University of Groningen

Antidumping, intra-industry trade, and quality reversals

Moraga González, José L.; Viaene, Jean-Marie

Published in:
International Economic Review

DOI:
[10.1111/iere.12122](https://doi.org/10.1111/iere.12122)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2015

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Moraga González, J. L., & Viaene, J-M. (2015). Antidumping, intra-industry trade, and quality reversals. *International Economic Review*, 56(3), 777-803. <https://doi.org/10.1111/iere.12122>

Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

ANTIDUMPING, INTRA-INDUSTRY TRADE, AND QUALITY REVERSALS*

BY JOSÉ L. MORAGA-GONZÁLEZ AND JEAN-MARIE VIAENE¹

VU University Amsterdam and University of Groningen, The Netherlands; Erasmus University Rotterdam, The Netherlands

We examine an export game where two (home and foreign) firms produce vertically differentiated products. The foreign firm is more R&D efficient and is based in a larger and richer market. The unique (risk-dominant) Nash equilibrium exhibits intra-industry trade, and the foreign producer manufactures a higher-quality product. When transport costs are low, unilateral dumping by the foreign firm arises; otherwise, reciprocal dumping occurs. For some parameters, a domestic antidumping policy leads to a quality reversal in the international market whereby the home firm becomes the quality leader. This policy is desirable for the implementing country, though world welfare decreases.

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 nonmarket and market instruments, including trade and industrial policy as well as antidumping (AD) policy.

A classic example is the battle between U.S. 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. Toward the middle of the 1980s, several U.S. firms,

*Manuscript received August 2007; revised January 2014.

¹ We are most grateful to Charles Horioka, the Editor, and three anonymous referees for their helpful comments on earlier versions of the article. In addition, we thank Alan Deardorff, Joe Francois, Amy Glass, Abraham Hollander, Henrik Horn, Jee-Hyeong Park, Thomas Prusa, Santanu Roy, Kamal Saggi, Robert Stern, and the seminar participants at CESifo, Michigan, SMU, Texas A and M, and the Tinbergen Institute for helpful comments and suggestions. We also thank Olga Zelenko for her skillful research assistance. This article was partly written while Jean-Marie Viaene was visiting the Department of Economics of the University of Michigan, whose hospitality and financial support are gratefully acknowledged. He also thanks the Center for European Studies of the University of Michigan and the Royal Netherlands Academy of Arts and Sciences for financial support. Moraga is fellow of CEPR, CESifo, The Tinbergen Institute, and the PPSRC Center at IESE. Viaene is fellow of CESifo and Tinbergen Institute. Please address correspondence to: José L. Moraga-González, Department of Economics, Faculty of Economics and Business Administration, VU University Amsterdam, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands. E-mail: j.l.moragagonzalez@vu.nl.

TABLE 1
ANTIDUMPING INITIATIONS BY REPORTING COUNTRY

Country	1995	2001	2008	1995–2010 ¹
World	157 ²	371	213	3,752
Traditional users	63 (40.1%) ³	153 (41.2%)	44 (20.7%)	1,220 (32.5%)
Australia	5	23	6	212
Canada	11	25	3	152
E.U.	33	28	19	414
United States	14	77	16	442
New users	62 (39.5%)	169 (45.6%)	143 (67.1%)	1,822 (48.6%)
Argentina	27	28	19	277
Brazil	5	17	23	184
China	0	14	14	182
India	6	79	55	613
South Korea	4	4	5	111
Mexico	4	6	1	98
South Africa	16	6	3	212
Turkey	0	15	12	145
Rest of the world	32 (20.4%)	49 (13.2%)	20 (10.0%)	710 (18.9%)

¹June 2010. ²Number of new initiations. ³Share of group of users in total initiations in a particular year or period (in percentages).
SOURCE: Authors' own calculations based on WTO Web site.

including Micron Technology Inc., Intel, and Advanced Micro Devices, Inc. (AMD), accused their Japanese competitors of dumping in the U.S. 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 U.S. and the Japanese administrations.

The Chinese newsprint industry is another example illustrating the use of antidumping 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 antidumping regime promoted rapid development in the domestic newsprint industry, and industry 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 U.S., Canada, and South Korea's newsprint imports. Lee and Lim (2001) stress the important role of the government in providing market protection of fixed duration in their analysis of the catching-up experience of the Korean industries, another classic example of leapfrogging. More recently, new cases include China's antidumping duties on automobiles from the United States and on X-ray security inspection equipment from the E.U.²

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, antidumping measures whose application is governed by Article VI of General Agreement on Tariffs and Trade (GATT) are not limited.³

Table 1 documents the worldwide upward trend in the use of antidumping laws and illustrates that, while only a few developed countries—mainly Australia, Canada, the European Union (E.U.), and the United States—were traditional users of antidumping action in the old days,

² These are, respectively, disputes DS440 and DS425 in the catalog of Dispute Settlements reported by the WTO.
³ For example, the Chinese antidumping case in chloroprene rubber applies a 151% antidumping duty against U.S. exports (Bown, 2010). This is low compared to the U.S. antidumping case in vector supercomputers that imposed a record antidumping duty of 454% against Nippon Electric Company (NEC) (Maur and Messerlin, 1999).

TABLE 2
SHARE OF AD INITIATIONS AGAINST EXPORTING COUNTRIES WITH A HIGHER GDP PER CAPITA¹

Argentina	Brazil	China	India	South Korea	Mexico	South Africa	Turkey
0.35 ²	0.59	0.95	0.99	0.52	0.58	0.64	0.34

¹GDP per capita in 2008. ²Share of cumulative AD initiations targeted at exporting countries with a higher GDP per capita than the reporting country, for varying periods that span between 1987 and 2009.

SOURCE: GDP per capita from the World Bank; authors' own calculations based on the Global Antidumping Database (Bown, 2010).

antidumping is nowadays the trade policy of choice of developing and transition countries as well. Of the 3,752 antidumping initiations reported by the WTO from January 1995 to June 2010, about 48.6% are issued by the so-called new users. In 1995, new users initiated almost the same number of cases as traditional users but initiated 45.6% of the new investigations in peak year 2001 and 67.1% in 2008, in the midst of the financial crisis. By June 2010, the WTO members with the most investigations include India, the United States, the E.U., Argentina, Australia, and South Africa.

Remarkably, developing and emerging economies target many AD initiations against firms from more developed countries. As Table 2 indicates, the percentage of initiations aimed at firms from countries with a larger (2008) income per capita is 99% for India, the largest initiator of AD measures, and range between 34% and 95% for other new users.

This article introduces a novel model of intra-industry trade with product quality differentiation where country size and income differences help explain these observations. We first examine the incentives of oligopolistic firms to dump exports in developing economies. We then study the incentives of the domestic firm to file a petition for antidumping action and, in turn, of the domestic government to honor such a petition. Our most important result is that an antidumping intervention can lead to a quality reversal, that is, the government policy can induce a less efficient domestic firm to leapfrog the foreign firm's quality and become the quality leader in the international market. In this case, the incentives of both the domestic firm and the home government coincide, and AD actions are then expected to materialize. To the best of our knowledge, this is the first article identifying conditions under which an antidumping action is welfare improving for the intervening country.

To define dumping, our framework adopts the standard rules put forward by the WTO, of which the following is key: "*If a company exports a product at a price lower than the price it normally charges on its own home market, it is said to be 'dumping' the product. Is this unfair competition? The WTO agreement does not pass judgement*" (WTO Web site, accessed September 1, 2013).

