ANTI-DUMPING, INTRA-INDUSTRY TRADE AND QUALITY REVERSALS

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Abstract

We examine an export game where two firms (home and foreign), located in two different countries, produce vertically differentiated products. The foreign firm is the most efficient in terms of R&D costs of quality development and the foreign country is relatively larger and endowed with a relatively higher income. The unique (risk-dominant) Nash equilibrium involves intra-industry trade where the foreign producer manufactures a good of higher quality than the domestic firm. This equilibrium is characterized by unilateral dumping by the foreign firm into the domestic economy. Two instruments of anti-dumping (AD) policy are examined, namely, a price undertaking (PU) and an anti-dumping duty. We establish an equivalence result between the effects of an AD duty and a PU. For certain parameter configurations, AD policy appears to be desirable on welfare grounds. This is the case when AD policy leads to a quality reversal in the international market whereby the low-quality firm becomes the producer of high-quality goods.

JEL Classification: F12, F13

Keywords: anti-dumping duty, intra-industry trade, price undertaking, product quality, quality reversals

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1 Introduction

Leapfrogging is central to the catching-up process of developing and transition economies. The underlying idea is that latecomers may be able to bypass old vintages of technology and thereby become highly competitive. In addition, quality reversals are important for making industry leadership persistent, since the higher profits accruing from high-quality production provide firms with the financial resources needed for the continued adoption of the latest technologies and cost-reducing investments.

The cases of leapfrogging have been diverse, depending upon industries and countries, but there is strong evidence against the outward-oriented argument by which the market mechanism gives enough incentives for firms in emerging markets to reach the technology frontier (Brutton, 1998). Instead, the policy issue has been to design market protection schemes to induce learning, knowledge accumulation and quality leadership. In doing so, governments have traditionally used an array of non-market and market instruments, including trade and industrial policy and antidumping laws.

A classic example is the battle between US and Japanese semiconductor manufacturers, which dates back to 1960s when the American producers started to expand their operations in Japan. The Japanese government employed quotas and tariffs to slow down the penetration of the American companies; in addition, it subsidized heavily the development of semiconductor manufacturing technology and the expansion of its industry worldwide (Borrus et al., 1986). In the early 1980s, American companies saw their market shares and profits fall, making it difficult to maintain cost and quality standards. Towards the middle of the 1980s several US firms, including Micron Technology Inc., Intel and AMD, accused their Japanese competitors of dumping in the US market and elsewhere (Hughes et al. 1997). Antidumping duties and retaliatory tariffs on Japanese imports of electronic gear helped the American firms catch up in terms of learning-by-doing and quality standards later in the 1980s. The battle was ended by a series of pacts between the US and the Japanese administrations.1

The Chinese newsprint industry is another example illustrating the use of anti-dumping measures as an instrument to gain time for development and acquisition of advanced equipment. In 1997 Chinese newsprint makers made dumping allegations against overseas producers. As a result, the Chinese government started to levy antidumping tariffs in 1999, for a period of five years. The anti-dumping regime promoted rapid development in the domestic newsprint industry, and indus-

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1Lee and Lim (2001) also stress the important role of the government in providing market protection of fixed duration in their study of the catching-up experience of the Korean industries, another classic example of leapfrogging.
try production increased by 40% during the period (Lu, 2004). In 2004, the Chinese Ministry of Commerce announced that it would continue to impose antidumping duties on US, Canada and South Korea’s newsprint imports.

For members of the World Trade Organization (WTO), market protection via tariff barriers is nowadays limited by countries’ commitments to bind their customs duty rates during multilateral trade negotiations. In contrast, anti-dumping measures whose application is governed by the WTO (article VI of GATT) are not limited.\(^2\) As a result, it is not surprising that, while only a few developed countries –mainly Australia, Canada, the EU and the US– were users of anti-dumping action in the old days, anti-dumping is nowadays the trade policy of choice of developing and transition countries.\(^3\)

The aim of this paper is to shed some light on the issue of whether anti-dumping laws can lead to quality reversals. For this purpose, we introduce a novel model of intra-industry trade with endogenous quality. We first examine the strategic incentives of oligopolistic firms to dump exports in developing economies and then identify conditions under which quality reversals can be induced by anti-dumping actions. To the best of our knowledge, this is the first paper identifying trade conditions under which anti-dumping law is welfare improving.

Bearing in mind that AD actions by a government sanction findings of dumping by exporting firms into a particular country, a number of stylized facts have inspired our framework of analysis:

- Emerging economies target most of their AD initiations against firms from more developed countries. The percentage of initiations (up to 2003) aimed at countries with a larger (2003) income per capita is: 44% for Argentina, 57% for Brazil, 95% for China, 98% for India, 59% for Mexico and 65% for South Africa (own calculations based on Bown (2006)).

- The heterogeneity of countries involved in international trade suggests substantial differences in consumer tastes and incomes across countries as well as cost asymmetries across firms.

- There is substantial empirical evidence that product quality matters, as globalization of the international economy involves more trade with transition and developing countries. Because of lower quality standards in these countries, local firms produce and export goods whose quality is inferior to that of Western firms. As a result, a significant proportion of trade is now

\(^2\)For example, the Chinese anti-dumping case in chloroprene rubber applies a 151% anti-dumping duty against US exports (Bown, 2006). This is low compared to the US anti-dumping case in vector supercomputers that imposed a record anti-dumping duty of 454% against NEC (Maur and Messerlin, 1999).

\(^3\)Recent statistics reveal that, of the 2840 anti-dumping initiations reported by the WTO, from January 1995 to 2005, about 61% are issued by new users like Argentina, Brazil, China, India, South Africa, and Turkey.
characterized by different levels of quality. Hallack (2006) shows in a sample of 60 countries that there are large differences in the quality of products that are exported. Greenaway et al. (1994, 1995) show that over two thirds of all intra-industry trade in the UK involves trade of vertically differentiated goods. Numerous anti-dumping investigations also show considerable differences in the types of products made worldwide. In particular, hearings and public reports reveal that, besides prices, perceived quality differences are important in many anti-dumping (AD) cases (USITC, 2001, 2002a, 2002b, 2003).

- Petitions filed by a US industry against imports concern products which are usually classified under 10 digit subheadings of the Harmonized Tariff Schedule of the United States. At this level of disaggregation, sources of supply of this product in a domestic market are a few firms. Even in large trading blocs like the US or the EU, it is common that the case concerns two players, a local and a foreign producer. See, for example, USITC (2001, 2002b), or EC (2002b, p. 25 and 48).

We analyze an international trade game between two firms located in two different countries (developed vs. developing) that produce quality-differentiated goods. Domestic and foreign consumers have heterogenous preferences for the sole product attribute, quality. Markets are asymmetric in that they differ in size and in the distribution of consumer tastes. The quality-differentiated good is supplied at home and abroad by a local firm and by imports from the foreign producer. Both markets are not totally served in equilibrium, implying endogenous market sizes. Quality development is costly and firms in developing countries face higher costs in order to produce a given quality level. We study a three-stage game. In the first stage, governments either opt for free trade or enact anti-dumping law. This AD regulation includes two popular instruments, namely, AD duties and price undertakings (PU). In the second stage, firms select the qualities to be produced, and incur the fixed costs; the third stage is an export game where firms compete in prices.

We show the existence of a unique (risk-dominant) free trade equilibrium that is characterized by intra-industry trade. The foreign firm, which is more efficient, produces a good of higher quality than the domestic firm. Since consumers across countries differ in their concern for quality, unilateral dumping by the foreign firm into the domestic market arises in equilibrium. In this context, looking for a rationale for an AD policy by the domestic government, we find that when differences in size and income across countries are large, a PU forces the high-quality foreign firm out of the export market. For some parameters, this leads to a quality reversal in the international market whereby the domestic firm becomes the producer of high-quality goods. Since high-quality
production is much more profitable than the manufacturing of low-quality goods, this increases firm’s profits substantially. Though domestic consumers lose, the increase in profits is of first order so domestic welfare increases. When countries are of similar size instead, a price undertaking cannot be justified, neither on the basis of home firm’s profits nor on the basis of domestic consumer welfare. These results also hold under AD duties since they are found to be equivalent to price undertakings in our framework.

Our paper is a contribution to the study of anti-dumping in oligopolistic industries. The literature on anti-dumping is extensive and the reader is referred to Feenstra (2003) and the survey of Blonigen and Prusa (2003) for a detailed discussion of this work. With the exception of Vandenbussche and Wauthy (2001), the literature has dedicated little attention to the role of quality differences in the determination of dumping and the optimality of AD law. As we will show, this is an important omission since AD policies modify firms’ incentives to invest in product quality which, in turn, affects the extent of competition in the international market and hence firms’ profits and social welfare. In some situations AD legislation might even lead to a quality reversal in the international market. Various papers (see e.g. Ethier and Fisher, 1987; Fisher, 1992; Leidy and Hoekman, 1990; and Reitzes, 1993) have examined how AD protection gives firms incentives to alter their price or output decisions vis-à-vis free trade in order to influence the AD outcome. This may lead to higher or lower welfare depending on the existing market structure. Anderson et al. (1995) examine a variant of the reciprocal dumping model of Brander and Krugman (1983) where two governments can enact AD law or not. They find that welfare-maximizing governments impose no law in equilibrium. Moreover, though an individual firm has an incentive to lobby for AD law, consumer welfare increases and firm profits fall if laws are bilaterally enacted. Another branch in the literature studies how AD policy influences the incentives of firms to collude (see e.g. Staiger and Wolak, 1992 and Veugelers and Vandenbussche, 1999).

