly price is $p_1 = s_1t_2/s_2$, and the monopoly profit equals $\Pi_1 = (\bar{\theta} - t_2/s_2)(s_1t_2/s_2)$.

Case **(M1/m1)**, unconstrained monopoly of the high-quality firm with exactly covered market, occurs when $t_2 \geq \underline{\theta}s_2$ and $\Theta \geq 1/2$. The monopoly price is $p_1 = \underline{\theta}s_1$, and the monopoly profit equals $\Pi_1 = (\bar{\theta} - \underline{\theta})\underline{\theta}s_1$.

Case **(m1)**, unconstrained monopoly of the high-quality firm with non-covered market, occurs when $t_2 \geq \bar{\theta}s_2/2$ and $\Theta < 1/2$. The monopoly price is $p_1 = \bar{\theta}s_1/2$, and the monopoly profit equals $\Pi_1 = \bar{\theta}^2s_1/4$.

Case **(D/0)**, singular duopoly with over-covered market, occurs when

$$t_2 \leq (2\underline{\theta} - \bar{\theta})(s_1 - s_2)/2,\ \Theta < 1/2.$$

The equilibrium prices are

$$p_1 = \bar{\theta}(s_1 - s_2)/2, \quad p_2 = 0,$$

and the profits equal

$$\Pi_1 = \bar{\theta}^2(s_1 - s_2)/4, \quad \Pi_2 = -(\bar{\theta} - 2\underline{\theta})t_2/2$$

(this case can only occur when t_2 is negative.)

Case **(D)**, duopoly with over-covered market, occurs when

$$t_2 > (2\underline{\theta} - \bar{\theta})(s_1 - s_2)/2,\ t_2 < \Big((2\underline{\theta} - \bar{\theta})s_1 + (\bar{\theta} + \underline{\theta})s_2\Big)/2,\ t_2 < (\bar{\theta} - 2\underline{\theta})(s_1 - s_2),$$

which implies $0 < \Theta < 1/2$. The first constraint always binds, and the second one is stronger than the last one iff $\Theta \le (s_1 - s_2)/(2s_1 - s_2)$. The equilibrium prices are

$$p_1 = \frac{(2\bar{\theta} - \underline{\theta})(s_1 - s_2) + t_2}{3}, \quad p_2 = \frac{(\bar{\theta} - 2\underline{\theta})(s_1 - s_2) + 2t_2}{3},$$

the indifferent consumer is located at

$$\theta_{12} = \frac{\bar{\theta} + \underline{\theta}}{3} - \frac{t_2}{3(s_1 - s_2)},$$

and the profits equal

$$\Pi_1 = \frac{\Big((2\bar{\theta} - \underline{\theta})(s_1 - s_2) + t_2\Big)^2}{9(s_1 - s_2)}, \quad \Pi_2 = \frac{\Big((\bar{\theta} - 2\underline{\theta})(s_1 - s_2) - t_2\Big)^2}{9(s_1 - s_2)}.$$

Case **(D/d)**, duopoly with exactly covered market, occurs when

$$t_2 \ge \Big((2\underline{\theta} - \bar{\theta})s_1 + (\bar{\theta} + \underline{\theta})s_2\Big)/2,\ t_2 \le \Big((4\underline{\theta} - \bar{\theta})s_1 + (\bar{\theta} - \underline{\theta})s_2\Big)s_2/(2s_1),$$

which implies $\Theta \le (s_1 - s_2)/(2s_1 - s_2)$. The equilibrium prices are

$$p_1 = \Big(\bar{\theta}(s_1 - s_2) + \underline{\theta}s_2\Big)/2, \quad p_2 = \underline{\theta}s_2,$$

the indifferent consumer is located at

$$\theta_{12} = \frac{\bar{\theta}(s_1 - s_2) - \underline{\theta}s_2}{2(s_1 - s_2)},$$

and the profits equal

$$\Pi_1 = \frac{\Big(\bar{\theta}(s_1 - s_2) + \underline{\theta}s_2\Big)^2}{4(s_1 - s_2)}, \quad \Pi_2 = \frac{(\underline{\theta}s_2 - t_2)\Big((\bar{\theta} - 2\underline{\theta})s_1 + (\underline{\theta} - \bar{\theta})s_2\Big)}{2(s_1 - s_2)}.$$

Finally, case **(d)**, duopoly with non-covered market, occurs when

$$t_2 \ge \Big((4\underline{\theta} - \bar{\theta})s_1 + (\bar{\theta} - \underline{\theta})s_2\Big)s_2/(2s_1),\ t_2 < \bar{\theta}s_2(s_1 - s_2)/(2s_1 - s_2),$$

which implies $\Theta < (s_1 - s_2)/(2s_1 - s_2)$. The equilibrium prices are

$$p_1 = \frac{s_1\Big(2\bar{\theta}(s_1 - s_2) + t_2\Big)}{4s_1 - s_2}, \quad p_2 = \frac{s_2\bar{\theta}(s_1 - s_2) + 2s_1t_2}{4s_1 - s_2},$$

the indifferent consumers are located at

$$\theta_{12} = \frac{2s_1 - s_2}{4s_1 - s_2}\bar{\theta} - \frac{s_1 t_2}{(4s_1 - s_2)(s_1 - s_2)}, \quad \theta_{20} = \frac{s_1 - s_2}{4s_1 - s_2}\bar{\theta} + \frac{2s_1 t_2}{s_2(4s_1 - s_2)},$$

and the profits equal

$$\Pi_1 = \frac{s_1^2\Big(2\bar{\theta}(s_1 - s_2) + t_2\Big)^2}{(s_1 - s_2)(4s_1 - s_2)^2}, \quad \Pi_2 = \frac{s_1\Big(\bar{\theta}s_2(s_1 - s_2) - t_2(2s_1 - s_2)\Big)^2}{s_2(s_1 - s_2)(4s_1 - s_2)^2}.$$

The sets of parameters Θ and tariffs t_2 leading to these market structures are depicted in Figure 6.

Low-quality domestic firm

Let $t_2 = 0$, i.e., let the low-quality firm be domestic. Then the following equilibria can occur according to Kúnin (2003).

Case **(M1/D)**, (constrained) monopoly of the high-quality firm with over-covered market, occurs when the tariff on the high-quality firm is low, $t_1 \leq (2\underline{\theta} - \bar{\theta})(s_1 - s_2)$. Then the monopoly price is $p_1 = \underline{\theta}(s_1 - s_2)$, and the last stage monopoly profit of the foreign firm equals $\Pi_1 = (\bar{\theta} - \underline{\theta})\underline{\theta}(s_1 - s_2)$.

Case **(M2/D)**, constrained monopoly of the low-quality firm with over-covered market, occurs when

$$(2\bar{\theta} - \underline{\theta})(s_1 - s_2) \leq t_1 < \bar{\theta}(s_1 - s_2) + \underline{\theta}s_2,$$

which implies $\Theta > 1 - S$. The monopoly price is $p_2 = t_1 - \underline{\theta}(s_1 - s_2)$, and the monopoly profit equals $\Pi_2 = (\bar{\theta} - \underline{\theta})(t_1 - \underline{\theta}(s_1 - s_2))$.