An implementation of this definition requires a model that allows for intra-industry trade between two trading nations. Moreover, this definition implies that dumping will arise as a natural outcome of the competitive process when international firms have market power and sell their products in asymmetric markets. One would then expect there to be a lot of antidumping cases as a response. As will be shown later, this is not the case because AD actions can simply lower the profits of the filing firm and/or be welfare reducing for the intervening country. In the former cases, firms are not expected to file complaints in the first place; in the latter cases, welfarist governments will not intervene because tolerating dumping is beneficial for social welfare.

Models of vertical product differentiation are particularly suited to analyze dumping issues because, first, they stress the importance of quality leadership for firms and country welfare. Incentives for a firm to be a quality leader arise from the typical large market shares and high profits that are associated with high-quality production. AD policies modify firms' incentives to select product quality, which, in turn, affect the extent of competition and social welfare. Second, there is substantial empirical evidence that product quality matters in the global economy. This is shown in the increasing availability of detailed databases, many of which are based on firm surveys. For example, the Analytical Database on International Trade (BACI) covers 200

countries and explicitly accounts for intra-industry trade in vertically differentiated products (Gaulier and Zignago, 2010). Bastos and Silva (2010) use micro-data from Portugal to uncover the quality of exports and their drivers. Using a yearly panel survey conducted by the Mexican statistical agency, Verhoogen (2008) investigates the quality-upgrading mechanism as a source of wage inequality. In a sample of 60 countries, Hallack (2006) shows that there are large differences in the quality of products that are exported. Using a novel method to account for variation in trade balances induced by horizontal and vertical differentiation, Hallack and Schott (2011) substantiate the importance of product quality by tracing the evolution of manufacturing quality for the world's top exporters. Finally, from the numerous antidumping investigations, considerable differences in the types of products made worldwide emerge. In particular, hearings and public reports reveal that, besides prices, perceived quality differences are important in many AD cases (United States International Trade Commission [USITC] 2001, 2002a, 2002b, 2003).

Our framework of analysis includes also other features such as the heterogeneity of countries and of firms involved in trade. This heterogeneity reflects not only substantial cost asymmetries across firms but also substantial differences in consumer tastes and incomes across countries. Elements of market structure matter as well. Petitions filed by a U.S. industry against imports concern products that are usually classified under 10-digit subheadings of the HTS 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 United States and the E.U., it is common that a case concerns two players, a local and a foreign producer. See, for example, European Community (EC; 2002, pp. 25 and 48) and USITC (2001, 2002b, 2008).

We analyze an international trade game between two firms located in two different countries (developed vs. developing) that produce quality-differentiated products. Domestic and foreign consumers have heterogeneous preferences for 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. 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. After the domestic government opts for either free trade or an AD policy, firms play a two-stage game.⁴ In the first stage, firms select the qualities to be produced and possibly exported and incur the fixed costs; in the second stage, firms engage in a price competition game.

We first show the existence of a unique (risk-dominant) free trade equilibrium that is characterized by intra-industry trade. The foreign firm, being 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. When transport costs are sufficiently high, reciprocal dumping obtains instead. Focusing on situations where dumping is unilateral, we study the effects of an AD policy that mainly consists of either of two policy instruments: a price undertaking and an AD duty. The latter equalizes the price that consumers in different countries pay for the same good by means of a duty. The former is a binding commitment to raise the export price so that dumping is eliminated (GATT, 1991, pp. 74).

A number of influential papers have contributed to our understanding of the working of antidumping procedures. Staiger and Wolak (1994) describe the time dimension of a regular AD process: it starts with the filing of a petition by a local firm and ends with the final injury determination. Any settlement like a price undertaking takes place at an intermediate stage, the levying of a duty in the latest stage. In this setting, Panagariya and Gupta (2002) offer a quantity duopoly model to show why so few petitions are withdrawn. A withdrawal is indicative that the negotiated solution dominates the outcome under the AD duty solution. In contrast, Prusa (1992) develops a Bertrand duopoly model to show why so many AD petitions are withdrawn.

⁴ In our model, the enactment and application of law are assumed to be simultaneous since there will be plain evidence that the WTO dumping criteria are met. In practice, however, cases are less clear-cut, implying that more stages in the game could be included to embed administrative costs and recognize the discrete time intervals between the enactment of law, the filing process, and the application of law.

In this context, Zanardi (2004) finds empirically that, under an AD policy, firms have incentives to collude. Following this branch of the literature, we compare an AD duty with two types of price undertakings. First, we study a constrained price undertaking (PU), which is the traditional agreement under which firms are restricted so as to hold the price at the level that would prevail if an AD duty was imposed. Later in Section 7, we examine a free price undertaking (FPU), that is, an agreement under which firms can freely choose the prices they charge in order to solve the dumping case. The first agreement involves price undertakings that must be in the public interest, whereas the second set comprises also agreements in the private interest of the firms.⁵ In both cases, dumping must cease and no new dumping case can be created elsewhere.

We then show that an AD policy may lead to radical changes in market structure compared to the free trade equilibrium. Particularly, we derive the following results: (i) In the absence of collusion and transaction costs, an AD duty and a price undertaking are shown to be equivalent. For rational firms, what matters is the threat of an AD action, not whether a price undertaking or an AD duty is levied. Later, in Section 7, we allow for collusion among firms and show that a pro-business government would prefer an FPU over an AD duty. (ii) For some parameter constellations, a price undertaking may result in a quality reversal such that the home firm becomes the quality leader. This AD action is then socially desirable for the domestic country, though world welfare decreases. (iii) Under other parameter combinations, free trade remains the equilibrium of the game though high-quality products continue to be dumped into the domestic economy. (iv) Under other conditions, the foreign firm exits strategically the domestic market in response to an AD action. The domestic firm will clearly file a petition since, if honored, its profits would increase. However, a domestic government that cares about aggregate domestic welfare would not honor the petition. (v) The imposition of a price undertaking may also lead to the strategic exit of the domestic firm from its export market because by doing so it leads to an increase in all prices at home and abroad. As before, the domestic firm may wish to file a petition for AD action, but again it will not be honored by a welfarist domestic government.

The rest of the article is organized as follows: The next section discusses results of the model in light of the related literature. Section 3 presents the details of our model. Section 4 solves for the free trade equilibrium and establishes the conditions for dumping. Section 5 establishes an equivalence result between an AD duty and a price undertaking. Building on this result, Section 6 uncovers the effects of a price undertaking in our model. Section 7 extends our framework to show that an AD law can be a collusive device and that our results are not undermined if firms endogenously select the quality level they produce. Section 8 concludes.

2. RELATED LITERATURE

Our article is a contribution to the study of antidumping in oligopolistic industries. The literature is extensive, and the reader is referred to Feenstra (2004) and the survey of Blonigen and Prusa (2003) for a detailed discussion. However, little attention has been paid to the role of quality differences, and the distinctive feature of our article is the study of AD legislation in such a context. In this regard, Vandenbussche and Wauthy (2001) is the contribution 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 price undertaking 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. In contrast, we use a model of intra-industry trade that allows for a more thorough treatment of the WTO’s standard definition of dumping.

⁵ As Prusa (1992) indicates, collusive agreements in the United States are usually tolerated by the Department of Commerce and exempted from antitrust prosecution under the *Noerr-Pennington* doctrine.

A related literature examines 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 (see, e.g., Ethier and Fischer, 1987; Leidy and Hoekman, 1990; Reitzes, 1993). 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.