The distinctive feature of our paper is the study of the effects of anti-dumping legislation in an international market where firms produce vertically differentiated products. In this regard, Vandenbussche and Wauthy (2001) is the paper most closely related to ours. They study a game of one-way trade between a domestic and a foreign firm. Using the “lay” definition of dumping (Weinstein, 1992) where the competing local price is used as a proxy for the “normal” value of the good, they show that, relative to free trade, a PU gives the foreign firm incentives to be more aggressive and become the quality leader in the domestic market. AD law leads in this case to lower social welfare for the home country. By contrast, using a model of intra-industry trade our setting allows for the use of the more standard definition of dumping, the one put forward by the WTO.
In this framework, a price undertaking may modify the market structure in such a way that the domestic firm becomes the quality leader in the international market.

Our paper is also related to the work explaining how product quality matters in international trade. The monopoly problem is discussed in Musa and Rosen (1978) and Krishna (1987), and oligopoly versions of this model have received substantial attention in the international trade literature. The models most closely related to our work are Herguera et al. (2002) and Motta et al. (1997). Herguera et al. (2002) study optimal trade policy in a model of one-way trade. Motta et al. (1997) analyze the sustainability of quality leadership once countries open up to trade. Saggi and Sara (2007), extending the work of Horn (2006), analyze the WTOs national treatment clause in a two-country model where quality of goods and/or market size are heterogenous across countries. Our paper contributes to this work on quality leadership by showing that the export game has a unique equilibrium characterized by intra-industry trade and that firms’ cost asymmetries are crucial to sustain quality leadership.

The rest of the paper is organized as follows. Next section presents the details of our model. Section 3 solves for the free trade equilibrium and establishes the conditions for dumping. Section 4 examines AD legislation in the form of price undertakings while Section 5 establishes the equivalence result between AD duties and price undertakings. Section 6 concludes. Some of the proofs are relegated to the Appendix to ease the reading of the paper.

2 The Model

We examine an international trade game between two firms producing goods that are vertically differentiated. These two firms, located in two different countries, produce goods for their own market and, eventually, for exports. The firm located in the foreign (home) country is referred to as the foreign (home) firm and all foreign variables are denoted by an asterisk “∗”. We index destination countries by \( i = 1, 2 \) where subscript 1 refers to the home country and subscript 2 to the foreign country. Let \( q_i^* \) denote the quality of the product manufactured by the foreign firm to be sold in country \( i, \ i = 1, 2 \). Likewise, let \( q_i \) be the quality of the product manufactured by the home firm to be sold in country \( i, \ i = 1, 2 \). As firms incur fixed R&D costs of quality development we assume flexible production (Eaton and Schmitt, 1994), that is, once firms invest in the necessary technology and organize their facilities to develop and produce one basic product, they can produce various downgrades of this basic product at no cost. The idea is modelled via the following specification of R&D costs: domestic firm’s costs of producing variants \( q_1 \) and \( q_2 \) are \( C(q_1, q_2) = c \max\{q_1, q_2\}^2 / 2 \); likewise, foreign firm costs of producing variants \( q_1^* \) and \( q_2^* \) are given...
by \( C^*(q_1^*, q_2^*) = c^* \max\{q_1^*, q_2^*\}^2/2 \), where \( c \) and \( c^* \) are development cost parameters which measure R&D efficiency. We assume \( c^* = 1 \) without loss of generality and \( c > 1 \), that is, the home firm is less efficient than the foreign firm in developing any level of quality.\(^4\) Once the quality of the goods to be offered is determined, we assume that production takes place at a common marginal cost which is normalized to zero.\(^5\)

Define \( m^* \) as the number of potential consumers of the product in the foreign country. Assume \( m^* \geq 1 \) and a population of measure 1 at home. Consumers buy at most one unit and have preferences given by the following quasi-linear (indirect) utility function: \( U = \theta q - p \), if she buys a unit of a good of quality \( q \) at price \( p \), and 0 otherwise. Parameter \( \theta \) is consumer specific and measures the utility a consumer derives from consuming a unit of quality. Assume that \( \theta \) is uniformly distributed over \([0, \overline{\theta}]\) at home, and over \([0, \lambda^* \overline{\theta}]\) abroad, with \( \lambda^* \geq 1 \), \( \overline{\theta} > 0 \). Tirole (1988) shows that \( \theta \) is the inverse of the marginal utility of income so our assumption \( \lambda^* \geq 1 \) implies that foreign consumers have higher incomes on average and more sophisticated tastes. Our specification of demand thus captures both size and income differences between countries via \( m^* \) and \( \lambda^* \) respectively.\(^6\) Finally, we assume there are transaction costs associated to parallel trade which render goods arbitrage unprofitable for consumers.

We study a three-stage game. In the first stage of the game, governments opt for free trade or enact anti-dumping law. In the second stage, firms choose the quality of the goods to be produced, and incur the fixed costs. Finally, firms engage in an export game where they compete in prices. The appropriate solution concept is subgame perfect equilibrium. The model is solved by backward induction.

3 \ Trade Equilibrium

The assumptions of our model depict a situation in which a domestic firm, located in a smaller and poorer country, considers, besides supplying its own market, to export to a larger and richer

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\(^4\)Cost asymmetries across firms in different countries may capture differences in the available production technologies as well as in the costs of labor and capital. They are important here because they help pin down a unique equilibrium in qualities. The specification of the cost function could be more general without affecting results qualitatively. For example, Moraga-González and Viaene (2005) use cost functions with a degree of homogeneity \( k \geq 2 \). While larger \( k \) values affect results quantitatively, they do not alter them qualitatively.

\(^5\)This cost specification captures the distinctive features of pure vertical product differentiation models, where the costs of quality improvements mainly fall on fixed costs and involve only a small or no increase in unit variable costs (see Shaked and Sutton, 1982, 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.

\(^6\)As we will see later, asymmetries between countries may play an equilibrium selection role for some export strategy profiles; moreover they are important for the effects of anti-dumping policy.
country. It faces competition from a foreign firm, which is more efficient. Given this, the following three questions arise: What is the pattern of trade that emerges in equilibrium once both countries open up to trade? What are the product qualities that are produced by each firm in equilibrium? For which of the two firms, if any, is it optimal to dump its good in the international market? We address these three issues in the rest of this Section.

To solve the export game outlined above, it is useful to obtain preliminary results that describe firms’ pricing and quality decisions for different export strategies. These export strategy profiles lead to the different patterns of international trade of Table 1.

<table>
<thead>
<tr>
<th>Home firm</th>
<th>Export (E)</th>
<th>Not export (NE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Export (E)</td>
<td>Intra-industry trade</td>
<td>Duo. abroad, mono. at home</td>
</tr>
<tr>
<td>Not export (NE)</td>
<td>Mono. abroad, duo. at home</td>
<td>No trade</td>
</tr>
</tbody>
</table>

Table 1

This matrix contains four cells, each corresponding to a different export strategy profile. The demands firms face are different across trade patterns, and so are their optimal quality and pricing decisions. The games we analyze have typically two Nash equilibria, one where the foreign firm is quality leader and one where the domestic firm is quality leader. To select amongst equilibria, we use the risk-dominance criterion of Harsany and Selten (1988).7

3.1 Export Game

No trade (NE,NE): In this case each firm produces only for its own market. Simple derivations lead to the demands at home and abroad:

\[ D_1(p_1, q_1) = 1 - \frac{p_1}{\bar{q}_1} \]  
\[ D_2^*(p_2^*, q_2^*) = m^* \left( 1 - \frac{p_2^*}{\lambda^* \bar{q}_2} \right) \]

Maximization of profits leads to the following result:

**Lemma 1** In absence of trade the domestic firm produces a good of quality \( q_1 = \bar{q} / 4c \) and charges \( p_1 = \bar{q}_1 / 2 \), while the foreign firm produces a good of quality \( q_2^* = m^* \lambda^* \bar{q} / 4 \) and charges \( p_2^* = \bar{q} \lambda^* q_2^* / 2 \).\[^7^]\n
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\[^7^]\text{This criterion is also used in related work by Motta et al. (1997), Cabrales et al. (2000), Bonroy and Constantatos (2005) and Moraga-González and Vlaene (2005)}
Though both firms are monopolists in their own country, the foreign firm always produces the highest quality because it is more efficient and produces in a larger and richer country where the average consumer is willing to pay more for each unit of quality.