Case **(m2/d)**, constrained monopoly of the low-quality firm with non-covered market, occurs when

$$t_1 < \bar{\theta}(s_1 - s_2/2),\ t_1 \geq 2\bar{\theta}s_1(s_1 - s_2)/(2s_1 - s_2),\ t_1 \geq \bar{\theta}(s_1 - s_2) + \underline{\theta}s_2.$$

This implies $\Theta < 1/2$. The first constraint always binds, and the second one is stronger than the last one iff $\Theta \leq (s_1 - s_2)/(2s_1 - s_2)$. The monopoly price is the same as in (M2/D), $p_2 = t_1 - \underline{\theta}(s_1 - s_2)$, and the monopoly profit equals $\Pi_2 = \Big(\bar{\theta}s_1 - t_1\Big)\Big(t_1 - \bar{\theta}(s_1 - s_2)\Big)/s_2$.

Case **(M2/m2)**, unconstrained monopoly of the low-quality firm with exactly covered market, occurs when $t_1 \geq \bar{\theta}(s_1 - s_2) + \underline{\theta}s_2$ and $\Theta \geq 1/2$. The monopoly price is $p_2 = \underline{\theta}s_2$, and the monopoly profit equals $\Pi_2 = (\bar{\theta} - \underline{\theta})\underline{\theta}s_2$.

Case **(m2)**, unconstrained monopoly of the low-quality firm with non-covered market, occurs when $t_1 \geq \bar{\theta}(s_1 - s_2/2)$ and $\Theta < 1/2$. The monopoly price is $p_2 = \bar{\theta}s_2/2$, and the monopoly profit equals $\Pi_2 = \bar{\theta}^2 s_2/4$.

Case **(D)**, duopoly with over-covered market, occurs when

$$t_1 > (2\underline{\theta} - \bar{\theta})(s_1 - s_2),\ t_1 < (2\underline{\theta} - \bar{\theta})s_1 + (\bar{\theta} + \underline{\theta})s_2,\ t_1 < (2\bar{\theta} - \underline{\theta})(s_1 - s_2).$$

The first constraint always binds, and the second one is stronger than the last one iff $\Theta \leq 1 - S$. The equilibrium prices are

$$p_1 = \frac{(2\bar{\theta} - \underline{\theta})(s_1 - s_2) + 2t_1}{3}, \quad p_2 = \frac{(\bar{\theta} - 2\underline{\theta})(s_1 - s_2) + t_1}{3},$$

the indifferent consumer is located at

$$\theta_{12} = \frac{\bar{\theta} + \underline{\theta}}{3} + \frac{t_1}{3(s_1 - s_2)},$$

and the profits equal

$$\Pi_1 = \frac{\big((2\bar{\theta} - \underline{\theta})(s_1 - s_2) - t_1\big)^2}{9(s_1 - s_2)}, \quad \Pi_2 = \frac{\big((\bar{\theta} - 2\underline{\theta})(s_1 - s_2) + t_1\big)^2}{9(s_1 - s_2)}.$$

Case **(D/d)**, duopoly with exactly covered market, occurs when

$$t_1 \geq (2\underline{\theta} - \bar{\theta})s_1 + (\bar{\theta} + \underline{\theta})s_2, \; t_1 \leq (4\underline{\theta} - \bar{\theta})s_1 + (\bar{\theta} - \underline{\theta})s_2, \; t_1 < \bar{\theta}(s_1 - s_2) + \underline{\theta}s_2,$$

which implies $\Theta < 1 - S$. The first constraint always binds, and the second one is stronger than the last one iff $\Theta \leq (s_1 - s_2)/(2s_1 - s_2)$. The equilibrium prices are

$$p_1 = \big(\bar{\theta}(s_1 - s_2) + \underline{\theta}s_2 + t_1\big)/2, \quad p_2 = \underline{\theta}s_2,$$

the indifferent consumer is located at

$$\theta_{12} = \frac{\bar{\theta}(s_1 - s_2) - \underline{\theta}s_2 + t_1}{2(s_1 - s_2)},$$

and the profits equal

$$\Pi_1 = \frac{\big(\bar{\theta}(s_1 - s_2) + \underline{\theta}s_2 - t_1\big)^2}{4(s_1 - s_2)}, \quad \Pi_2 = \frac{\underline{\theta}s_2\big((\bar{\theta} - 2\underline{\theta})s_1 + (\underline{\theta} - \bar{\theta})s_2 + t_1\big)}{2(s_1 - s_2)}.$$

Finally, case **(d)**, duopoly with non-covered market, occurs when

$$t_1 > (4\underline{\theta} - \bar{\theta})s_1 + (\bar{\theta} - \underline{\theta})s_2, \; t_1 < 2\bar{\theta}s_1(s_1 - s_2)/(2s_1 - s_2),$$

which implies $\Theta < (s_1 - s_2)/(2s_1 - s_2)$. The equilibrium prices are

$$p_1 = \frac{2s_1\big(\bar{\theta}(s_1 - s_2) + t_1\big)}{4s_1 - s_2}, \quad p_2 = \frac{s_2\big(\bar{\theta}(s_1 - s_2) + t_1\big)}{4s_1 - s_2},$$

the indifferent consumers are located at

$$\theta_{12} = \frac{2s_1 - s_2}{4s_1 - s_2}\bar{\theta} + \frac{(2s_1 - s_2)t_1}{(4s_1 - s_2)(s_1 - s_2)}, \quad \theta_{20} = \frac{s_1 - s_2}{4s_1 - s_2}\bar{\theta} + \frac{t_1}{4s_1 - s_2},$$

and the profits equal

$$\Pi_1 = \frac{\big(2\bar{\theta}s_1(s_1 - s_2) - t_1(2s_1 - s_2)\big)^2}{(s_1 - s_2)(4s_1 - s_2)^2}, \quad \Pi_2 = \frac{s_1 s_2\big(\bar{\theta}(s_1 - s_2) + t_1\big)^2}{(s_1 - s_2)(4s_1 - s_2)^2}.$$

The sets of parameters Θ and tariffs t_2 leading to these market structures are depicted in Figure 7. The Figure corresponds to the case $S < 1/2$; if $S > 1/2$, then the point joint for the boundaries of (D/d), (D), and (M2/D), is situated on the lower-right boundary of (m2/d) rather than on that of (M2/m2).

C Welfare maximisation

High-quality domestic firm

When the domestic firm produces the high quality, then $t_1 = 0$ and the equilibria that can occur depending on Θ and S are listed in Appendix B and depicted in Figure 6.

It can be shown that the domestic welfare W_1 does not depend on t_2 in cases (D/0)-singular, (M1/D), (M1/m1), and (m1).

In (m1/d), W_1 strictly decreases in t_2 for $t_2 > 0$, and (m1/d)-equilibrium implies $t_2 > \bar{\theta} s_2(s_1 - s_2)/(2s_1 - s_2) > 0$. In (D/d), W_1 strictly increases in t_2 when $\Theta < (s_1 - s_2)/(2s_1 - s_2)$, which is the only possible case in equilibrium. In (D/0)-regular, W_1 strictly increases in t_2 when $\Theta < 1/2$, which is again the only possible case in equilibrium.

In (D), W_1 is maximised at $t_2 = (\bar{\theta} - \underline{\theta})(s_1 - s_2)$, but (D) occurs when *inter alia* $t_2 < (\bar{\theta} - 2\underline{\theta})(s_1 - s_2)$. This implies that W_1 increases in t_2 whenever t_2 leads to duopoly with over-covered market.