Vandenbussche and Zanardi (2008) identify factors that explain why countries adopt and use AD laws. Among the potential drivers of the emergence of AD laws, their empirical results suggest that retaliatory motives are at the heart of proliferation. Against this background that depicts a certain misuse of AD law by governments, this article introduces a new interpretation of *domino dumping*.⁶ Once the home government enacts AD law, foreign rival firms that suffer from AD enforcement have incentives to react strategically by exiting the home market. As a result of decreased competitive pressures in the home market, local firms that charge higher prices may dump their products abroad and lead the foreign government to take AD actions as well.⁷

Our article is also related to the work explaining how product quality matters in international trade. The monopoly problem is discussed in Mussa and Rosen (1978) and Krishna (1987), and oligopoly versions of this model have received substantial attention in the international trade literature. More related to our model, Herguera et al. (2002) study optimal trade policy in a model of one-way trade, and Motta et al. (1997) analyze the sustainability of quality leadership once countries open up to trade. Moraga-González and Viaene (2005) study trade and industrial policy in transition economies. Saggi and Sara (2008), extending the work of Horn (2006), analyze the WTO's national treatment clause in a two-country model where quality of goods and/or market size are heterogeneous across countries. Our article contributes to this work on quality leadership by showing that the export game has a unique free trade equilibrium characterized by intra-industry trade and that firms' cost asymmetries are crucial in sustaining quality leadership.

Finally, there is increasing empirical evidence supporting the main features of our model. For example, a key point of Anderton (1999) is the estimation of low price elasticities of demand in sectors with a high degree of vertical product differentiation. Econometric studies by Crozet and Erkel-Rousse (2004) establish a tight link between quality and innovation, justifying our cost function of quality development. The empirical estimates of Bastos and Silva (2010) provide support to characteristics of our market equilibria, namely, that producers of high quality have higher outputs and charge higher prices. In addition, they find that firms adjust optimally the quality of their products to countries with a higher economic development. Similar observations have been obtained in Bils and Klenow (2001) for the United States.

3. THE MODEL

Two firms sell goods that are vertically differentiated. These two firms, located in two different countries, home and foreign, produce goods for their own market and, eventually, for exports.

⁶ A domino effect in trade policy arises when a protectionist measure in one country leads to another. For example, in Anderson (1992, 1993) domino dumping arises when exporting firms dump to obtain more export licences in the future when there is a positive probability of a future voluntary export restraint. Increased enforcement may not eliminate dumping and may even lead to a rise in dumping, toppling another domino. In our setting, though a domino effect may arise, antidumping enforcement is effective in the first place.

⁷ Though AD measures may have small effects on global trade, these trade effects may be large for some AD-imposing countries. For example, Vandenbussche and Zanardi (2010) find chilling trade effects that are sufficiently large to offset the gain in trade volumes obtained from various rounds of trade liberalization. In our setting, we show that although some Nash equilibria are indeed characterized by a reduction in trade volumes, other equilibria with intra-industry trade do not show such a pattern.

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. We assume there are transport costs, denoted by r , associated to moving goods from country to country. For convenience, we suppose transport costs are of the “iceberg” type.

Product quality may be one of two types: high-quality q_h and low-quality q_ℓ , with $q_h > q_\ell$. As in Motta et al. (1997) and Shaked and Sutton (1984), we adopt the cost specification of *pure* vertical product differentiation models, where the costs of quality mainly fall on fixed costs and involve only a *small* or *no* increase in unit variable costs. In particular, once the home (foreign) firm picks the quality of the goods to be offered, it pays a fixed cost $C(q) = cq^2/2$, $q = \{q_h, q_\ell\}$ ($C^*(q) = c^*q^2/2$) and produces at a marginal cost which is normalized to zero.⁸ Fixed 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 in this article because they help us pin down a unique equilibrium in qualities. As we will see later, the size of these costs is not relevant and can then be taken to be arbitrarily small; in particular, we let $c \rightarrow 0$, and $c^* \rightarrow 0$, with $c^*/c = \gamma \in (0, 1)$.⁹

Assume there is a population of measure m (1) at the home (foreign) country, with $0 < m \leq 1$. Consumers buy at most one unit and have preferences given by the following quasi-linear (indirect) utility function: $U = \theta q - p$, if a unit of a good of quality q is bought at price p , and 0 otherwise. Parameter θ is consumer specific and measures the utility a consumer derives from consuming a unit of quality. Assume that θ is uniformly distributed over $[0, \lambda\bar{\theta}]$ at home and over $[0, \bar{\theta}]$ abroad, with $0 < \lambda \leq 1, \bar{\theta} > 0$. Tirole (1988) shows that θ is the inverse of the marginal utility of income so our assumption $\lambda \leq 1$ implies that foreign consumers have higher incomes on average and more sophisticated tastes. Our specification of demand thus captures income differences between countries via λ and size differences between countries via parameter m . The assumption that λ is less than 1 serves to focus the model on the interaction between firms located in developing and developed countries.¹⁰

Let p_ℓ and p_h be the prices for low- and high-quality products in the domestic country. Suppose, for a moment, that $p_h > p_\ell$, that is, high quality is sold at a higher price, an assumption that will be verified later. Firms’ demand functions are obtained as follows: There is a consumer, denoted by $\tilde{\theta}$, who is indifferent between buying high quality or low quality. Using the utility function, it is readily seen that $\tilde{\theta} = (p_h - p_\ell)/(q_h - q_\ell)$. Likewise, let $\hat{\theta}$ denote the consumer indifferent between acquiring the low-quality good or nothing at all, that is, $\hat{\theta} = p_\ell/q_\ell$. Then, the high-quality good is demanded by those consumers such that $\tilde{\theta} \leq \theta \leq \bar{\theta}$ and the low-quality variant is demanded by those buyers such that $\hat{\theta} \leq \theta < \tilde{\theta}$. As θ is uniformly distributed on $[0, \lambda\bar{\theta}]$, home demands for high- and low-quality goods are

$$(1) \quad D_l(\cdot) = m \left(\frac{p_h - p_\ell}{\lambda\bar{\theta}(q_h - q_\ell)} - \frac{p_\ell}{\lambda\bar{\theta}q_\ell} \right), \quad D_h(\cdot) = m \left(1 - \frac{p_h - p_\ell}{\lambda\bar{\theta}(q_h - q_\ell)} \right).$$

Note that one of these demands is met by imports from the foreign firm. Proceeding in the same way, we can compute the foreign demands for high- and low-quality goods:

$$(2) \quad D_\ell^*(\cdot) = \frac{p_h^* - p_\ell^*}{\bar{\theta}(q_h - q_\ell)} - \frac{p_\ell^*}{\bar{\theta}q_\ell}, \quad D_h^*(\cdot) = 1 - \frac{p_h^* - p_\ell^*}{\bar{\theta}(q_h - q_\ell)},$$

⁸ This normalization is without loss of generality provided that the main bulk of costs falls on fixed costs instead of on variable costs. Adding small marginal costs of production makes computations cumbersome and obscures the presentation of the results substantially without adding further insights.

⁹ 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 $k \geq 2$. Although larger k values affect results quantitatively, they do not alter them qualitatively.

¹⁰ This sets our article apart from Vandenbussche and Wauthy (2001), who study dumping into a developed country.

TABLE 3
QUALITY STRATEGY PROFILES UNDER FREE TRADE

		Foreign Firm	
		$q_h \& E$	$q_\ell \& E$
Home firm	$q_\ell \& E$	$R_\ell - \frac{cq_\ell^2}{2}, R_h - \frac{c^*q_h^2}{2}$	$-\frac{cq_\ell^2}{2}, -\frac{c^*q_\ell^2}{2}$
	$q_h \& E$	$-\frac{cq_h^2}{2}, -\frac{c^*q_h^2}{2}$	$R_h - \frac{cq_h^2}{2}, R_\ell - \frac{c^*q_\ell^2}{2}$

where p_ℓ^* and p_h^* are foreign prices of low- and high-quality, $p_h^* > p_\ell^*$. As before, one of these demands is met by imports from the home firm.