**International duopoly abroad and monopoly at home (E,NE):** This is a situation where the home firm produces a good of quality $q_1$ for its domestic market and exports a good of quality $q_2$ to the foreign country; the foreign firm produces just for its local market.

Since there is just one good sold in the home country, this country’s demand is given by (1) as before. By contrast, since two variants are sold in the foreign country, we need to calculate the demands faced by each firm. Note that the explicit derivation of each firm’s demand abroad depends on whether the foreign firm’s good is of higher or of lower quality than the domestic variant.

Consider first the case where the foreign firm sells a good of quality $q^*_2$ in its own market and faces competition from low-quality exports, i.e., $q^*_2 > q_2$. Denote by $\tilde{\theta}$ the buyer who is indifferent between buying high quality or low quality. From the buyers’ utility function, it follows that $\tilde{\theta} = \frac{p^*_2 - p_2}{q^*_2 - q_2}$.

Consider now the opposite case where home firm’s exports are of higher quality, i.e., $q_2 > q^*_2$. Demands can be calculated as in (3) and have the following form:

$$D_2(.) = m_1^* \left( \frac{p^*_2 - p_2}{\lambda^* \tilde{\theta}(q_2 - q^*_2)} \right), \quad D^*_2(.) = m_1^* \left( 1 - \frac{p^*_2 - p_2}{\lambda^* \tilde{\theta}(q_2 - q^*_2)} \right).$$  \(3\)

Using these demands in (3) and in (4) we can solve the game for the different quality equilibria using the Harsany-Selten criterion. As equilibrium profits depend on $c$ and on the product $\lambda^* m^*$, we find that for each product $\lambda^* m^*$ there exists a threshold value of the home firm’s cost parameter denoted $\tau(\lambda^* m^*)$ such that below $\tau(\cdot)$ the domestic firm is quality leader in the international market whereas above $\tau(\cdot)$ the foreign firm produces the high-quality good instead.

**Lemma 2** If an equilibrium exists where the home firm is the only exporter, then $q_1 = q_2$; moreover for every $\lambda^* m^*$ there exists $\tau(\lambda^* m^*)$ such that: (i) $q_1 = q_2 > q^*_2$ for all $c < \tau(\lambda^* m^*)$; (ii) $q_1 = q_2 < q^*_2$ for all $c > \tau(\lambda^* m^*)$. 


This result has two important implications. First, the exporting firm produces a single product for the international market. Any other quality profile is ruled out by the possibility that firms leapfrog the quality produced by the competitor or by virtue of the flexible production technology. The second implication of Lemma 2 is that when the home firm is the sole exporter of goods, though it is less efficient than the foreign firm, it may become the quality leader in the international market. This happens for low cost asymmetries and the reason is that the firm can use larger world revenues to compensate for its larger development costs. The leadership of the domestic firm, however, is difficult to sustain when its relative inefficiency increases.

**International duopoly at home and monopoly abroad (NE,E):** When the foreign firm is the sole exporter and the home firm produces for its domestic market only, one good is sold in the foreign country and thus the demand for this good is given in (2). In contrast, two variants are sold in the home country; as before the demand faced by each firm in the home country depends on which firm is the quality leader. Derivations as above can be repeated for the case where the home firm sells a good of quality $q_1$ in its own market and faces competition from exports of a good of lower quality, i.e., $q_1 > q_1^*$.

\begin{align*}
D_1(\cdot) &= 1 - \frac{p_1 - p_1^*}{\theta(q_1 - q_1^*)}, \quad D_1^*(\cdot) = \frac{p_1 - p_1^*}{\theta(q_1 - q_1^*)} - \frac{p_1^*}{\theta q_1^*}, \\
\text{(5)}
\end{align*}

In the opposite case where foreign exports are of higher quality, i.e., $q_1^* > q_1$, we obtain the following demands:

\begin{align*}
D_1(\cdot) &= \frac{p_1^* - p_1}{\theta(q_1 - q_1)}, \quad D_1^*(\cdot) = 1 - \frac{p_1^* - p_1}{\theta(q_1 - q_1)}.
\text{(6)}
\end{align*}

Given these demands the following result offers a necessary condition for an equilibrium to exist.

**Lemma 3** If an equilibrium exists where the home firm produces for its local market only and the foreign firm exports goods then $q_2^* = q_1^* > q_1$.

As in the preceding trade pattern, there are only two qualities in the international market. Moreover, when the foreign firm is the sole exporter it is always the quality leader; this is because this firm is more efficient and can spread the development costs over the world market.

**Intra-industry trade (E,E):** When both firms export, the demands faced by each firm depend on which of the two firms is quality leader. Demands for the different cases are given in the expressions (3) to (6). The following result is a necessary condition for an intra-industry trade equilibrium.

**Lemma 4** If an equilibrium exists with intra-industry trade, then $q_1 = q_2 < q_1^* = q_2^*$.
Hence, only two variants can be sold in an equilibrium with intra-industry trade. Moreover, the quality leader in the international market is the most efficient foreign producer.

Summarizing Lemmas 1 to 4, the restrictions on the range of qualities produced imposed by the concept of equilibrium are given in Table 2:

<table>
<thead>
<tr>
<th>Home firm</th>
<th>Export (E)</th>
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</tr>
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<tbody>
<tr>
<td>Export (E)</td>
<td>$q_1 = q_2 &lt; q_1^* = q_2^*$</td>
<td>$q_1 &lt; q_1^<em>$ if $c &gt; (&gt;)\bar{\sigma}(\lambda^</em> m^*)$</td>
</tr>
<tr>
<td>Not export (NE)</td>
<td>$q_1 &lt; q_1^* = q_2^*$</td>
<td>$q_1^* &lt; q_2^*$</td>
</tr>
</tbody>
</table>

### 3.2 Equilibrium under Free Trade

Having computed firms’ equilibrium payoffs under different export strategy profiles, we are now ready to examine the equilibria of the export game. Denote by $\pi_{i,j}$ ($\pi_{i,j}^*$) the profits of the domestic (foreign) firm under export strategy profile $(i, j)$, $i, j = E, NE$. We find that $\pi_{E,E}^* > \pi_{E,NE}^*$ and that $\pi_{NE,E}^* > \pi_{NE,NE}^*$, which implies that exporting is a dominant strategy for the foreign firm. Likewise exporting is a dominant strategy for the home firm since $\pi_{E,E} > \pi_{NE,E}$ and $\pi_{E,NE} > \pi_{NE,NE}$. As a result the game is dominance solvable and the unique equilibrium involves two-way trade.

![Figure 1: Firms’ payoffs for low cost asymmetries ($\lambda^* = m^* = 1, \bar{\theta} = 100$)](image)

Figures 1 and 2 illustrate the various firm payoffs. The difference between these two graphs is the extent of cost asymmetries between the firms. In Figure 1, the home firm is not very inefficient compared to the foreign firm. This implies that the home firm is leader in quality for the export strategy profile $\{E, NE\}$ (cf. Lemma 2). Figure 2 is constructed assuming that firm cost asymmetries are large; in this case the foreign firm is quality leader for any export strategy profile.
Let us define $\mu = q^*/q$, with $\mu > 1$ since $q^* > q$. Variable $\mu$ represents the quality gap between the two firms’ variants and measures the degree of product differentiation. Then:

**Proposition 1** There is a unique free trade equilibrium of the export game. This equilibrium involves intra-industry trade and is characterized as follows: (i) The home firm produces a good of quality

$$q = \frac{\theta(1 + \lambda^* m^*) \mu^2(4\mu - 7)}{c(4\mu - 1)^3}$$

that is sold locally and exported to the foreign country; (ii) the foreign firm produces a good of higher quality

$$q^* = 4\theta(1 + \lambda^* m^*) \frac{\mu(4\mu^2 - 3\mu + 2)}{(4\mu - 1)^3}$$

for its own market and for exports to the home country; (iii) $\mu$ is the quality gap between the variants and is the solution to

$$\frac{4(4\mu^2 - 3\mu + 2)}{\mu^2(4\mu - 7)} = \frac{1}{c}.$$ 

(iv) These goods sell at prices

$$p_1 = \frac{\theta q(\mu - 1)}{4\mu - 1}; \quad p_2 = \lambda^* p_1 \quad \text{(10)}$$

$$p_2^* = \frac{2\lambda^* \theta q^*(\mu - 1)}{4\mu - 1}; \quad p_1^* = p_2^*/\lambda^*.$$ 

\[12\]
in the two countries. (v) Market demands for each firm are

\[ D_1 = \frac{\mu}{4\mu - 1}; \quad D_2 = m^* \frac{\mu}{4\mu - 1} \]  \hspace{1cm} (12)

\[ D_1^* = \frac{2\mu}{4\mu - 1}; \quad D_2^* = m^* \frac{2\mu}{4\mu - 1} \]  \hspace{1cm} (13)

(vi) The Grubel-Lloyd measure of two-way trade (in value) is

\[ GL = 100 \left\{ 1 - \frac{|p_2D_2 - p_1^*D_1^*|}{p_2D_2 + p_1^*D_1^*} \right\} = 100 \left\{ 1 - \frac{|\lambda^*m^* - 4\mu|}{\lambda^*m^* + 4\mu} \right\} \]  \hspace{1cm} (14)

(vii) Domestic firm’s profits are \( \pi = q^*q/8 \) and foreign firm’s profits are \( \pi^* = 2cq^*q \).