In (d), W_1 is maximised at $t_2 = t_2^d = \bar{\theta} s_2(s_1 - s_2)/(3s_1 - 2s_2)$. Recall that (d) with $t_1 = 0$ occurs when

$$t_2 \geq \Big((4\underline{\theta} - \bar{\theta})s_1 + (\bar{\theta} - \underline{\theta})s_2\Big)s_2/(2s_1), \;\; t_2 < \bar{\theta} s_2(s_1 - s_2)/(2s_1 - s_2).$$

The second of these conditions always holds at $t_2 = t_2^d$, and the first one holds at $t_2 = t_2^d$ when

$$\Theta \leq \Theta_2 = \frac{(s_1 - s_2)(5s_1 - 2s_2)}{(4s_1 - s_2)(3s_1 - 2s_2)} = \frac{(1 - S)(5 - 2S)}{(4 - S)(3 - 2S)}.$$

If $\Theta > (s_1 - s_2)/(2s_1 - s_2)$, then the value of t_2 maximising W_1 is not unique (moreover, if $\Theta \geq 1/2$, then the foreign firm is out of the market for any t_2 and the only effect of t_2 is redistributive.) By assumption, the government selects the minimal non-negative t_2 of the optimal ones.

The tariff levels t_2 selected by the government and the corresponding equilibrium structures are given in the following table.

Range of values of Θ	Equilibrium	Optimal tariff t_2
$[0, \Theta_2)$	(d)	$t_2^d = \bar{\theta} s_2(s_1 - s_2)/(3s_1 - 2s_2)$
$[\Theta_2, (s_1 - s_2)/(2s_1 - s_2))$	(D/d)/(d)	$\Big((4\underline{\theta} - \bar{\theta})s_1 + (\bar{\theta} - \underline{\theta})s_2\Big)s_2/(2s_1)$
$[(s_1 - s_2)/(2s_1 - s_2), 1/2)$	(M1/D)/(D)	$(\bar{\theta} - 2\underline{\theta})(s_1 - s_2)$
$[1/2, 1]$	(M1/D)/(D/0)	0

The optimal tariff t_2 as a function of Θ (with S fixed) is shown as the bold line in Figure 8. After welfare maximisation, the market structure is determined by Θ and S as shown in Figure 3, where the label '(D/d)' stands for case (D/d)/(d) and both monopoly outcomes are labelled '(M1)'.

The firms' second stage profits at the optimal tariff levels are

$$\Pi_1 = \bar{\theta}^2 \frac{9s_1^2(s_1-s_2)(2s_1-s_2)^2}{(3s_1-2s_2)^2(4s_1-s_2)^2}, \quad \Pi_2 = \bar{\theta}^2 \frac{s_1 s_2(s_1-s_2)^3}{(3s_1-2s_2)^2(4s_1-s_2)^2}$$

when the outcome is duopoly with non-covered market (d),

$$\Pi_1 = \bar{\theta}^2 \frac{(s_1-s_2+\Theta s_2)^2}{4(s_1-s_2)}, \quad \Pi_2 = \bar{\theta}^2 \frac{s_2(s_1-s_2+\Theta(s_2-2s_1))^2}{4s_1(s_1-s_2)}$$

when the outcome is duopoly with exactly covered market (D/d)/(d),

$$\Pi_1 = \bar{\theta}^2(1-\Theta)^2(s_1-s_2)$$

(and $\Pi_2 = 0$) when the outcome is monopoly and $\Theta < 1/2$, and

$$\Pi_1 = \bar{\theta}^2\Theta(1-\Theta)(s_1-s_2)$$

(and $\Pi_2 = 0$) when the outcome is monopoly and $\Theta \geq 1/2$.

Low-quality domestic firm

When the domestic firm produces the low quality, then $t_2 = 0$ and the equilibria that can occur depending on Θ and S are listed in Appendix B and depicted in Figure 7.

It can be shown that the domestic welfare W_2 does not depend on t_1 in cases (M2/D), (M2/m2), and (m2).

In (M1/D), W_2 strictly increases in t_1. In (m2/d), W_2 strictly decreases in t_1 for $t_1 > \bar{\theta}(s_1-s_2)$, and (m2/d)-equilibrium implies $t_1 \geq 2\bar{\theta}s_1(s_1-s_2)/(2s_1-s_2) > \bar{\theta}(s_1-s_2)$.

In (D), W_2 is maximised at $t_1 = t_1^D = (\bar{\theta}-\underline{\theta})(s_1-s_2)$. Recall that (D) with $t_2 = 0$ occurs when

$$t_1 > (2\underline{\theta}-\bar{\theta})(s_1-s_2),\ t_1 < (2\underline{\theta}-\bar{\theta})s_1 + (\bar{\theta}+\underline{\theta})s_2,\ t_1 < (2\bar{\theta}-\underline{\theta})(s_1-s_2).$$

The last condition always holds at $t_1 = t_1^D$, and the first two hold at $t_1 = t_1^D$ when

$$2(1-S)/3 < \Theta < 2/3.$$

In (D/d), W_2 is maximised at $t_1 = t_1^{D/d} = \bar{\theta}(s_1-s_2)/3 + \underline{\theta}s_2$. Recall that (D/d) with $t_2 = 0$ occurs when

$$t_1 \geq (2\underline{\theta}-\bar{\theta})s_1 + (\bar{\theta}+\underline{\theta})s_2,\ t_1 \leq (4\underline{\theta}-\bar{\theta})s_1 + (\bar{\theta}-\underline{\theta})s_2,\ t_1 < \bar{\theta}(s_1-s_2) + \underline{\theta}s_2.$$

The last condition always holds at $t_1 = t_1^{D/d}$, and the first two hold at $t_1 = t_1^{D/d}$ when

$$(2/3)(s_1-s_2)/(2s_1-s_2) = (2/3)(1-S)/(2-S) = \Theta_1^+ \leq \Theta \leq 2(1-S)/3.$$

In (d), W_2 is maximised at $t_1 = t_1^d = \bar{\theta} s_1(s_1 - s_2)/(3s_1 - 2s_2)$. Recall that (d) with $t_2 = 0$ occurs when

$$t_1 > (4\underline{\theta} - \bar{\theta})s_1 + (\bar{\theta} - \underline{\theta})s_2,\ t_1 < 2\bar{\theta} s_1(s_1 - s_2)/(2s_1 - s_2),$$

The last condition always holds at $t_1 = t_1^d$, and the first one holds at $t_1 = t_1^d$ when

$$\Theta < \Theta_1^- = \frac{(s_1 - s_2)(4s_1 - 2s_2)}{(4s_1 - s_2)(3s_1 - 2s_2)} = \frac{(1 - S)(4 - 2S)}{(4 - S)(3 - 2S)}.$$

Thus, the tariff levels t_1 selected by the government and the corresponding equilibrium structures are given by the following table.