4. FREE 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, exporting to a larger and richer country. It faces competition from a foreign firm, which is more efficient. Given this, the following three questions arise: (1) What is the pattern of trade that emerges in equilibrium once both countries open up to trade? (2) What are the product qualities that are produced by each firm in equilibrium? (3) 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 this section and focus on the market equilibrium under free trade. Since there are two quality levels available for choice, q_h and q_ℓ , this section studies an export game where the domestic and foreign firms can freely pick which of the two qualities to offer and which prices to set in the two different countries.¹¹

4.1. Risk-Dominant Nash Equilibrium. There are four relevant continuation games,¹² each of them ensuing after the firms have picked a quality-and-export strategy profile. The quality-and-export strategy set of a firm i is $S_i = \{q_\ell \& E, q_h \& E\}$ for $i = 1, 2$ where E stands for export and means that the firm will export its good to the other market. In what follows, we compute the price equilibrium corresponding to each quality-and-export strategy profile.

Suppose first that the two firms choose to produce different quality levels. Firms choose their prices to maximize their world revenues. The firm selling high quality has revenues equal to $p_h(1 - r)D_h + p_h^*D_h^*$ whereas the corresponding revenues for the low-quality firm are $p_\ell D_\ell + p_\ell^*(1 - r)D_\ell^*$. Taking the first-order conditions and solving for the Nash equilibrium yields the following prices in the domestic country:

$$p_\ell = \frac{\bar{\theta}\lambda(q_h - q_\ell)q_\ell}{4q_h - q_\ell}, \quad p_h = \frac{2\bar{\theta}\lambda q_h(q_h - q_\ell)}{4q_h - q_\ell}.$$

In the foreign country, we have $p_\ell^* = p_\ell/\lambda, p_h^* = p_h/\lambda$.

Suppose now that firms choose to produce the same quality levels. Since firms compete in a Bertrand fashion, it is clear that competition will drive prices down to zero thereby eroding all variable profits of the firms.

Given this information, we can now fold the game backward and write down in Table 3 the

¹¹ To be sure, quality choices are endogenous here, though the quality levels are exogenously fixed. In Section 7, we examine the case in which quality levels are also endogenous.

¹² Strategies for which a firm refrains from exporting are strictly dominated under free trade, so they can be ignored in this section. Later in Section 5, we show that, once AD action is in place, either the home or the foreign firm may strategically choose to exit the export market, thereby relaxing price competition and gaining a competitive advantage.

normal-form game at the choice-of-quality and export stage, where R_ℓ and R_h , which are given by

$$(3) \quad R_\ell = \frac{\bar{\theta}q_h(q_h - q_\ell)q_\ell(1 + m\lambda - r)}{(4q_h - q_\ell)^2}; \quad R_h = \frac{4\bar{\theta}q_h^2(q_h - q_\ell)(1 + \lambda m(1 - r))}{(4q_h - q_\ell)^2}$$

denote the revenues of a low- and a high-quality firm under free trade, respectively.

Assuming product differentiation gives sufficient revenues to cover the (small) fixed costs, this game has two Nash equilibria. In one equilibrium, $\{q_\ell \& E, q_h \& E\}$, the domestic firm produces the low-quality product, and in the alternative equilibrium, $\{q_h \& E, q_\ell \& E\}$, it is the home firm that produces high quality. As discussed in detail in Motta et al. (1997) and in Moraga-González and Viaene (2005), selection of equilibria in this type of games requires to use the Harsanyi–Selten risk-dominance criterion (Harsanyi and Selten, 1988). Applying this criterion to our game, we now show that as long as firms' costs differ, irrespective of whether they are large or small, one of the equilibria can readily be refined away.¹³

Let $G_{11} = R_\ell + \frac{c}{2}(q_h^2 - q_\ell^2)$ be the gains the domestic firm obtains by predicting correctly that the foreign firm will select equilibrium 1, $\{q_\ell \& E, q_h \& E\}$. Likewise, $G_{12} = R_h - \frac{c}{2}(q_h^2 - q_\ell^2)$ denotes the gains the domestic firm derives by forecasting correctly that the foreign firm will select equilibrium 2, $\{q_h \& E, q_\ell \& E\}$. Similarly, for the foreign firm we have $G_{21} = R_h - \frac{c^*}{2}(q_h^2 - q_\ell^2)$ and $G_{22} = R_\ell + \frac{c^*}{2}(q_h^2 - q_\ell^2)$. It is said that equilibrium 1 risk-dominates equilibrium 2 whenever $G_{11}G_{21} > G_{12}G_{22}$. It is straightforward to verify that this inequality holds whenever $\gamma < 1$. In fact, we need to show that

$$\left(R_\ell + \frac{c}{2}(q_h^2 - q_\ell^2)\right) \left(R_h - \frac{c^*}{2}(q_h^2 - q_\ell^2)\right) > \left(R_h - \frac{c}{2}(q_h^2 - q_\ell^2)\right) \left(R_\ell + \frac{c^*}{2}(q_h^2 - q_\ell^2)\right).$$

Define $Z = \frac{c}{2}(q_h^2 - q_\ell^2)$. Then,

$$(R_\ell + Z)(R_h - \gamma Z) > (R_h - Z)(R_\ell + \gamma Z) \iff Z(R_h + R_\ell)(1 - \gamma) > 0.$$

The next proposition characterizes the assignment of qualities across firms under free trade.

PROPOSITION 1. *In the unique risk-dominant free trade equilibrium, the foreign firm produces high quality and the domestic firm chooses low quality.*

The quality leader is thus the most efficient firm in terms of development costs.¹⁴ This important result indicates that the sustainability of quality leadership under free trade hinges on firms' cost asymmetries only and not on market size or income differences.

To assess welfare effects of antidumping action, we shall use the weighted sum of consumer surplus and firms' payoffs as a measure of social welfare in every country:

$$(4) \quad W = \beta_1 CS + \beta_2 R, \quad \beta_j \in [0, 1], j = 1, 2.$$

With exogenous levels of quality, firms' payoffs are equal to revenues. In Section 6, where we allow firms to choose the level of the quality of their products, development costs are included as part of welfare calculations. Weights β_1 and β_2 characterize policymakers' preferences. If $\beta_1 = \beta_2 = 1$, we have the usual (neutral) definition of social welfare; if $\beta_1 = 1$ and $\beta_2 = 0$, the

¹³ See also Zhou et al. (2002), who show that there is only one Nash equilibrium provided cost differences across firms are sufficiently large.

¹⁴ In our article, quality leadership refers to the fact that one firm produces higher quality than the other and such leadership is obtained via cost differences. By contrast, in Aoki and Prusa (1997) leadership refers to Stackelberg leadership.

government cares only about consumer surplus; finally when $\beta_1 = 0$ and $\beta_2 = 1$, only firms' revenues matter for the policymaker.¹⁵ Domestic consumer surplus is given by

$$CS = m \int_{\frac{p_h - p_\ell}{q_h - q_\ell}}^{\bar{\lambda}\bar{\theta}} (xq_h - p_h) dF(\theta) + m \int_{p_\ell/q_\ell}^{\frac{p_h - p_\ell}{q_h - q_\ell}} (xq_\ell - p_\ell) dF(\theta),$$

where $F(\theta)$ is the cumulative distribution function of θ .