In the market equilibrium of Proposition 1, variable \( \mu \) is the unique solution to the third degree polynomial in (9). Besides being a measure of product differentiation, \( \mu \) relates to the extent of price competition between the firms. To show this, take the ratio (11) to (10) to compute the relative prices in each market: \( p_1^*/p_1 = 2\mu \) and \( p_2^*/p_2 = 2\mu \). An increase in \( \mu \) widens the quality gap, thereby mitigating competition and increasing relative prices in both countries. For any \( \mu \), demands are positive so the market equilibrium involves intra-industry trade in vertically differentiated products, like in the contributions of Falvey (1981) and Shaked and Sutton (1984). The Grubel-Lloyd index depends on the primitive parameters of the model: the relative country size \( m^* \), the relative taste difference \( \lambda^* \), and the relative cost difference \( c \) (via the solution to (9)).

Proposition 1 describes a market equilibrium that emerges from a specific configuration of parameters: \( \lambda^* \geq 1, m^* \geq 1 \), and \( c > 1 \). Different parameter configurations would lead to different market outcomes but this choice reflects the nature of the problem at hand. The intra-industry trade nature of the trade equilibrium is a crucial result for our analysis because it allows us to use the traditional WTO definition of dumping.

3.3 Conditions for Dumping

A product is considered as being dumped if its export price to a particular country is less than a “normal value,” standard used by the WTO, or less than a “fair value,” standard used by the US government. There are different ways of calculating a product’s “normal” or “fair” value. The standard definition of dumping, the one put forward by the WTO (see the WTO website), is when a company exports a product at a price lower than the price it normally charges on its own home market. In our framework, this definition of dumping amounts to comparing \( p_1^* \) with \( p_2^* \) and \( p_1 \)
with $p_2$ in (10) and (11). This yields the following result:\textsuperscript{8}

**Proposition 2** Under free trade only unilateral dumping arises; in particular, the foreign firm dumps its high-quality goods into the domestic market.

A popular belief is that low-quality goods are dumped in the export markets because they usually command a lower price. In our setting, the reverse occurs: it is the high-quality good that is dumped into the smaller and poorer country. Dumping arises because cross-country differences in the distribution of tastes provide the foreign firm with incentives to cut its export price relative to the price it charges in its own market. The intuition is simple: higher income, here translated into more sophisticated tastes, gives rise to higher prices in the foreign market for all goods.

This proposition leads to a number of observations. First, to substantiate a case for anti-dumping law the local firm must also suffer injury from dumped imports. In our framework, the share of imports in the domestic economy is $D_1^*/(D_1 + D_1^*) = 2/3$ (see Proposition 1). It is clear that this market share is sufficiently large to justify injury. Another important issue to substantiate a case for anti-dumping law is that, besides price differences and material injury from imports, the products involved must be “like products”. Proposition 2 and its discussion would point to there being a lot of anti-dumping cases in the developed countries against higher-quality products from the rest of the world. This is simply not the case in the data: though the number of AD initiations is large, imports concerned represent a small fraction of trade to developing countries. The criterion that the import product must be a “like product” to the domestic petitioner’s product is a very good reason for this. If product quality is different enough, it may be hard to make the case of like products.

Second, traditional treatments of dumping have shown the possibility of reciprocal dumping based on transportation costs (Anderson et al. 1995; Brander and Krugman, 1983; Weinstein, 1992). Here dumping is unilateral and the introduction of transportation costs or import tariffs does not undermine this result, unless they are so large that they offset the influence of the cross-country differences in the distribution of tastes.

Assume now that all criteria are fulfilled and that there is a claim for AD legislation. Whether the government responds to such a demand positively or negatively depends on its objectives. We

\textsuperscript{8}Another possibility is to consider the competing local price as a proxy for the normal value. Though this is characterized as the “lay” definition of dumping (Weinstein, 1992) and the method has been used in theory (Vandenbussche and Wauthy, 2001) and applied in a number of cases, among others in Mexico (Niels, 2004), this is a definition of last resort, useful only when other methods of calculations are not possible.
use the weighted sum of consumer surplus and firms’ profits as a measure of social welfare:

\[ W = \beta_1 CS + \beta_2 \pi, \ \beta_j \in \{0, 1\}, j = 1, 2 \]  

(15)

When revenues accrue from the imposition of an AD duty, we add them to the welfare expression in (15). The weights \( \beta_1 \) and \( \beta_2 \) characterize policymaker’s preferences. If \( \beta_1 = \beta_2 = 1 \) we have the usual definition of social welfare; if \( \beta_1 = 1 \) and \( \beta_2 = 0 \), the government cares only about consumer surplus; finally when \( \beta_1 = 0 \) and \( \beta_2 = 1 \), only firm’s profits matter for the policy maker.\(^9\) Domestic consumer surplus is given by:

\[ CS_1 = \int_0^{\theta} (xq^* - p_1^*)dF(\theta) + \int_{p_1/q}^{p_1^*} (xq - p_1)dF(\theta) \]

where \( F(\theta) \) is the cumulative distribution function of \( \theta \) over the interval \([0, \theta]\). Using equilibrium prices in (10), consumers surplus can be written more conveniently as:

\[ CS_1 = \frac{\bar{\theta} \mu^2(4\mu + 5)q}{2(4\mu - 1)^2}. \]  

(16)

4 Anti-dumping Policy

Two AD policy instruments are commonly used by governments, namely, price undertakings and anti-dumping duties. The former is more commonly used in the EU while the latter is observed more frequently in the US. A price undertaking is a binding commitment to raise export prices so that either the dumping or the injury suffered from dumped imports by the domestic country is eliminated (GATT, 1991, p. 74). An anti-dumping duty equalizes the price that consumers in different countries pay for the same good by means of a duty. The following analysis examines price undertakings and anti-dumping duties and offers an equivalence result between these two AD instruments. Another important result is that, for certain parameter configurations, AD policy appears to be desirable on welfare grounds because it leads to a quality reversal.

4.1 Price Undertakings

Under a price undertaking, the foreign firm must set an export price that is equal to its local price, i.e., \( p_1^* = p_2 = p^* \). Given this constraint, and assuming that the foreign firm produces high quality,

---

\( ^9 \)The case \( \beta_1 = 0 \) and \( \beta_2 = 0 \) is not interesting. Note that AD actions seem to be in favour of firms. Dominant players have good lobbying power and consequently they find it easier to get governmental support. In contrast, there are practical problems in dealing with consumer interests as it requires educating consumers about the role of anti-dumping.
the demands faced by the different firms are:

\[ D_1(.) = \frac{p^* - p_1}{\theta(q^* - q)} \quad D_2(.) = m^* \left( \frac{p^* - p_2}{\lambda^* \theta(q^* - q)} - \frac{p_2}{\lambda^* \theta q} \right) \]

\[ D_1^*(.) = 1 - \frac{p^* - p_1}{\theta(q^* - q)} \quad D_2^*(.) = m^* \left( 1 - \frac{p^* - p_2}{\lambda^* \theta(q^* - q)} \right). \]

The profits of the foreign and the home firm are then given by

\[ \pi^* = p^* (D_1^* + D_2^*) - q^2 / 2 \]

\[ \pi = p_1 D_1 + p_2 D_2 - cq^2 / 2, \]

respectively. Each firm takes as given the product qualities and the rival’s prices and chooses its price to maximize profits. Taking the first order conditions \( d\pi / dp_1 = 0 \) and \( d\pi / dp_2 = 0 \) and rearranging terms, one obtains \( p_1 = p_2 \). Hence a price undertaking for high-quality imports leads to equal local and export prices of low-quality goods as well. Given this and using the first order condition \( d\pi^* / dp^* = 0 \) we can solve for equilibrium prices. Anticipating the optimal prices, firms select qualities to maximize reduced-form profits:

\[ \pi^* = \frac{4\theta \lambda^* (1 + m^*)^2 q^2 (q^* - q)}{\lambda^* + m^*} \frac{q^2}{2} \]

\[ \pi = \frac{\theta \lambda^* (1 + m^*)^2 q^2 q (q^* - q)}{\lambda^* + m^*} - \frac{cq^2}{2}. \]

The first order conditions with respect to qualities lead to the following equilibrium qualities under a price undertaking:

\[ q = \frac{\theta \lambda^* (1 + m^*)^2 \mu^2 (4\mu - 7)}{c(\lambda^* + m^*) (4\mu - 1)^3}, \]

\[ q^* = \frac{4\theta \lambda^* (1 + m^*)^2 \mu (4\mu^2 - 3\mu + 2)}{(\lambda^* + m^*) (4\mu - 1)^3}. \]

where \( \mu = q^*/q \), with \( \mu > 1 \) since \( q^* > q \). Taking the ratio of (20) to (19) leads to an expression for \( \mu \) which is exactly identical to (9). Hence, a price undertaking need not affect the equilibrium degree of product differentiation, nor the extent of international price competition. If \( \mu \) is unaltered by the policy, the qualities in (19) and (20) can easily be compared to those under free trade in (7) and (8). It is readily seen that a price undertaking leads to a decrease in the quality of both variants.