Range of values of Θ	Equilibrium	Optimal tariff t_1
$\left[0, \Theta_1^-\right)$	(d)	$t_1^d = \bar{\theta} s_1(s_1 - s_2)/(3s_1 - 2s_2)$
$\left[\Theta_1^-, \Theta_1^+\right)$	(D/d)/(d)	$(4\underline{\theta} - \bar{\theta})s_1 + (\bar{\theta} - \underline{\theta})s_2$
$\left[\Theta_1^+, 2(1 - S)/3\right]$	(D/d)	$t_1^{D/d} = \bar{\theta}(s_1 - s_2)/3 + \underline{\theta} s_2$
$(2(1 - S)/3, 2/3)$	(D)	$t_1^D = (\bar{\theta} - \underline{\theta})(s_1 - s_2)$
$[2/3, 1]$	(M1/D)/(D)	$(2\underline{\theta} - \bar{\theta})(s_1 - s_2)$

The optimal tariff t_1 as a function of Θ (with S fixed) is shown as the bold line in Figure 9. The alignment of market structures in this figure corresponds to $S < 1/2$. Though this alignment is slightly different for $S > 1/2$ (see Appendix B), the optimal tariff levels are determined by the same expressions and by the same conditions.

After welfare maximisation, the market structure is determined by Θ and S as shown in Figure 4, where the label '(M1)' stands for the monopoly outcome. In this figure, the area corresponding to case (D/d)/(d) is not shown as being out of scale since $\Theta_1^+ - \Theta_1^- \in [0, 0.008)$ for all S.

The firms' second stage profits at the optimal tariff levels are

$$\Pi_1 = \bar{\theta}^2 \frac{s_1^2(s_1 - s_2)(4s_1 - 3s_2)^2}{(3s_1 - 2s_2)^2(4s_1 - s_2)^2}, \quad \Pi_2 = \bar{\theta}^2 \frac{4s_1 s_2(s_1 - s_2)(2s_1 - s_2)^2}{(3s_1 - 2s_2)^2(4s_1 - s_2)^2}$$

when the outcome is duopoly with non-covered market (d),

$$\Pi_1 = \bar{\theta}^2 \frac{(s_1 - s_2 + \Theta(s_2 - 2s_1))^2}{s_1 - s_2}, \quad \Pi_2 = \bar{\theta}^2 \frac{s_1 s_2 \Theta^2}{s_1 - s_2}$$

in case (D/d)/(d), which is a special case of duopoly with exactly covered market,

$$\Pi_1 = \bar{\theta}^2(s_1 - s_2)/9, \quad \Pi_2 = \bar{\theta}^2\Theta(2 - 3\Theta)s_2/3$$

when the outcome is "regular" duopoly with exactly covered market (D/d),

$$\Pi_1 = \bar{\theta}^2(s_1 - s_2)/9, \quad \Pi_2 = \bar{\theta}^2(2 - 3\Theta)^2(s_1 - s_2)/9$$

when the outcome is duopoly with over-covered market, and

$$\Pi_1 = \bar{\theta}^2(1 - \Theta)^2(s_1 - s_2)$$

(and $\Pi_2 = 0$) when the outcome is monopoly.

D Proof of Proposition 1

Recall that if $\Theta \in [1/3, 2/3]$ and the domestic firm produces the low quality, then the profit of the high-quality firm (all profits are divided by $\bar{\theta}^2$) equals

$$\Pi_1 = (s_1 - s_2)/9 - k_1 s_1^2/2$$

under both exactly covered and over-covered market. The profit of the low-quality firm equals

$$\Pi_2 = \Theta(2 - 3\Theta)s_2/3 - k_2 s_2^2/2$$

when the market is exactly covered (i.e., $S < 1 - 3\Theta/2$) and

$$\Pi_2^+ = (2 - 3\Theta)^2(s_1 - s_2)/9 - k_2 s_2^2/2$$

when the market is over-covered ($S \geq 1 - 3\Theta/2$.)

The following conditions are necessary for a pair (s_1, s_2) to be an equilibrium. First, s_1 should deliver an interior (i.e., $S < 1$) maximum to Π_1 given s_2. Second, for an interior equilibrium s_2 should deliver an interior maximum to Π_2, whereas for a boundary equilibrium Π_2 should be increasing in S under exactly covered market and decreasing in S under over-covered market.

From the (unconstrained) first-order conditions it follows that

$$\partial\Pi_1/\partial s_1 = 0 \Rightarrow s_1 = 1/(9k_1)$$

and, for an interior equilibrium,

$$\partial\Pi_2/\partial s_2 = 0 \Rightarrow s_2 = \Theta(2 - 3\Theta)/(3k_2).$$

This implies $S = 3\Theta(2-3\Theta)/K$, which should satisfy $0 \leq S < 1-3\Theta/2$, whence $K > 6\Theta$.

For a boundary equilibrium, from $s_1 = 1/(9k_1)$ it follows that

$$s_2 = (1 - 3\Theta/2)s_1 = (2 - 3\Theta)/(18k_1).$$

By construction, $S = 1 - 3\Theta/2$. The condition on firm 2's profit is

$$\partial\Pi_2/\partial s_2 \geq 0 \Leftrightarrow K \leq 6\Theta.$$

(The other condition, $\partial\Pi_2^+/\partial s_2 \leq 0$, holds for any s_2.)

It remains to check whether the values obtained lead to non-negative profits. For an interior equilibrium, the profits are

$$\Pi_1 = (K - 6\Theta(2 - 3\Theta))/(162k_2), \quad \Pi_2 = \Theta^2(2 - 3\Theta)^2/(18k_2),$$

i.e. Π_2 is never negative and Π_1 is non-negative when $K \geq 6\Theta(2-3\Theta)$, which is a weaker condition than $K > 6\Theta$ when $\Theta \geq 1/3$. For a boundary equilibrium, the profits are

$$\Pi_1 = (3\Theta - 1)/(162k_1), \quad \Pi_2 = (12\Theta - K)(2 - 3\Theta)^2/(648k_1),$$

which are both non-negative when $\Theta \in [1/3, 2/3]$ and $K \leq 6\Theta$.

Q.E.D.

E Proof of Proposition 2

Scaling

The following auxiliary result is used.

Lemma 1 *Let $\bar{\theta}$ and $\underline{\theta}$ be fixed, and let (s_1, s_2) be an equilibrium of the whole game when firms' cost functions are characterised by k_1 and k_2. Let $k_i' = \alpha k_i$, $\alpha > 0$. Then (s_1', s_2'), where $s_i' = s_i/\alpha$, is an equilibrium of the whole game when firms' cost functions are characterised by k_1' and k_2'.*

This result follows from the fact that the firms' second stage profits are homogeneous of degree one in qualities, whereas the cost functions are homogeneous of degree two in qualities and of degree one in k_i. Thus, if the first stage profit function of firm i is $\Pi_i(s_1, s_2; k_1, k_2)$, then

$$\Pi_i(s_1', s_2'; k_1', k_2') = \Pi_i(s_1, s_2; k_1, k_2)/\alpha,$$

whence the claim of the Lemma follows immediately.

According to this Lemma, it is possible to fix one of the k_i at some given k_i^0 and then the other k_j is determined from the relation $k_2 = Kk_1$.

Profits and deviations

Recall that the candidate equilibrium in question is the following. The high-quality firm always (for any K) chooses $s_1 = 1/(9k_1)$. The low-quality firm's choice is $s_2 = \Theta(2 - 3\Theta)/(3k_2)$ when $K > 6\Theta$ and $s_2 = (2 - 3\Theta)/(18k_1)$ when $K \leq 6\Theta$. Without losing generality (by Lemma 1), let $k_1 = 1/9$, which implies $k_2 = K/9$, $s_1 = 1$, $s_2 = 3\Theta(2 - 3\Theta)/K$ when $K > 6\Theta$ and $s_2 = 1 - 3\Theta/2$ when $K \leq 6\Theta$.