Let us define $\mu = q_h/q_\ell$, with $\mu > 1$ since $q_h > q_\ell$. Variable μ represents the quality gap between firms' variants and measures the degree of product differentiation. The next proposition characterizes the free trade equilibrium.

PROPOSITION 2. *There is a unique risk-dominant free trade equilibrium of the export game. This equilibrium involves intra-industry trade and is characterized as follows: (i) The domestic firm picks q_ℓ and the foreign firm picks q_h . (ii) These goods sell at prices*

$$(5) \quad p_\ell = \frac{\bar{\theta}\lambda(\mu - 1)q_\ell}{4\mu - 1}, \quad p_h = \frac{2\bar{\theta}\lambda q_h(\mu - 1)}{4\mu - 1},$$

$$(6) \quad p_\ell^* = p_\ell/\lambda, \quad p_h^* = p_h/\lambda$$

in the two countries. (iii) Market demands for each firm are

$$(7) \quad D_\ell = m \frac{\mu}{4\mu - 1}; \quad D_\ell^* = \frac{\mu}{4\mu - 1}; \quad D_l + D_l^* = \frac{(1 + m)\mu}{(4\mu - 1)}$$

and $D_h = 2D_\ell$; $D_h^* = 2D_\ell^*$. (iv) Firms' revenues are given by (3), with R_ℓ and R_h being domestic and foreign firms' revenue, respectively. The ratio of revenues is

$$(8) \quad \frac{R_h}{R_l} = 4\mu \left[\frac{1 + \lambda m(1 - r)}{1 + \lambda m - r} \right].$$

(v) Consumer surplus in each country is

$$(9) \quad CS_{FT} = \frac{\lambda m \bar{\theta} q_h \mu (4\mu + 5)}{2(4\mu - 1)^2}, \quad CS_{FT}^* = \frac{\bar{\theta} q_h \mu (4\mu + 5)}{2(4\mu - 1)^2} = CS_{FT}/\lambda m.$$

(vi) Assuming $\beta_1 = \beta_2 = 1$, social welfare is

$$W_{FT} = \frac{\bar{\theta} q_h [2(\mu - 1)(1 - r) + \lambda m(4\mu - 1)(\mu + 2)]}{2(4\mu - 1)^2},$$

$$W_{FT}^* = \frac{\bar{\theta} q_h \mu (12\mu - 3 + 8m\lambda(1 - r)(\mu - 1))}{2(4\mu - 1)^2}.$$

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

$$(10) \quad GL = 100 \left\{ 1 - \frac{|p_l^*(1 - r)D_l^* - p_h^*D_h^*|}{p_l^*(1 - r)D_l^* + p_h^*D_h^*} \right\} = 100 \left\{ 1 - \frac{|(1 - r) - 4\lambda m\mu|}{1 - r + 4\lambda m\mu} \right\}.$$

¹⁵ Note that AD actions seem to be in favor 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 them about the role of antidumping and achieving coordination between them to undertake pressure (Becker, 1983).

This proposition describes the benchmark of our analysis. For any μ , 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 (10) depends on the primitive parameters of the model: relative country size m , relative taste difference λ , transport cost r , and the gap between qualities q_h and q_ℓ . Besides being a measure of product differentiation, μ relates to the extent of price competition between firms since, by taking the ratio of prices in (5) and (6), we obtain $p_h/p_\ell = p_h^*/p_\ell^* = 2\mu$. The importance of producing high quality is further stressed by the ratio of revenues in (8), which is equal to 4μ when $r = 0$. This is partly explained by the discrepancy in hedonic prices, the hedonic price of high quality being twice that of low quality ($p_h/q_h = 2p_\ell/q_\ell$).

4.2. WTO Rules. Is dumping arising in this free trade equilibrium? The intra-industry trade nature of the trade equilibrium is useful since it allows us to apply the traditional WTO definition of dumping. The latter relies on three principles. First, a local firm may petition the government for relief if dumped imports materially injure the competing domestic firm. In the market equilibrium just described, domestic and foreign demands are such that the foreign firm's market share $D_h/(D_\ell + D_h)$ is two-thirds of the domestic market (see (7)). It is clear that this proportion is large enough to justify injury. Second, to substantiate a case for antidumping action, products involved must be “like” products. The “likeness” means alike in all respects or, alternatively, having characteristics closely resembling those of the product under consideration, like in our model. Third, a product is to be considered as being dumped if its export price to a particular country is less than a “normal” value, the standard used by the WTO, or less than a “fair value,” the standard used by the U.S. government. There are different ways of calculating a product's “normal” or “fair” value. The standard definition of dumping of the WTO is when the *FOB* export price to a particular country is less than the price the firm normally charges in its own market. In our framework, this definition of dumping amounts to comparing p_ℓ with $p_\ell^*(1 - r)$, and p_h^* with $p_h(1 - r)$. This yields the following result.¹⁶

PROPOSITION 3. *Under free trade, high-quality products are always dumped. In addition, when $\lambda > 1 - r$, both types of product are dumped and dumping becomes reciprocal.*

Our result above is in line with traditional treatments of dumping in that it shows the possibility of *reciprocal* dumping based on transportation costs (Brander and Krugman, 1983; Weinstein, 1992; Anderson et al., 1995). However, dumping is *unilateral* when transportation costs are small. Even with positive transportation costs, only the high-quality product may be dumped, but it all depends on the cross-country difference in the distribution of tastes. A popular belief is that low-quality goods are dumped in export markets because they usually command a lower price. In our setting, the reverse occurs more often: It is the high-quality good that is dumped into the smaller and poorer country. Dumping of high-quality products 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.

As the focus of our analysis is on the new users of AD policy (cf. Table 1), we limit the number of issues by considering only the case where high-quality products are dumped in the free trade equilibrium. This corresponds to the parameter space where $\lambda < 1 - r$. For any nonnegative

¹⁶ 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) 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.

value of r , we can appropriately choose λ so that condition $\lambda < 1 - r$ is satisfied. To make things simple, let us assume $r = 0$ in which case λ can vary freely between 0 and 1.¹⁷

5. ON THE EQUIVALENCE BETWEEN A PU AND AN AD DUTY

Let us now compare AD duties to price undertakings in the form of PUs, that is, when collusion (FPU) between the home and the exporting firms is prohibited. The imposition of a duty equalizes the price that consumers in different countries pay for the same good. Given that the price the foreign firm charges locally is p_h^* and the export price is p_h , an AD 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:

$$(11) \quad p_h(1+t) = p_h^*.$$

With an antidumping duty t , demands faced by the foreign and domestic firms are, respectively,

$$(12) \quad D_l(\cdot) = m \left(\frac{p_h(1+t) - p_\ell}{\lambda \bar{\theta}(q_h - q_\ell)} - \frac{p_\ell}{\lambda \bar{\theta} q_\ell} \right), \quad D_h(\cdot) = m \left(1 - \frac{p_h(1+t) - p_\ell}{\lambda \bar{\theta}(q_h - q_\ell)} \right),$$

$$(13) \quad D_\ell^*(\cdot) = \frac{p_h^* - p_\ell^*}{\bar{\theta}(q_h - q_\ell)} - \frac{p_\ell^*}{\bar{\theta} q_\ell}, \quad D_h^*(\cdot) = 1 - \frac{p_h^* - p_\ell^*}{\bar{\theta}(q_h - q_\ell)}.$$