Equilibrium (hedonic) prices can be written as follows:

\[ \frac{p_1}{q} = \frac{p^*}{q} = \frac{p^*}{2q^*} \]

\[ \frac{p^*}{q^*} = \frac{\lambda^* (1 + m^*)^2 2\theta(\mu - 1)}{\lambda^* + m^* (4\mu - 1)}. \]
A comparison of these prices with those in Proposition 1 reveals that, compared to free trade, a price undertaking leads to an increase in all (hedonic) prices in the domestic market and to a decrease in all (hedonic) prices in the foreign market.

Equilibrium demands are given by:

\[
D_1 = \frac{\lambda^*(1 + m^*)}{\lambda^* + m^*} \frac{\mu}{4\mu - 1}; \quad D_2 = \frac{m^*(1 + m^*)}{\lambda^* + m^*} \frac{\mu}{4\mu - 1};
\]

(23)

\[
D_1^* = \frac{2\mu}{4\mu - 1} - \frac{m^*(\lambda^* - 1)}{\lambda^* + m^*} \frac{2\mu - 1}{4\mu - 1}; \quad D_2^* = \frac{2m^*\mu}{4\mu - 1} + \frac{m^*(\lambda^* - 1)}{\lambda^* + m^*} \frac{2\mu - 1}{4\mu - 1}.
\]

(24)

It is clear from (23) and (24) that the world demand for low-quality products faced by the domestic firm, \((D_1 + D_2)\), is not affected by a price undertaking. However, the distribution of quantities does: domestic firm’s local sales increase and its exports decrease. Likewise, \((D_1^* + D_2^*)\) is similar both under free trade and under a price undertaking but, in the latter case, the exports of the foreign firm decrease while its local sales increase by the same amount. More importantly, note that all demands are strictly positive except for possibly \(D_1^*\). The fact that \(D_1^*\) can become zero for certain parameter configurations is of paramount importance in our setting since it means that a price undertaking may force a high-quality foreign firm out of the export market. This might potentially be welfare improving because it may confer the domestic firm an advantage to become the quality leader in the market (cf. Lemma 2).

**Proposition 3** Let \(\mu\) be the solution to (9). If the parameters of the model satisfy the following inequality

\[
\lambda^* < \frac{m^* (4\mu - 1)}{m^* (2\mu - 1) - 2\mu}.
\]

(25)

then a price undertaking leads to the exit of the foreign firm, high-quality exports being no longer profitable \((D_1^* < 0)\).\(^{10}\)

Hence the analysis of a price undertaking involves three possible situations depending on whether condition (25) is satisfied or not. We start by exploring the situation where parameters of the model are such that a price undertaking does not alter the international market structure. The set of parameters described by condition (25) can be seen in Figure 3. The condition is fulfilled for sets of parameter values below the surface.

**Price undertakings leaving market structure unchanged**

\(^{10}\)A sufficient condition is \(\lambda^* > 1.91m^*/(0.9m^* - 1)\), and \(m^* > 1/0.9\). These conditions are obtained by solving \(D_1^* \leq 0\) for \(\lambda^*\) and using the fact that the solution to (9) is monotonically increasing in \(c\), but bounded below by approximately 5.25123.
A price undertaking does not alter market structure if the parameters of the model fail to satisfy (25). A sufficient condition for this is that countries are similar in size \((m^* \approx 1)\).\(^{11}\) If this is the case, the effects of a price undertaking on firms’ profits and consumer surplus can easily be obtained. Using \(\mu\), the first order conditions, and the expressions for qualities in (19) and (20), the profits of the firms are:

\[
\pi^* = 2cq^*q \tag{26}
\]

\[
\pi = \frac{q^*q}{8}. \tag{27}
\]

As qualities are lower under a price undertaking, it is clear that both firms profits are lower than under free trade. Hence, there is no incentive for the domestic firm to lobby for an implementation of AD legislation in the form of a PU. Moreover, since a price undertaking does not change \(\mu\) but decreases \(q\), we conclude that domestic consumers lose as well. The following Proposition summarizes the result:

**Proposition 4** Assume the parameters of the model violate condition (25). Then, relative to free trade, a price undertaking imposed by the domestic government results in: (i) a decrease in the quality of both variants; (ii) an increase in the (hedonic) prices of both variants in the domestic country; (iii) a decrease in (hedonic) prices of both variants in the foreign country; (iv) a decrease in profits of both firms, and (v) a decrease in domestic consumer surplus.

\(^{11}\)More generally, \(D^*_1 > 0 \) if \(\lambda^* < 2m^*/(m^* - 1)\).
Hence, a price undertaking is not justified in the case where the market structure remains the same as under free trade.

Price undertakings changing the market structure

What kind of trade equilibrium does prevail in the presence of a price undertaking when condition (25) holds? To answer this question we refer to Lemma 2 above, in particular to cell \( \{E, NE\} \) in Tables 1 and 2. In the proof of this Lemma we show that when the foreign firm sells only locally while the domestic firm sells its good both locally and internationally, if cost asymmetries are sufficiently large then the foreign firm will remain quality leader in the international market. The profits of the local firm increase while domestic consumer surplus decreases in this case. This is because of the monopoly position of the home firm in the domestic market. Implementation of anti-dumping legislation in this case can only be a response to home firm lobbying for AD law \((\beta_1 = 0; \beta_2 = 1)\) in (15).

**Proposition 5** Assume that (25) holds. Then, for every pair \((\lambda^*, m^*)\) there exists a \(\tau(\lambda^*, m^*)\) such that if \(c \geq \tau(\lambda^*, m^*)\) a price undertaking by the domestic government results in an equilibrium where the foreign firm exits the domestic market but holds its quality leadership. In this case, compared to free trade, the domestic firms profits increase while consumer surplus decreases. As a result, anti-dumping policy in the form of a price undertaking can only be rationalized on the basis of lobbying by the domestic firm.

Price undertakings inducing quality reversals

Let us now examine the more interesting case where price undertakings lead to radical changes in the equilibrium market structure. We focus on the possibility of a quality reversal, that is, on the shift of quality leadership from the foreign to the domestic firm.

Suppose that the domestic firm produces a good of higher quality than the foreign firm after AD law has been enacted. The payoffs of the two firms are:

\[
\begin{align*}
\pi^* &= p^* \left( \frac{m^* (p_2 - p^*)}{\lambda^* \theta (q - q^*)} - \frac{m^* p^*}{\lambda^* \theta q^*} + \frac{p_1 - p^*}{\theta (q - q^*)} - \frac{p^*}{\theta q^*} \right) - \frac{q^2}{2} \\
\pi &= p_2 m^* \left( 1 - \frac{p_2 - p^*}{\lambda^* \theta (q - q^*)} \right) + p_1 \left( 1 - \frac{p_1 - p^*}{\theta (q - q^*)} \right) - \frac{cq^2}{2},
\end{align*}
\]

where the foreign firm’s pricing behavior is subject to a price undertaking, that is, \(p_1^* = p_2^* = p^*\).

Taking the first order conditions with respect to \(p^*\), \(p_1\) and \(p_2\) yields the following equilibrium prices:
\[
p^* = \frac{\lambda^*(1 + m^*)\theta q^*(q - q^*)}{\lambda^* + m^* - 4q - q^*}
\]
\[
p_1 = \frac{p^* + \theta (q - q^*)}{2}; \quad p_2 = \frac{p^* + \lambda^* \theta (q - q^*)}{2}.
\]

Inspection of these prices reveals immediately that no firm dumps on the world market.