Then the profits equal

$$\Pi_1 = (K - 6\Theta(2 - 3\Theta))/(18K), \quad \Pi_2 = \Theta^2(2 - 3\Theta)^2/(2K)$$

when $K > 6\Theta$ and

$$\Pi_1 = (3\Theta - 1)/18, \quad \Pi_2 = (12\Theta - K)(2 - 3\Theta)^2/72$$

when $K \leq 6\Theta$.

A quality reversal by the low-quality firm as defined by Herguera et al. (2002) takes place when in the candidate equilibrium above s_2 is not *the global* maximum of the low-quality firm's profit. In Proposition 1 it is shown that s_2 maximises Π_2 subject to the constraint $s_2 < s_1$, where s_1 is taken as given. Thus, a quality reversal occurs when there exists $s_2' > s_1$ such that the deviation profit exceeds the maximal profit provided above.

If the low-quality firm deviates to become the high-quality one, then according to Appendix C and taking into account that $k_2 = K/9$ and $s_1 = 1$ its deviation profits are the following (all profits are divided by $\bar{\theta}^2$; note that $S = s_1/s_2$ and $s_1 = 1$ is substituted for s_2 in the formulae of Appendix C.) If $\Theta \geq 1/2$, then the market structure after the deviation is always monopoly and

$$\Pi_2' = \Theta(1-\Theta)(s_2 - 1) - Ks_2^2/18.$$

If $\Theta < 1/2$ and the market structure after deviation is monopoly, which happens when $S \geq (1-2\Theta)/(1-\Theta)$, then

$$\Pi_2' = (1-\Theta)^2(s_2 - 1) - Ks_2^2/18.$$

If $\Theta < 1/2$ and the market structure after deviation is duopoly with exactly covered market, which happens when $S < (1-2\Theta)/(1-\Theta)$ and either $\Theta \geq 5/12$ or $S \geq S_2(\Theta)$, where

$$S_2(\Theta) = \frac{7 - 11\Theta - \sqrt{9 - 18\Theta + 25\Theta^2}}{4(1-\Theta)},$$

then

$$\Pi_2' = \frac{(s_2 - 1 + \Theta)^2}{4(s_2 - 1)} - Ks_2^2/18.$$

Finally, if $\Theta < 5/12$ and the market structure after deviation is duopoly with non-covered market, which happens when $S < S_2(\Theta)$, then

$$\Pi_2' = \frac{9s_2^2(s_2 - 1)(2s_2 - 1)^2}{(3s_2 - 2)^2(4s_2 - 1)^2} - Ks_2^2/18.$$

Reversal to monopoly

Two cases are distinguished, $\Theta \in [1/2, 2/3]$, when the only constraint is $S = s_1/s_2 \leq 1$, and $\Theta \in [1/3, 1/2)$, when there also is a lower bound on S. If the deviation profit is maximised at the upper bound on S, i.e. at $s_2 = s_1$, then there is no reversal because the profit of the low-quality firm in the candidate equilibrium is non-negative whereas any firm's profit is negative when $s_1 = s_2 \neq 0$.

If $\Theta \in [1/2, 2/3]$, then the deviation profit is unconditionally maximised at $s_2 = 9\Theta(1-\Theta)/K$, which is interior ($S < 1$) when $K < 9\Theta(1-\Theta)$. This upper bound on K is less than 6Θ for $\Theta \in [1/2, 2/3]$ so that there is no reversal to monopoly if the original equilibrium is interior. If the original equilibrium is boundary ($K < 6\Theta$), then the original profit is not less than the deviation profit when

$$K \geq \frac{54\Theta(1-\Theta)^2}{10 - 18\Theta + 9\Theta^2 + \sqrt{(4-3\Theta)(16 - 33\Theta + 18\Theta^2)}}.$$

This threshold belongs to $(1, 1.1)$ for $\Theta \in [1/2, 2/3)$ and equals 1 when $\Theta = 2/3$.

If $\Theta \in [1/3, 1/2)$, then the deviation monopoly profit is unconditionally maximised at $s_2 = 9(1-\Theta)^2/K$, which is interior when $9(1-\Theta)(1-2\Theta) < K < 9(1-\Theta)^2$. If $K \leq 9(1-\Theta)(1-2\Theta)$, then the maximum occurs at the lower bound on S, $S = (1-2\Theta)/(1-\Theta)$. If $K \geq 9(1-\Theta)^2$, then the maximum occurs at $S = 1$ so that there is no reversal.

Since $9(1-\Theta)(1-2\Theta) \leq 6\Theta$ for $\Theta \in [1/3, 1/2)$, the deviation profit cannot be maximised at the lower bound on S when the original equilibrium is interior. If $K \geq 6\Theta$ and the deviation profit has an interior maximum, then the original profit is not less than the deviation profit when $K \geq (9 - 36\Theta + 50\Theta^2 - 24\Theta^3)/(2(1-\Theta)^2)$, which is strictly less than 6Θ for $\Theta \in [1/3, 1/2)$. Thus, there is no quality reversal from an interior equilibrium to monopoly for $\Theta \in [1/3, 1/2)$.

If the original equilibrium is boundary and the deviation profit has an interior maximum, then there is no deviation when

$$K \geq \frac{6 - 8\Theta - 6\Theta^2 + 9\Theta^3 + \sqrt{\Theta(13 - 30\Theta + 18\Theta^2)(12 - 29\Theta + 18\Theta^2)}}{(2-3\Theta)^2/6}.$$

This threshold belongs to $(1, 2)$ and is a decreasing function of Θ for $\Theta \in [1/3, 1/2)$. It equals the lower bound on K for interior maximisation of the deviation profit, $9(1-\Theta)(1-2\Theta)$, at $\Theta = \Theta^b \approx 0.3478$, whence for $1/3 \leq \Theta \leq \Theta^b$ there is no reversal from a boundary equilibrium to monopoly at interior maximum.

If the original equilibrium is boundary and the deviation profit is maximised at the lower bound on S, then there is no deviation when

$$K \geq \frac{12(1-2\Theta)(2 + 8\Theta - 27\Theta^2 + 18\Theta^3)}{20 - 69\Theta + 84\Theta^2 - 36\Theta^3}.$$

This threshold lies above $9(1-\Theta)(1-2\Theta)$ for $\Theta \geq \Theta^b$, which means that for $\Theta^b < \Theta < 1/2$ there is a quality reversal when the deviation profit is maximised at the lower bound on S. At $\Theta = \Theta^b$, this threshold equals the previous one, and for $1/3 \leq \Theta < \Theta^b$ it belongs to $(1.75, 2)$ and is a decreasing function of Θ for $\Theta \in [1/3, 1/2)$. Specifically, the value of this threshold at $\Theta = 1/3$, which is the maximal value of K such that there is a quality reversal by the low-quality domestic firm when $\Theta \in [1/3, 2/3]$, is $28/15$.