Firms maximize their profits, which are given by

$$\pi = p_l D_l + p_l^* D_l^* - \frac{c q_l^2}{2}, \quad \pi^* = p_h D_h + p_h^* D_h^* - \frac{c^* q_h^2}{2},$$

and they do so anticipating the antidumping duty t given by

$$(14) \quad t = \frac{p_h^* - p_h}{p_h}.$$

Plugging (14) in (12) and taking the FOC $d\pi^*/dp_h$ yields

$$\frac{d\pi^*}{dp_h} = m \left(1 - \frac{p_h^* - p_l}{\lambda \bar{\theta}(q_h - q_\ell)} \right) = D_h(\cdot).$$

The RHS of this FOC is simply the domestic demand for high quality. As long as $D_h(\cdot)$ is greater than zero, the profits of the foreign firm are increasing in its export price p_h . The optimal pricing behavior of the foreign firm is then to set $p_h = p_h^*$, which implies that revenues from the duty are zero. A similar result has been shown earlier, for example, in Feenstra (2004). Since a constrained price agreement must be such that $p_h = p_h^*$, we obtain the following equivalence result:

PROPOSITION 4. *An antidumping duty imposed by the domestic government results in an equalization of international prices. Hence, antidumping duties and price undertakings in the form of PUs are equivalent in our model.*

¹⁷ An array of interesting situations arise when both governments decide to enact an AD policy. With $r \neq 0$ and reciprocal dumping, both governments may have an incentive to take antidumping actions. However, governments have opposite incentives in that actions by the home government are aimed at helping the home firm to gain quality leadership whereas the foreign government wants to counter that.

TABLE 4
QUALITY AND EXPORT STRATEGY PROFILES OF HOME (ROW) AND FOREIGN (COLUMN) FIRMS

	$q_h \& E$	$q_h \& NE$	$q_\ell \& E$	$q_\ell \& NE$
$q_\ell \& E$	$R(s^{11}), R^*(s^{11})$	$R(s^{12}), R^*(s^{12})$	0, 0	$\frac{\bar{\theta}\lambda mq_\ell}{4}, 0$
$q_\ell \& NE$	$R(s^{21}), R^*(s^{21})$	$\frac{\bar{\theta}\lambda mq_\ell}{4}, \frac{\bar{\theta}q_h}{4}$	0, $\frac{\bar{\theta}q_\ell}{4}$	$\frac{\bar{\theta}\lambda mq_\ell}{4}, \frac{\bar{\theta}q_\ell}{4}$
$q_h \& E$	0, 0	$\frac{\bar{\theta}\lambda mq_h}{4}, 0$	$R(s^{33}), R^*(s^{33})$	$R(s^{34}), R^*(s^{34})$
$q_h \& NE$	0, $\frac{\bar{\theta}q_h}{4}$	$\frac{\bar{\theta}\lambda mq_h}{4}, \frac{\bar{\theta}q_h}{4}$	$R(s^{43}), R^*(s^{43})$	$\frac{\bar{\theta}\lambda mq_h}{4}, \frac{\bar{\theta}q_\ell}{4}$

It is clear from Proposition 4 that, for rational firms, it does not matter for outcomes whether an AD duty or a price undertaking in the form of PU is used to correct a dumping case.¹⁸ A different issue is whether the domestic government wishes to address the dumping case at all. Answering this question is the objective of the next section, and we focus on PUs only, the study of FPU's being relegated to Subsection 7.1.

6. ANTIDUMPING POLICY

What are the domestic government's incentives to intervene? The answer to this question is obtained by comparing domestic welfare attained under free trade with that under a PU. The latter constrains the foreign firm to set an export price that is equal to its local price, that is,

$$(15) \quad p_h = p_h^*.$$

We note that this constraint gives rise to an array of strategic responses by the firms at play. For example, for some parameter values, the foreign firm will prefer to exit the home market. The question is then whether it prefers to continue to produce high quality or instead prefers to deviate by producing low quality. In the latter case, we say that a quality reversal occurs. For alternative parameter values, it is the domestic firm that exits its export market since by doing so it raises prices in all markets, which ultimately benefits it. Therefore, to find out when it is optimal for the domestic government to impose a PU, we need to solve the continuation game played by the firms once the PU is in place. This is the objective of the rest of this section.

6.1. Quality, Price, and Export Strategies of Firms. Let E and NE denote an exporting and nonexporting strategy, respectively. The strategy set of a firm i is

$$S_i = \{q_h \& E, q_h \& NE, q_\ell \& E, q_\ell \& NE\}, \quad i = 1, 2,$$

and the game played by the two firms is summarized in Table 4.

In each cell, R (R^*) is a shorthand notation for expressions representing the international revenues of the home (foreign) firm under different strategies. Other cells report the simpler expressions for either monopoly profits when one firm selects itself out of the export market or for zero duopoly profits when firms choose to produce the same quality level. To shorten the expressions, we do not write the corresponding fixed costs of quality.

The different strategies have a different impact on international trade. As Table 5 indicates, only cells s^{11} and s^{33} allow for intra-industry trade. Trade chilling effects arise when, for strategic reasons, one or two firms decide not to export. Extreme chilling effects are observed in cells $(s^{22}, s^{24}, s^{42}, s^{44})$, where both firms refrain from exporting and trade is zero. Trade promotion can take place as well, when firms produce similar qualities and compete in a Bertrand fashion.

¹⁸ It is straightforward to extend the argument in Proposition 4 to the case in which there is reciprocal dumping.

TABLE 5
TRADE PROPERTIES OF FIRM STRATEGIES

Concepts	Strategies
Quality reversal	$s^{33}, s^{34}, s^{43}, s^{44}$
Intra-industry trade	s^{11}, s^{33}
Trade chilling effects	$s^{12}, s^{21}, s^{22}, s^{24}, s^{34}, s^{42}, s^{43}, s^{44}$
Trade promotion	s^{13}, s^{31}
Ambiguous trade effects	$s^{14}, s^{23}, s^{32}, s^{41}$

Finally, some firm strategies have no clear-cut effect on trade, with one flow increasing, the other decreasing.

Revenues in each cell of Table 4 are obtained from derivations similar to those for the free trade equilibrium while imposing the price constraint (15). Let us start by looking closer at the pair of strategies $s^{11} = \{q_\ell \& E, q_h \& E\}$, payoffs from other strategy pairs being obtained in a similar way. Under strategy profile s^{11} , the foreign firm produces and exports high quality whereas the domestic firm produces and exports low quality. This is basically the same as under free trade, but, because a PU is in place, the foreign firm must set an export price that is equal to its local price to maximize $p_h D_h + p_h^* D_h^*$; the domestic firm has revenues equal to $p_\ell D_\ell + p_\ell^* D_\ell^*$, where $D_\ell, D_h, D_\ell^*, D_h^*$ are given in (1) and (2). Solving for the new Nash equilibrium in prices, we get

(16)
$$p_\ell(s^{11}) = \frac{\bar{\theta}\lambda(1+m)q_\ell(\mu-1)}{(m+\lambda)(4\mu-1)}, p_\ell^*(s^{11}) = p_\ell(s^{11}),$$

(17)
$$p_h^*(s^{11}) = \frac{2\bar{\theta}\lambda(1+m)q_h(\mu-1)}{(m+\lambda)(4\mu-1)}, p_h(s^{11}) = p_h^*(s^{11}).$$

Demands become

(18)
$$D_\ell(s^{11}) = \frac{m(1+m)\mu}{(m+\lambda)(4\mu-1)}; \quad D_\ell^*(s^{11}) = \frac{(1+m)\lambda\mu}{(m+\lambda)(4\mu-1)}$$
$$D_\ell(s^{11}) + D_\ell^*(s^{11}) = \frac{(1+m)\mu}{(4\mu-1)},$$
$$D_h(s^{11}) = \frac{2m\mu}{(4\mu-1)} - \frac{m(1-\lambda)(2\mu-1)}{(m+\lambda)(4\mu-1)}; \quad D_h^*(s^{11}) = \frac{2\mu}{(4\mu-1)} + \frac{m(1-\lambda)(2\mu-1)}{(m+\lambda)(4\mu-1)}$$