Using prices in (28) and (29), equilibrium demands can easily be calculated:

\[
D_1 = 4\tilde{\mu}(\lambda^* + m^*) + m^*(\lambda^* - 1) - \frac{2(\lambda^* + m^*)(4\tilde{\mu} - 1)}{2(\lambda^* + m^*)}\; \quad D_2 = \frac{2m^* (\lambda^* - 1) + 2\tilde{\mu}m^*(1 + m^*)}{4\tilde{\mu} - 1}
\]

where \(\tilde{\mu}\) is again the high-to-low quality ratio. It is straightforward to verify that the domestic firm faces strictly positive demands. The same applies to the local demand of the foreign firm; however exports of the foreign firm are strictly positive only if:

\[
\lambda^*(m^*(2\tilde{\mu} - 1) - 2\tilde{\mu}) < m^*(4\tilde{\mu} - 1).
\]

Note that the difference between this condition and that in (25) is that \(\tilde{\mu}\) is different than \(\mu\). Obviously, for this market structure to be an equilibrium, the parameters of the model have to satisfy both conditions (25) and (32) simultaneously. We proceed now to calculate \(\tilde{\mu}\). Anticipating equilibrium prices in (28) and (29), firms select the quality of their goods to maximize reduced-form profits. Derivations similar to the ones above yield the equilibrium quality gap \(\tilde{\mu}\) as a function of the parameters of the model. This is given by the solution to:

\[
\frac{4(1 + \lambda^* m^*)(\lambda^* + m^*)}{\lambda^*(1 + m^*)^2} \left[ \frac{4\tilde{\mu}^3 - 3\tilde{\mu}^2 + 2\tilde{\mu} - \beta(20\tilde{\mu} + 1)}{\tilde{\mu}^3(4\tilde{\mu} - 7)} \right] = c
\]

where

\[
\beta = \frac{m^*(\lambda^* - 1)^2}{16(\lambda^* + m^*)(1 + \lambda^* m^*)}
\]

It is straightforward to see that parameters exist for which a quality reversal arises as a result of anti-dumping legislation. For example, consider \(\theta = 1, m^* = 3, \lambda^* = 3.3\) and \(c \in [2, 10]\). For these parameters, condition (25) holds so the intra-industry trade equilibrium where the foreign

\footnote{In our framework the value of \(\theta\) is not essential, hence the set of parameters is three-dimensional. Fixing \(c\) we can vary \(\lambda^*\) and/or \(m^*\) and maintain our claim.}
firm supplies high quality fails to exist; in addition, condition (32) also holds so the equilibrium where high quality is produced by the domestic firm exists.

The question now is how the policy affects the profits of the domestic firm and domestic welfare. Given parameters and the equilibrium product differentiation $\hat{\mu}$ obtained from (33), we can calculate qualities from the first order conditions. Demands and prices follow from the expressions above in (28), (29), (30) and (31). Consumer surplus is given as in (16), and social welfare equals consumer surplus plus domestic firm’s profits. Figures 3 and 4 below compare firms profits, consumer surplus and welfare under free trade and under a price undertaking. Figure 4(a) depicts domestic firm’s profits while Figure 4(b) shows foreign firm’s profits. In all figures, free trade is depicted by the thicker lines and price undertakings by the thinner lines.

![Figure 4: Effects of a price undertaking on firms profits ($\lambda^* = 3.3, m^* = 3, \theta = 1$)](image)

Clearly, the profits of the local firm are always greater under a PU than under free trade and the opposite holds for the foreign firm; this is due to the quality reversal. An implication is that these higher profits could potentially finance the future adoption of new technologies and of cost-reducing investments. If this is the case, the quality leadership of the domestic firm could then be sustained in the long-run.

Graphs 5(a) and 5(b) represent domestic surplus and the usual measure of social welfare ($\beta_1 = \beta_2 = 1$) under free trade and under price undertakings. Clearly domestic consumer surplus is lower under a price undertaking; however, as the welfare figure shows gains in domestic profits more than offset the decline in consumer surplus. In summary:

**Proposition 6** There exist parameters for which a price undertaking leads to a quality reversal in international trade whereby the domestic firm exports high-quality products and does not dump. In this case a price undertaking increases domestic firm’s profits and social welfare.
4.2 Anti-dumping Duties

The other popular instrument of AD legislation involves the imposition of a duty that equalizes the price that consumers in different countries pay for the same good. Given that the price the foreign firm charges locally is $p^*_1$ and the export price is $p^*_2$, an anti-dumping policy in the form of a duty involves a commitment by the domestic government to levy an *ad valorem* duty $t$ that equalizes the price that is paid by consumers in different countries:

$$p^*_1(1 + t) = p^*_2$$

(34)

With an anti-dumping duty $t$, demands faced by the foreign and domestic firms are, respectively:

$$D_1(.) = \frac{p^*_1(1 + t) - p_1}{\theta(q^* - q)} - \frac{p_1}{\theta q}; \quad D_2(.) = m^* \left( \frac{p^*_2 - p_2}{\lambda^* \theta (q^* - q)} - \frac{p_2}{\lambda^* \theta q} \right)$$

(35)

$$D^*_1(.) = 1 - \frac{p^*_1(1 + t) - p_1}{\theta (q^* - q)}; \quad D^*_2(.) = m^* \left( 1 - \frac{p^*_2 - p_2}{\lambda^* \theta (q^* - q)} \right).$$

(36)

Firms maximize profits given by:

$$\pi^* = p^*_1 D^*_1 + p^*_1(1 + t)D^*_2 - \frac{q^*}{2}$$

$$\pi = p_1 D_1 + p_2 D_2 - \frac{q^*}{2},$$

anticipating the anti-dumping duty $t$ given by:

$$t = \frac{p^*_2 - p^*_1}{p^*_1}.$$  

(37)

Plugging (37) in (36) and taking the first order condition $d\pi^*/dp^*_1$ yields:

$$\frac{d\pi^*}{dp^*_1} = 1 - \frac{p^*_2 - p_1}{\theta (q^* - q)} = D^*_1(.).$$  

22
The RHS of this first order condition is simply the domestic demand for high quality. As long as \( D^*_1(\cdot) \) is greater than zero, the profits of the foreign firm are increasing in its export price \( p^*_1 \). The optimal pricing behavior of the foreign firm is then to set \( p^*_1 = p^*_2 \), which implies that revenues from the duty are zero, as has been shown earlier, for example in Feenstra (2003). In summary we obtain the following equivalence result.

**Proposition 7** An anti-dumping duty imposed by the domestic government results in an equalization of international prices. Hence, anti-dumping duties and price undertakings are equivalent in our model.

An important implication is that anti-dumping duties could lead to product quality reversals under the same conditions as for price undertakings.

5 Conclusions

We have presented a model of international trade where two firms located in two different countries produce quality-differentiated goods for their local markets and, eventually, for exports. An important feature of our model is the existence of size and income differences across countries, and of asymmetries in firms’ R&D costs. We have shown that, under free trade, the unique (risk-dominant) Nash equilibrium involves intra-industry trade; in addition, the most efficient firm, the foreign, is the quality leader in the international market. Since consumers in different countries differ in their concern for quality, in equilibrium, unilateral dumping by the foreign firm into the domestic country occurs. In this context we have looked for a rationale for AD law.

When countries differ substantially in income and size and when firms cost asymmetries are moderate, a PU leads to a quality reversal in the international market. This results in much greater profits for the home firm than under free trade which leads to a greater social welfare in spite of the fact that consumers lose. This gives the domestic government incentives to enact anti-dumping law. By contrast, no rationale for price undertakings exists if countries are of similar size, or if income differences are small and firms’ cost asymmetries very large. When AD duties are considered instead, we have derived an equivalence result between AD duties and PU.

Of course, an important issue is to establish the empirical relevance of our results. There is plenty of empirical evidence supporting the main features of the model analyzed here (see e.g. Anderton, 1999; Crozet and Erkel-Rousse, 2004). Also, as mentioned above, it is well-known that governments have traditionally used and continue to use an array a trade and industrial policy instruments to support local producers. For members of the WTO, market protection via tariff
barriers is nowadays limited; in contrast, anti-dumping measures whose application is governed by the WTO are not limited. The thesis of this paper is that anti-dumping is nowadays the trade policy of choice of developing and transition countries because it helps firms located in these countries in their race for the market. We have also provided some examples in which there presumably are quality upgrading effects of AD laws. As far as we know, there is no empirical study about the product quality implications of AD policy. Combining the WTO data on anti-dumping measures with recent databases like the “Analytical Database on International Trade (BACI)” of CEPII (Paris),\(^\text{13}\) which explicitly accounts for intra-industry trade in vertically differentiated products, may allow for the empirical testing of the various conclusions of the model.