The lower bound on relative cost efficiency

From the above it can be concluded that there is no quality reversal by the low-quality domestic firm to monopoly when $K \geq R(\Theta)$, where $R(\Theta)$ is given by

$$R(\Theta) = \frac{12(1-2\Theta)(2 + 8\Theta - 27\Theta^2 + 18\Theta^3)}{20 - 69\Theta + 84\Theta^2 - 36\Theta^3}$$

for $1/3 \leq \Theta \leq \Theta^b \approx 0.3478$,

$$R(\Theta) = \frac{6 - 8\Theta - 6\Theta^2 + 9\Theta^3 + \sqrt{\Theta(13 - 30\Theta + 18\Theta^2)(12 - 29\Theta + 18\Theta^2)}}{(2-3\Theta)^2/6}$$

for $\Theta^b \le \Theta \le 1/2$, and

$$R(\Theta) = \frac{54\Theta(1-\Theta)^2}{10 - 18\Theta + 9\Theta^2 + \sqrt{(4-3\Theta)(16-33\Theta+18\Theta^2)}}$$

for $\Theta \in [1/2, 2/3]$. The function $R(\Theta)$, which is a continuous function with values in $[1, 2)$, is depicted by the thick line in Figure 5.

Reversal to duopoly with exactly covered market

This reversal is possible only for $\Theta \in [1/3, 1/2)$. The constraints on S are $S < (1-2\Theta)/(1-\Theta)$ and $S \ge S_2(\Theta)$. The first-order condition for an interior maximum is

$$\frac{\partial \Pi_2'}{\partial s_2} = \frac{1}{4} - \frac{K s_2}{9} - \frac{\Theta^2}{4(s_2-1)^2} = 0,$$

and the second-order condition is

$$\frac{\partial^2 \Pi_2'}{\partial s_2^2} = -\frac{K}{9} + \frac{\Theta^2}{2(s_2-1)^3} < 0.$$

If the constraints on S are taken into account, then it should be noted that if the first derivative is negative for all s_2, then the deviation profit is maximised at the lower bound on s_2, which corresponds to the upper bound on $S = s_1/s_2$. The first derivative $\partial \Pi_2'/\partial s_2$ is maximised at $s_2 = 1 + (9\Theta^2/(2K))^{1/3}$ (this solves $\partial^2\Pi_2'/\partial s_2^2 = 0$; the third derivative is easily shown to be positive.) Hence, the maximal value the first derivative can attain equals $\left(9 - 4K - 3(6K\Theta)^{2/3}\right)/36$. If $\Theta \ge 1/3$, then the last expression can be positive only for $K < 1.0333$ and $\Theta < 0.3587$, but at those values of K and Θ there is a quality reversal to monopoly as is shown above.

Thus, if K and Θ are such that there is no reversal to monopoly ($K \ge R(\Theta)$), then the deviation profit when the deviation leads to duopoly with exactly covered market is maximised at the upper bound on S. However, at this bound duopoly turns into monopoly, and there is no reversal to monopoly. Therefore, neither is there a reversal to duopoly with exactly covered market.

Reversal to duopoly with non-covered market

This reversal is possible only for $\Theta \in [1/3, 5/12)$, and the constraint on S is $S < S_2(\Theta)$. The first derivative of the deviation profit is

$$\frac{\partial \Pi_2'}{\partial s_2} = -\frac{K s_2}{9} + \frac{9 s_2 (2s_2 - 1)(4 - 22 s_2 + 51 s_2^2 - 54 s_2^3 + 24 s_2^4)}{(3s_2-2)^3(4s_2-1)^3},$$

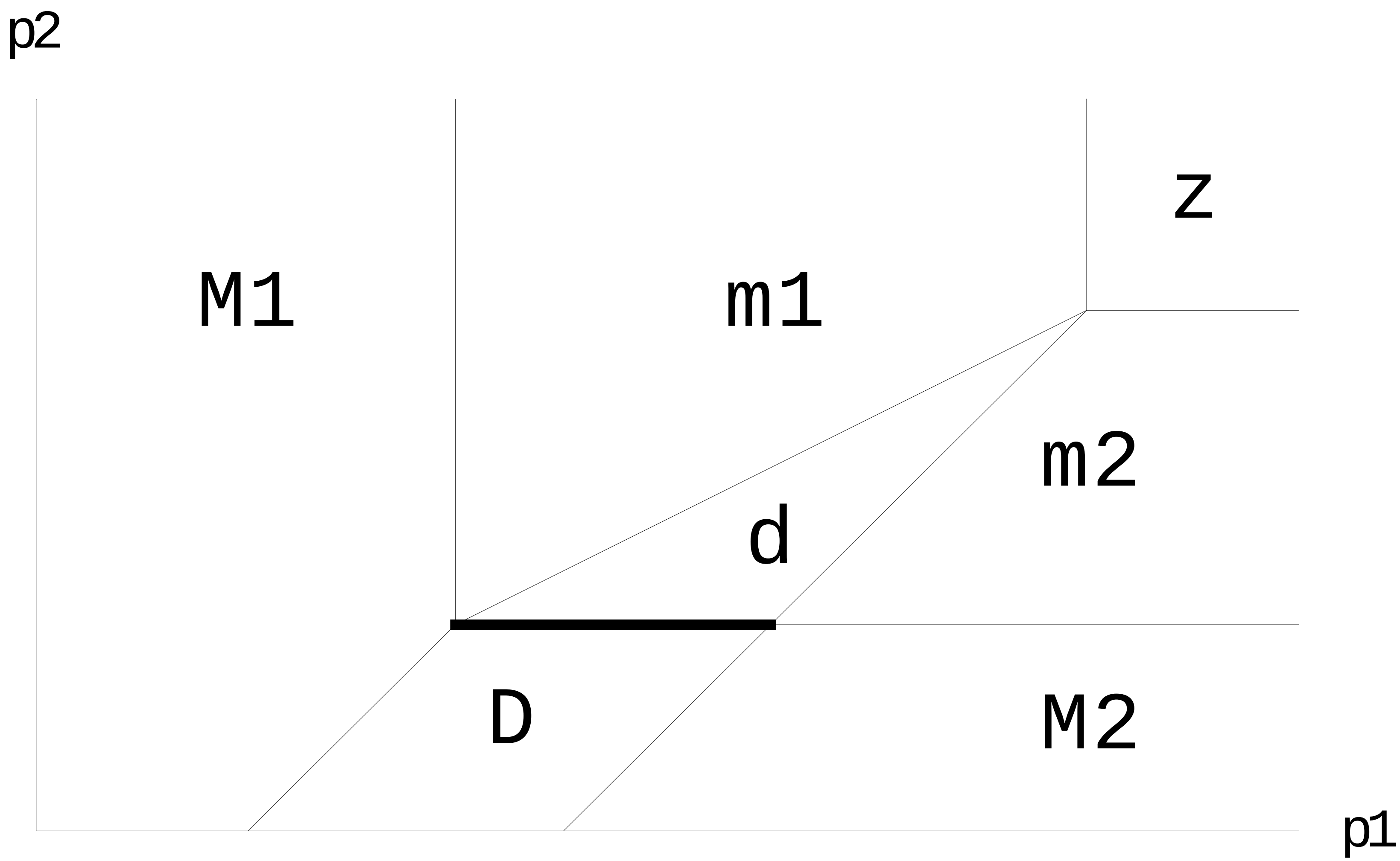
and the second derivative is

$$\frac{\partial^2 \Pi_2'}{\partial s_2^2} = -\frac{K(2 - 11 s_2 + 12 s_2^2)^4 + 648(1 - 4s_2 + 24 s_2^3 - 48 s_2^4 + 33 s_2^5)}{9(3s_2-2)^4(4s_2-1)^4},$$

which is negative for $s_2 \geq 1$. Substituting the value of s_2 corresponding to $S = S_2(\Theta)$ into the first derivative yields that if there is no quality reversal to monopoly then the first derivative is negative for all applicable s_2. Thus, the deviation profit is maximised at the upper bound, where duopoly with non-covered market turns into duopoly with exactly covered market. As is shown above, absence of a quality reversal to monopoly implies absence of a quality reversal to duopoly with exactly covered market. Hence, if there is no quality reversal to monopoly, then there is no quality reversal to duopoly with non-covered market either.