(19)
$$D_h(s^{11}) + D_h^*(s^{11}) = \frac{2(1+m)\mu}{(4\mu-1)}.$$

The revenues obtained by the firms in this case are

(20)
$$R(s^{11}) = \frac{\bar{\theta}\lambda(1+m)^2\mu(\mu-1)q_\ell}{(m+\lambda)(4\mu-1)^2}; \quad R^*(s^{11}) = \frac{4\bar{\theta}\lambda(1+m)^2\mu(\mu-1)q_h}{(m+\lambda)(4\mu-1)^2}.$$

Comparing demand expressions (7)–(18) and (19), it is clear that trade volumes are not modified by the imposition of a PU: World demand for low-quality products ($D_\ell + D_\ell^*$) and

for high-quality products ($D_h + D_h^*$) are similar under both free trade and PU. However, the distribution of quantities changes: Domestic firm's local sales increase whereas its exports decrease by the same volume. Likewise, exports of the foreign firm decrease whereas its local sales increase by the same volume.¹⁹

Note that all demands are strictly positive except for possibly $D_h(s^{11})$. The fact that $D_h(s^{11})$ can become zero for certain parameter configurations is of paramount importance in our setting, since it means that a PU gives incentives to the high-quality foreign firm to exit the export market. Therefore, suppose that firms play strategy $s^{12} = \{q_\ell \& E, q_h \& NE\}$ instead, that is, the foreign firm exits the home market. The home market would be monopolized by the domestic firm, and there would only be competition in the foreign market. Equilibrium prices in the foreign market in this situation are

$$p_\ell^*(s^{12}) = \frac{\bar{\theta}(\mu - 1)q_\ell}{(4\mu - 1)}; \quad p_l(s^{12}) = \frac{\bar{\theta}\lambda q_\ell}{2}; \quad p_h^*(s^{12}) = \frac{2\bar{\theta}q_h(\mu - 1)}{(4\mu - 1)}.$$

The revenues of the firms from the foreign market in that case turn out to be

$$(21) \quad R(s^{12}) = \frac{1}{4}m\lambda\bar{\theta}q_\ell + \frac{\bar{\theta}\mu(\mu - 1)q_\ell}{(4\mu - 1)^2}; \quad R^*(s^{12}) = \frac{4\bar{\theta}q_\ell\mu^2(\mu - 1)}{(4\mu - 1)^2}.$$

Consider now the pair of strategies $s^{21} = \{q_\ell \& NE, q_h \& E\}$. In this case, the foreign firm must maximize $p_h D_h + p_h^* D_h^*$ under the constraint that $p_h = p_h^*$. Likewise, the domestic firm has revenues equal to $p_\ell D_\ell$, where D_ℓ , D_h , and D_h^* are given in (1) and (2). Taking the FOCs and solving for the equilibrium prices yields

$$p_\ell(s^{21}) = \frac{\bar{\theta}\lambda(1 + m)q_\ell(\mu - 1)}{(m + \lambda)(4\mu - 1) - 3\lambda}; \quad p_h^*(s^{21}) = \frac{2\bar{\theta}\lambda(1 + m)q_h(\mu - 1)}{(m + \lambda)(4\mu - 1) - 3\lambda} = p_h(s^{21}).$$

Interestingly, the price of the foreign producer goes up and by implication so does the price of the domestic producer. This implies that, at least potentially, the domestic firm can increase its profit by exiting the foreign market. That this did not occur under free trade is due to the constraint the foreign firm faces when maximizing profits. The revenues of the firms are given by

$$(22) \quad R(s^{21}) = \frac{\bar{\theta}\lambda m(1 + m)^2\mu(\mu - 1)q_\ell}{[(m + \lambda)(4\mu - 1) - 3\lambda]^2}; \quad R^*(s^{21}) = \frac{4\bar{\theta}\lambda(1 + m)^2q_h(\mu - 1)[(m + \lambda)\mu - \lambda]}{[(m + \lambda)(4\mu - 1) - 3\lambda]^2}.$$

Suppose firms play strategy $s^{33} = \{q_h \& E, q_h \& E\}$, that is, there is a quality reversal. Both firms export to the distant markets. Prices are given by

$$p_h(s^{33}) = \frac{\bar{\theta}\lambda q_\ell(\mu - 1)(4\mu(\lambda + m) + (1 - \lambda))}{2(4\mu - 1)(m + \lambda)}, \quad p_h^*(s^{33}) = \frac{\bar{\theta}q_\ell(\mu - 1)(4\mu(\lambda + m) - m(1 - \lambda))}{2(4\mu - 1)(m + \lambda)}$$

$$p_\ell^*(s^{33}) = \frac{\bar{\theta}\lambda(1 + m)(\mu - 1)q_\ell}{(4\mu - 1)(m + \lambda)} = p_\ell(s^{33})$$

and the revenues of the firms are

$$R(s^{33}) = \frac{\bar{\theta}\lambda m q_\ell(\mu - 1)[4\mu(m + \lambda) + (1 - \lambda)]^2}{4(m + \lambda)^2(4\mu - 1)^2} + \frac{\bar{\theta}q_\ell(\mu - 1)[4\mu(m + \lambda) - m(1 - \lambda)]^2}{4(m + \lambda)^2(4\mu - 1)^2};$$

¹⁹ Notice that low-quality products would be dumped in this equilibrium if $r > 0$ since $p_l > (1 - r)p_l^* = (1 - r)p_l$. This observation reproduces again the notion of domino dumping: Once a country enacts antidumping law, the rival foreign firm that suffers from dumping may give an incentive to its own government to also take an antidumping action.

$$(23) \quad R^*(s^{33}) = \frac{\bar{\theta}\lambda(1+m)^2\mu(\mu-1)q_\ell}{(m+\lambda)(4\mu-1)^2}.$$

Suppose now firms play strategy $s^{43} = \{q_h \& NE, q_\ell \& E\}$. Prices would be given by

$$p_h(s^{43}) = \frac{\bar{\theta}\lambda q_\ell(\mu-1)[2(m+\lambda)\mu + (1-2\lambda)]}{(m+\lambda)(4\mu-1) - 3\lambda}, \quad p_\ell^*(s^{43}) = \frac{\bar{\theta}\lambda(2+m)(\mu-1)q_\ell}{(m+\lambda)(4\mu-1) - 3\lambda}$$

and the revenue expressions by

$$R(s^{43}) = \frac{\bar{\theta}\lambda m(\mu-1)q_\ell[2(m+\lambda)\mu + (1-2\lambda)]^2}{[(m+\lambda)(4\mu-1) - 3\lambda]^2}; \quad R^*(s^{43}) = \frac{\bar{\theta}\lambda(2+m)^2 q_\ell(\mu-1)[(m+\lambda)\mu - \lambda]}{[(m+\lambda)(4\mu-1) - 3\lambda]^2}.$$

Suppose finally that firms play the strategy $s^{34} = \{q_h \& E, q_\ell \& NE\}$. Prices would be given by

$$p_\ell^*(s^{34}) = \frac{\bar{\theta}(\mu-1)q_\ell}{4\mu-1}; \quad p_h^*(s^{34}) = \frac{2\bar{\theta}q_h(\mu-1)}{4\mu-1}$$

and the revenues of the firms by

$$(24) \quad R(s^{34}) = \frac{1}{4}m\lambda\bar{\theta}q_\ell\mu + \frac{4\bar{\theta}\mu^2(\mu-1)q_\ell}{(4\mu-1)^2}; \quad R^*(s^{34}) = \frac{\bar{\theta}q_\ell\mu(\mu-1)}{(4\mu-1)^2}.$$