6 Appendix

**Proof of Lemma 1:** The proof follows from simple profit-maximization. ■

**Proof of Lemma 2:** Let the home firm produce goods of quality \( q_1 \) and \( q_2 \) and the foreign firm a good of quality \( q^*_2 \). There are 6 possible quality configurations. Consider that \( q^*_2 > q_2 > q_1 \). We note that given optimal pricing of the home firm \( p_1 = \bar{q}_1 / 2 \), this firm’s profits are monotonically increasing in \( q_1 \); as a result, the firm would gain by deviating and increasing \( q_1 \). The same argument applies if \( q_2 > q_1 > q^*_2 \) and \( q_2 > q^*_2 > q_1 \). This leaves us with three more cases to consider. Consider now \( q_1 > q_2 > q^*_2 \). In this case, given qualities, firms choose their prices to maximize profits given as follows:

\[
\begin{align*}
\pi &= m^* \left( 1 - \frac{p_2 - p^*_2}{\lambda^* \bar{q}(q_2 - q^*_2)} \right) p_2 + \left( 1 - \frac{p_1}{\bar{q}_1} \right) p_1 - \frac{c q_1^2}{2} \\
\pi^* &= m^* \left( \frac{p_2 - p^*_2}{\lambda^* \bar{q}(q_2 - q^*_2)} - \frac{p^*_2}{\lambda^* \bar{q}^*_2} \right) p^*_2 - \frac{q^*_2^2}{2} 
\end{align*}
\]

We note that the problem of the home firm is separable in \( p_1 \) and \( p_2 \). Taking the first order conditions \( \partial \pi / \partial p_1 = 0 \), \( \partial \pi / \partial p_2 = 0 \) and \( \partial \pi^* / \partial p^*_2 = 0 \) and solving the reaction functions in prices yields:

\[
\begin{align*}
p_1 &= \frac{\bar{q}_1}{2}; \quad p_2 = \frac{2 \lambda^* \bar{q} q_2 - q^*_2}{4 q_2 - q^*_2}; \quad p^*_2 = \frac{\lambda^* \bar{q}^*_2 (q_2 - q^*_2)}{4 q_2 - q^*_2} 
\end{align*}
\]

Anticipating optimal pricing, it is easy to see now that the profits of the home firm are monotonically increasing in \( q_2 \). Indeed profits are given by

\[
\pi = \frac{4 m^* \lambda^* \bar{q}^*_2 (q_2 - q^*_2)}{(4 q_2 - q^*_2)^2} + \frac{\bar{q}_1}{4} - \frac{c q_1^2}{2}
\]

\(^\text{13}\)See http://www.cepii.fr/anglaisgraph/bdd/baci.htm.
and
\[
\frac{\partial \pi}{\partial q_2} = 4m^*\lambda^*q_2\bar{\theta}(4q_2^3 - 3q_2q_2^* + 2q_2^{*2})/(4q_2 - q_2^*)^3 > 0 \text{ since } q_2 > q_2^*.
\]

As a result, the home firm would gain by deviating and increasing \(q_2\).

We now turn to consider \(q_2^* > q_1 > q_2\). In this case we note that the foreign firm would obtain zero profits and would thus gain by deviating and choosing \(q_2^* < q_2\). To see this note that firms profits are as follows:

\[
\pi = m^*(\frac{p^*_2 - p_2}{\lambda^*\bar{\theta}(q_2^* - q_2)} - \frac{p_2}{\lambda^*\bar{\theta}q_2}) p_2 + \left(1 - \frac{p_1}{\bar{\theta}q_1}\right)p_1 - \frac{cq_1^2}{2}
\]

\[
\pi^* = m^*(1 - \frac{p^*_2 - p_2}{\lambda^*\bar{\theta}(q_2^* - q_2)}) p_2^* - \frac{q_2^*}{2}
\]

Taking the first order conditions \(\partial \pi/\partial p_1 = 0, \partial \pi/\partial p_2 = 0\) and \(\partial \pi^*/\partial p^*_2 = 0\) and solving the reaction functions in prices yields:

\[
p_1 = \frac{\bar{\theta}q_1}{2}; \quad p_2 = \frac{\lambda^*\bar{\theta}q_2(q_2^* - q_2)}{4q_2^* - q_2}; \quad p_2^* = \frac{2\lambda^*\bar{\theta}q_2^*(q_2^* - q_2)}{4q_2^* - q_2}
\]

Substituting these prices into the profits functions yields:

\[
\pi = \frac{m^*\lambda^*\bar{\theta}q_2q_2^*(q_2^* - q_2)}{(4q_2^* - q_2)^2} + \frac{\bar{\theta}q_1}{4} - \frac{cq_1^2}{2}
\]

\[
\pi^* = \frac{m^*\lambda^*\bar{\theta}q_2^2(q_2^* - q_2)}{(4q_2^* - q_2)^2} - \frac{q_2^*}{2}
\]

The first order conditions with respect to quality \(\partial \pi/\partial q_1 = 0, \partial \pi/\partial q_2 = 0\) and \(\partial \pi^*/\partial q_2^* = 0\) can be written as:

\[
\frac{\partial \pi}{\partial q_1} = \frac{\bar{\theta}}{4} - cq_1 = 0
\]

\[
\frac{\partial \pi}{\partial q_2} = \frac{\lambda^*\bar{\theta}q_2^2(4q_2^2 - 7q_2)}{(4q_2^* - q_2)^3} = 0
\]

\[
\frac{\partial \pi^*}{\partial q_2^*} = \frac{4\lambda^*\bar{\theta}q_2^*(4q_2^2 - 3q_2q_2^* + 2q_2^2)}{(4q_2^* - q_2)^3} - q_2^* = 0.
\]

From \(\partial \pi/\partial q_2 = 0\), it follows that \(q_2^* = 4q_2^*/7\). Substituting this into the equation \(\partial \pi^*/\partial q_2^* = 0\) and solving for \(q_2^*\) yields \(q_2^* = 7\lambda^*\bar{\theta}/4\) and thus \(q_2 = \lambda^*\bar{\theta}/6\). Substituting \(q_2\) and \(q_2^*\) into the expression for profits yields \(\pi^* = 0\).

We now prove that the foreign firm would gain by deviating and producing a good of quality \(q_2^* < q_2\) (downward leapfrogging). From the arguments above, equilibrium pricing would be as
follows:

\[ p_1 = \frac{\overline{\theta} q_1}{2}; p_2 = \frac{2 \lambda^* \overline{\theta} q_2(q_2 - q_2^*)}{4q_2 - q_2^*}; p_2^* = \frac{\lambda^* \overline{\theta} q_2^*(q_2 - q_2^*)}{4q_2 - q_2^*} \]

Given optimal pricing and the quality choices of the home firm, the foreign firm profits can be written as follows:

\[ \pi^d = \frac{\lambda^* \overline{\theta} \frac{\lambda^* q_2^*(\frac{\lambda^* \overline{\theta}}{6} - q_2^*)}{(4 \lambda^* \overline{\theta} - q_2^*)^2} - \frac{q_2^2}{2}}{2}. \]

The first order condition is

\[ \frac{\lambda^* \overline{\theta} \frac{\lambda^* q_2^*(9q_2^* - 2\lambda^* \overline{\theta})}{(2 \lambda^* \overline{\theta} - 3q_2^*)^2} - q_2^* = 0 \]

From this equation we can isolate \( q_2^* \) and plug it into the expression for \( \pi^d \). This yields:

\[ \pi^d = \frac{\lambda^* \overline{\theta} \frac{q_2^*}{36q_2^* - \lambda^* \overline{\theta}(9q_2^* - 2\lambda^* \overline{\theta})}}{8(2 \lambda^* \overline{\theta} - 3q_2^*)^3} > 0 \text{ since } q_2^* < \frac{\lambda^* \overline{\theta}}{6}. \]

We are left with the case \( q_1 > q_2^* > q_2 \). However, it is easy to see that this case is similar to the previous one. Note that firms profits would be given by the expression (38) and thus the arguments above also hold here. This completes the proof that the quality that the home firm offers abroad must be equal to the quality it sells domestically, i.e., \( q_1 = q_2 = q \).

Building in this remark, we note that two quality configurations can be part of an equilibrium: (i) \( q > q_2^* \) and (ii) \( q_2^* > q \). Consider first \( q > q_2^* \). The firms would choose prices to maximize:

\[ \pi = m^* \left( 1 - \frac{p_2 - p_2^*}{\lambda^* \overline{\theta}(q - q_2^*)} \right) p_2 + \left( 1 - \frac{p_1}{\overline{\theta} q} \right) p_1 - \frac{cq^2}{2} \]

\[ \pi^* = m^* \left( \frac{p_2 - p_2^*}{\lambda^* \overline{\theta}(q - q_2^*)} - \frac{p_2^*}{\lambda^* \overline{\theta} q_2^*} \right) p_2^* - \frac{q_2^*}{2}. \]

The solution to this problem is

\[ p_1 = \frac{\overline{\theta} q}{2}; p_2 = \frac{2 \lambda^* \overline{\theta} q(q - q_2^*)}{4q - q_2^*}; p_2^* = \frac{\lambda^* \overline{\theta} q_2^*(q - q_2^*)}{4q - q_2^*} \quad (40) \]

Anticipating equilibrium prices, qualities should be chosen to maximize:

\[ \pi = \frac{4 m^* \lambda^* \overline{\theta} q^2(q - q_2^*)}{(4q - q_2^*)^2} + \frac{\overline{\theta} q}{4} \frac{cq^2}{2} \]

\[ \pi^* = \frac{4 m^* \lambda^* \overline{\theta} q_2^*(q - q_2^*)}{(4q - q_2^*)^2} - \frac{q_2^*}{2}. \]
First order conditions are

\[ \frac{\partial \pi}{\partial q} = 4m^* \lambda^* \bar{q} \left(4q^2 - 3q^*q^2 + 2q^2 \right) + \frac{\bar{q}}{4} - cq = 0 \] (41)

\[ \frac{\partial \pi^*}{\partial q^*} = m^* \lambda^* \bar{q} \left(q - 7q^* \right) \left(4q - q^* \right)^2 - q^* = 0. \] (42)

Unfortunately, these equations cannot be solve analytically for \((q, q^*)\) and we are therefore led to use numerical methods in what follows. Numerical simulations show that the solution to the system of equations (41)-(42) with accompanying prices given in (40) is indeed an equilibrium for all parameters: for this we have checked that firms profits are positive and that a single firm does not have incentives to leapfrog the rival’s choice of quality.