Q.E.D.

Figure 1: Market structures and demand (the thick line corresponds to duopoly with exactly covered market)



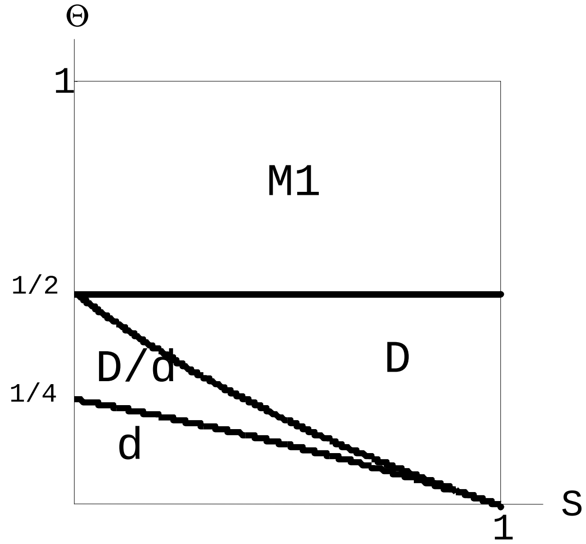


Figure 2: Free trade equilibria

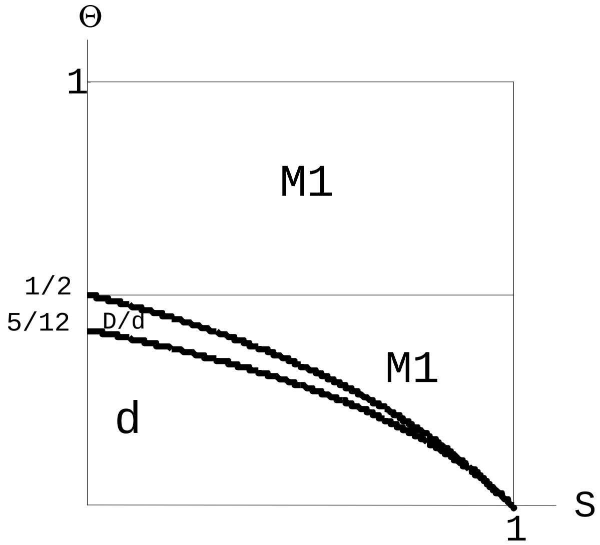


Figure 3: Equilibria under optimal tariff with h.q. domestic firm

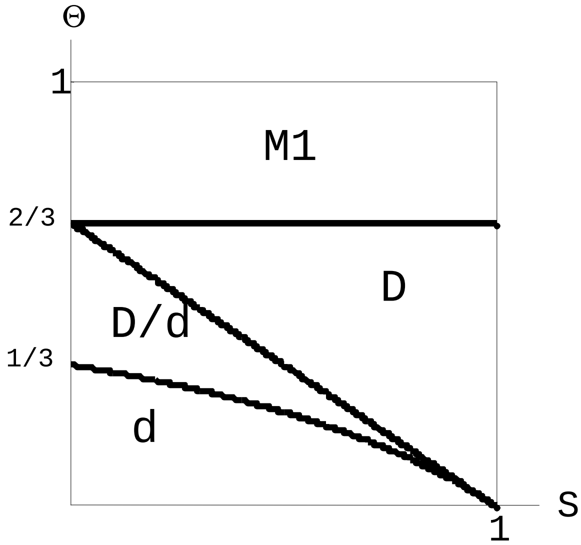


Figure 4: Equilibria under optimal tariff with l.q. domestic firm

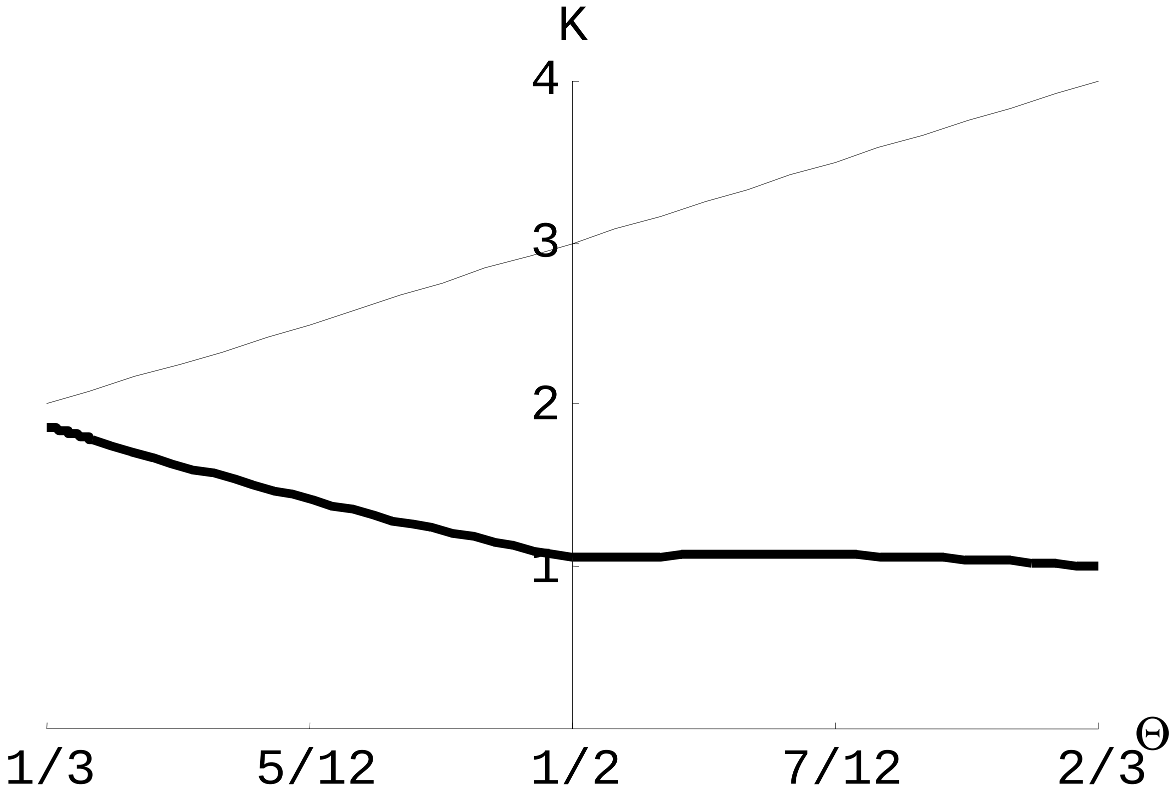


Figure 5: quality reversals in natural duopoly. The upper line is K=6Θ, the lower thick line is R(Θ), there is a reversal for K < R(Θ)