We now consider the case \(q < q^*\). In this case prices and profits are calculated similarly. Again the first order conditions in quality cannot be solved explicitly and thus we use numerical analysis. Our simulations show that there exists parameter combinations for which this assignment in qualities is also an equilibrium. We see that when \(\lambda^* m^*\) is large , this is always equilibrium; otherwise when \(\lambda^* m^*\) is small we need the cost of the home firm to be relatively large. These observations can be seen in Figure 6 where we have represented the profits firms obtain for these two cases. On the horizontal axis we have cost asymmetries; the first panel captures a situation where consumer preferences are similar across countries while the second panel shows the profits levels when consumers in the foreign country are willing to pay on average 50% more for one unit of quality.

\[ \begin{align*}
& (a) \quad \lambda^* = m^* = 1, \bar{q} = 1 \\
& (b) \quad \lambda^* = 1.5, m^* = 1, \bar{q} = 1 
\end{align*} \]

Figure 6: Firms’ profits for different quality equilibria

Since we have sets of parameters for which the two assignments in qualities can be equilibria, we are confronted with the question of which equilibrium is more reasonable. Using the Harsanyi-Selten risk-dominance notion of refined equilibrium as a selection criterion yields clear-cut results:
for every level of $\lambda^*m^*$, there exists a level of cost $\bar{c}(\lambda^*m^*)$ such that for all $c < \bar{c}(\lambda^*m^*)$ the unique refined equilibrium is such that the home firm produces a good of higher quality than that of the foreign firm; otherwise the home firm is too inefficient and produces low quality. The criterion is represented in Figure 7. Let us call the equilibrium where the home firm produces high quality “equilibrium 1” and the alternative equilibrium “equilibrium 2”; Figure 7(a) represents the quantities $G_{ij}$, which denote the gains to firm $i$ from predicting correctly that the other firm will select equilibrium $j$, $i = j, 1, 2$. Figure 7(b) shows the criterion: equilibrium 1 is selected whenever $G_{11}G_{21} > G_{12}G_{22}$ and from the graph it follows that the home firm will produce high quality provided that cost differences are not large.

![Figure 7: Harsany-Selten criterion](image)

**Proof of Lemma 3:** The proof goes along the lines of that of Lemma 2 and we skip it to save on space. The only difference is that the foreign firm is always the high-quality producer (in the Harsany-Selten refined equilibrium). The reason is that the foreign firm is more efficient than the home firm and in addition it serves two markets in this case.

**Proof of Lemma 4:** We need to rule out any other quality configuration. We note that there are 4! quality configurations but the majority of them can be ruled out easily. First, note that any quality configuration where $q_1 > q_2 > q_2^*$ cannot be an equilibrium because the home firm would deviate by increasing its quality $q_2$. This rules out 4 possible configurations. Likewise, any quality configuration such that $q_2 > q_1 > q_1^*$ cannot be equilibrium either since the home firm would gain by increasing its quality $q_1$. This rules out 4 quality configurations more. The same reasoning can be applied to the foreign firm. Quality configurations such that $q_2^* > q_1 > q_1^*$ cannot be part of an equilibrium because the foreign firm would gain by deviating and increasing
These two arguments together rule out 8 quality configurations more. Second, suppose that 
$q_2^* > q_2 > q_1^* > q_1$; again, the foreign firm would gain by increasing its quality $q_1^*$, which rules out 
this case. In the same vein, if $q_1^* > q_1 > q_2^* > q_2$, the foreign firm would gain by increasing $q_2^*$. 
Analogously, if $q_1 > q_1^* > q_2 > q_2^*$, then the home firm would deviate by increasing $q_2$. The home 
firm would also deviate if $q_2 > q_2^* > q_1 > q_1^*$, in this case by increasing $q_1$. So we are left with only 
four possible quality configurations which can be part of an equilibrium. We turn to examine these 
configurations. Consider first the case where $q_1 > q_2^* > q_1^* > q_2$. We note that the home firm is a 
quality leader in the domestic market but sells a low quality good in the foreign market. Using the 
prices we have derived above in Lemmas 1-3, the profits of the firms can be written as follows:

$$
\pi = \frac{4\theta q_1^2(q_1 - q_1^*)}{(4q_1 - q_1^*)^2} + \frac{\lambda^* m^* \theta q_2^2(q_2^* - q_2)}{(4q_2^* - q_2)^2} - \frac{q_1^2}{2} \\
\pi^* = \frac{4\lambda^* m^* \theta q_1^2(q_2 - q_2^*)}{(4q_2 - q_2^*)^2} + \frac{\theta q_1 q_1^*(q_1 - q_1^*)}{(4q_1 - q_1^*)^2} - \frac{q_2^2}{2}
$$

The home firm chooses $(q_1, q_2)$ to maximize $\pi$ and the foreign firm selects $(q_1^*, q_2^*)$ to maximize $\pi^*$. 
We note that the firms problem are separable in qualities. Taking the first order conditions and 
solving the system of four equations yields:

$$
q_1 = \frac{7\theta}{24c}, q_2 = \frac{\lambda^* m^* \theta}{6}; q_1^* = \frac{\theta}{6c}, q_2^* = \frac{7\lambda^* m^* \theta}{24}
$$

Equilibrium profits would be

$$
\pi = \frac{7\lambda^2 m^* \theta^2}{1152}; \pi^* = \frac{7\lambda^* m^* \theta^2}{1152c}.
$$

We now check that the home firm would gain by deviating and producing a higher quality abroad, 
in particular, we propose the following deviation $q_1 = q_2$ chosen to maximize profits. Deviating 
profits are

$$
\pi^d = \frac{4\theta q_1^2(q_1 - q_1^*)}{(4q_1 - q_1^*)^2} + \frac{4\lambda^* m^* \theta q_1^2(q_1 - q_1^*)}{(4q_1 - q_1^*)^2} - \frac{q_1^2}{2}
$$

Using the fact that $q_1^* = \frac{\theta}{6c}$ and $q_2^* = \frac{7\lambda^* m^* \theta}{24}$, the first order condition can be written as:

$$
0 = \frac{3456c^3 q_1^2 \theta}{(24 cq_1 - \theta)^3} + \frac{720c^2 q_1 \theta^2}{(24 cq_1 - \theta)^3} - c \left( 1 + \frac{48\theta^2}{(24 cq_1 - \theta)^2} \right) + \\
+ \frac{192\lambda^* m^* \theta (1152 q_1^2 - 252 \lambda^* m^* \theta q_1 + 49 \lambda^2 m^* \theta^2)}{(96q_1 - 7\lambda^* m^* \theta)^3}
$$

Unfortunately, there is no analytical solution for this equation. We have proceeded numerically 
and checked that the deviating firm always obtains higher profits than equilibrium profits. We note
that the remaining assignment in qualities have the same properties, that is, a firm is leader in quality in a market but is a low quality seller in the other market (the other firm vice-versa) and therefore similar arguments rule out these cases.

It remains to check that the Harsany-Selten criterion selects always the foreign firm as a high quality producer. The proof is also based on numerical simulations and is similar to the proof of Lemma 1; we skip it to save on space. ■

**Proof of Proposition 1:** In this case demands are given by (3) and (6). In the second stage of the game firms choose their prices to maximize profits, which yields equilibrium prices:

\[
p_1 = \frac{\theta q(q^* - q)}{4q^* - q}; \quad p_2 = \lambda^* p_1 \quad (43)
\]

\[
p_2^* = \frac{2\lambda^* \theta q^*(q^* - q)}{4q^* - q}; \quad p_1^* = \frac{p_2^*}{\lambda^*}, \quad (44)
\]

In the first stage firms choose their qualities to maximize reduced-form profits:

\[
\pi = (1 + \lambda^* m^*) \frac{\theta q^* q(q^* - q)}{(4q^* - q)^2} - \frac{cq^2}{2} \quad (45)
\]

\[
\pi^* = 4(1 + \lambda^* m^*) \frac{\theta q^{*2}(q^* - q)}{(4q^* - q)^2} - \frac{q^{*2}}{2} \quad (46)
\]

Taking the ratio of first order conditions and using \( \mu = q^*/q > 1 \) yields the expression in (9), which characterizes the equilibrium level of product differentiation. Qualities in (7) and (8) follow straightforwardly from the first order conditions. Simple manipulation of demands and profits formulae yields the expressions in the Proposition. ■

**References**


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