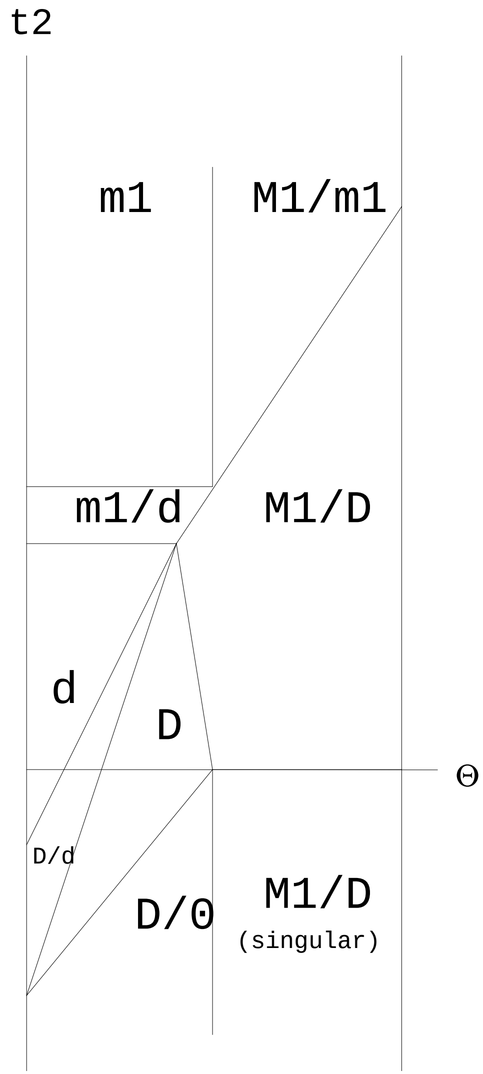


Figure 6: Equilibria with h.q. domestic firm

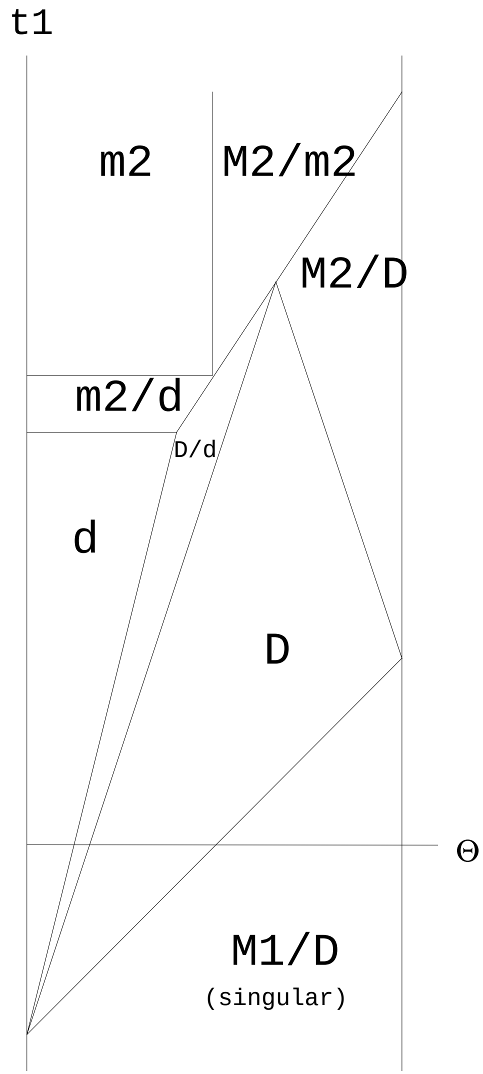


Figure 7: Equilibria with l.q. domestic firm

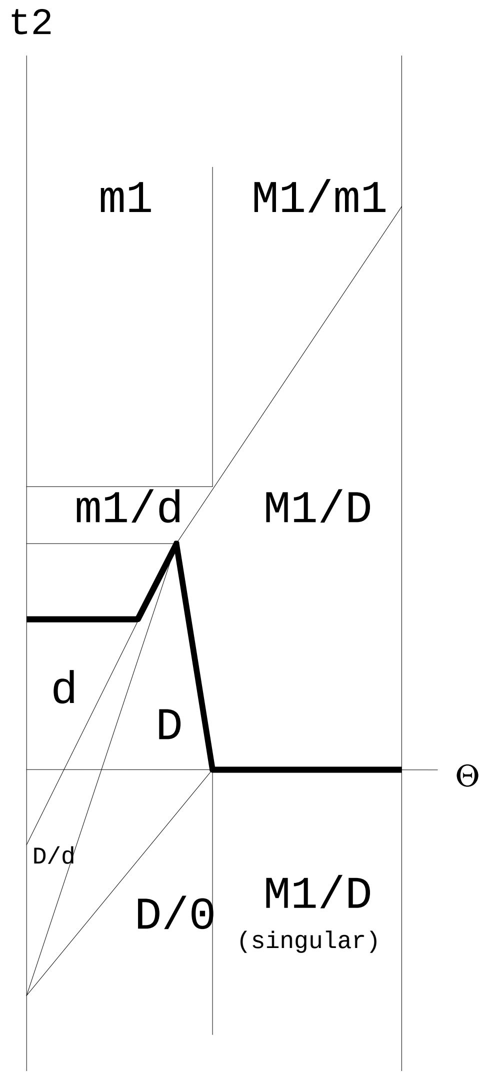


Figure 8: Optimal tariff with h.q. domestic firm

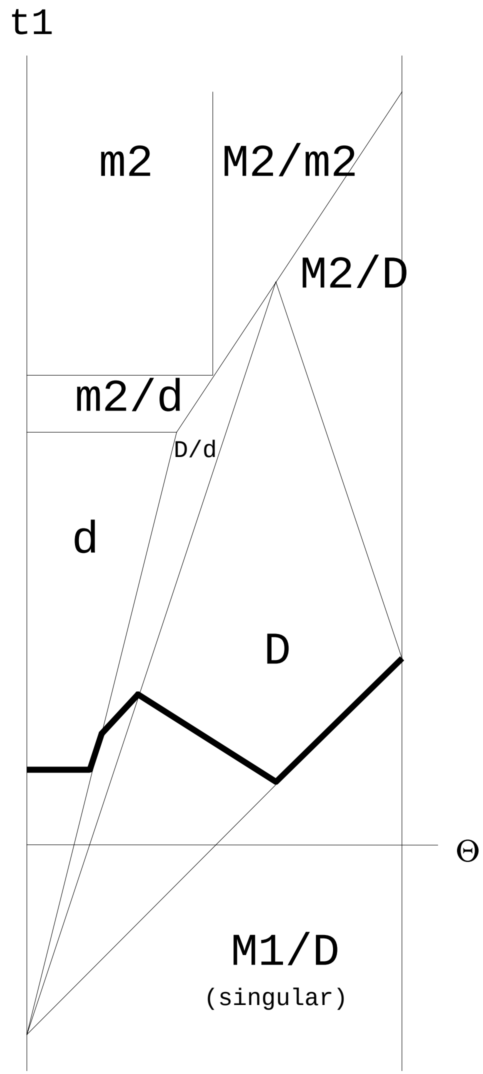


Figure 9: Optimal tariff with l.q. domestic firm

CERGE-EI
P.O.BOX 882
Politických vezòù 7
111 21 Prague 1
Czech Republic
http://www.cerge-ei.cz