6.2. Nash Equilibria. Having computed the profits of the firms under the different strategy profiles, we are now in a position to analyze the game described in Table 4. The objective is to search for all Nash equilibria of the continuation game between the two firms and study the conditions for their existence. There are five possible Nash equilibria, namely:

- s^{11} : under this strategy profile, the market structure remains unchanged. That is, the domestic firm continues to select the low-quality product and exports it to the foreign country; meanwhile the foreign firm chooses the high-quality product and exports it to the home country.
- s^{12} : under this strategy profile, the foreign firm selects the high-quality product but chooses to strategically exit the domestic market; meanwhile the home firm continues to choose the low quality and exports it to the foreign market.
- s^{21} : under this strategy profile, the domestic firm continues to pick the low-quality product but chooses to strategically exit the foreign market; meanwhile the foreign firm continues to choose high quality and exports it to the foreign market.
- s^{33} : under this strategy profile, a quality reversal occurs. The home firm chooses high quality and exports it to the foreign market; meanwhile, the foreign firm chooses low quality and exports it to the home market.
- s^{34} : under this strategy profile, a quality reversal occurs and in addition the foreign firm exits the home market.

To illustrate how existence conditions are computed, let us focus on the strategy profile $s^{11} = \{q_\ell \& E, q_h \& E\}$.²⁰ To establish when s^{11} is a Nash equilibrium, it is sufficient to compare $R^*(s^{11})$

²⁰ Existence conditions for other equilibria are computed similarly and all necessary derivations are provided in the Appendix S1 (Supporting Information).

FIGURE 1

EXISTENCE REGIONS FOR THE DIFFERENT TYPES OF EQUILIBRIA

with $R^*(s^{12})$ and $R(s^{11})$ with $R(s^{21})$ since payoffs from other strategies are strictly dominated. Using (20), (21), and (22), comparisons lead to the following:

$$(25) \quad R^*(s^{11}) > R^*(s^{12}) \text{ if and only if } \lambda > \frac{1}{2+m}$$

$$(26) \quad R(s^{11}) > R(s^{21}) \text{ if and only if } (\lambda + m)(4\mu - 1)(4\mu - 7) + 9\lambda > 0.$$

When these two conditions are met, an equilibrium where firms play s^{11} exists.

Figure 1 gives a summary of our findings. It illustrates the combinations of parameters m and λ for which each of these equilibria exists. The size of the different existence regions depends on the magnitude of the quality gap μ . Panel A of Figure 1 gives the existence regions for $\mu = 1.5$, whereas Panel B does so for $\mu = 5$. Consider the left panel first and suppose that λ is small. The foreign firm then prefers to exit the domestic market altogether and focus its activity on its own market. By doing so, it avoids the PU constraint, which increases the profits it derives from its local consumers. There are two Nash equilibria in that case, s^{12} and s^{34} , the difference between them being the identity of the firm choosing high quality. To select among them, we can apply the Harsanyi–Selten criterion of Section 4, and it turns out that s^{34} risk-dominates equilibrium s^{12} .²¹ This implies that enacting an AD policy leads to a quality reversal when λ is small.

²¹ Let $G_{11} = R(s^{12}) - \frac{\bar{\theta}\lambda mq_h}{4} + \frac{c}{2}(q_h^2 - q_\ell^2)$ be the gains the domestic firm obtains by predicting correctly that the foreign firm will select equilibrium s^{12} . Likewise, $G_{12} = R(s^{34}) - \frac{\bar{\theta}\lambda mq_\ell}{4} - \frac{c}{2}(q_h^2 - q_\ell^2)$ denotes the gains the domestic firm derives by forecasting correctly that the foreign firm will select equilibrium s^{34} . Similarly, for the foreign firm we have $G_{21} = R^*(s^{12}) - \frac{c}{2}(q_h^2 - q_\ell^2)$ and $G_{22} = R^*(s^{34}) + \frac{c}{2}(q_h^2 - q_\ell^2)$. Equilibrium s^{12} is said to risk-dominate equilibrium s^{34} whenever $G_{11}G_{21} - G_{12}G_{22} > 0$. Using the expressions above, we obtain

$$\frac{4(4\mu - 1)^2}{\bar{\theta}q_\ell^2\mu(\mu - 1)^2(4\mu + 1)} [G_{11}G_{21} - G_{12}G_{22}] = 2cq_\ell(1 - \gamma)(1 + \mu) - \bar{\theta}\lambda m.$$

When λ is relatively large and m intermediate, two equilibria, namely, s^{11} and s^{33} , emerge. Under s^{11} , the equilibrium is similar to free trade in that the market structure remains unchanged. Under s^{33} there is a quality reversal. We can again invoke the Harsanyi–Selten criterion to select among these two equilibria, though we can only do so numerically. It turns out that s^{11} risk-dominates s^{33} . For higher m only s^{33} is a Nash equilibrium. Finally, when both λ and m are large, we also have two equilibria (s^{21} and s^{33}).

The right panel gives the existence regions for $\mu = 5$ instead. The implication of a rise in μ is to reduce the number of possible equilibria with s^{34} being the unique equilibrium for relatively low λ and moderate to large m .

To summarize, we emphasize three important points. First, imposing a PU dramatically changes the nature of the game, and this gives rise to new and interesting equilibria. Second, unlike under free trade, for some parameter combinations there is a unique Nash equilibrium. One way to interpret this outcome is in terms of AD policy operating as an equilibrium selection mechanism. The final important point is that *a quality reversal may be the natural equilibrium outcome* following the imposition of a PU.

6.3. Antidumping Policy. Having determined the conditions for existence of each Nash equilibrium of the continuation game between the two firms, the important task of this section is to characterize the impact of an AD policy on the nature of the trade equilibrium and determine whether it is welfare improving for the domestic economy to implement it.

6.3.1. Unchanged market structure. Suppose that the parameters of the model are such that, after a price undertaking, s^{11} is a Nash equilibrium. In order to check whether the domestic country indeed wishes to impose a PU, we compute the difference between domestic welfare in this equilibrium, denoted $W(s^{11})$, and that under free trade, denoted $W(FT)$. The comparison gives

$$(27) \quad \frac{2(m + \lambda)^2(4\mu - 1)^2}{\theta(1 - \lambda)m\mu q_\ell(\mu - 1)} [W(s^{11}) - W(FT)] = -2m - \lambda [4(2m - 1)\mu + 5] \\ - 3\lambda^2(4\mu - 1) < 0,$$

where the sign follows because the first and third terms are negative and for the second term we can prove that $4(2m - 1)\mu + 5 > 4(2m - 1) + 5 = 8m - 4 + 5 > 0$. Then:

PROPOSITION 5. *If the domestic government introduces a PU and the Nash equilibrium that ensues has the foreign (home) firm continue to produce high (low) quality and export it to the home (foreign) country, then the PU results in (i) an increase in the (hedonic) prices of both variants in the domestic country. (ii) a decrease in (hedonic) prices of both variants in the foreign country. (iii) a decrease in profits of both firms, and (iv) a decrease in domestic consumer surplus. As a result, the domestic government has no incentive to introduce a PU, no matter whether it is a pro-industry or a pro-welfare government. In this situation, high-quality products continue to be dumped into the domestic economy.*

The existence conditions and the proofs of the propositions that follow are given in the online Appendix S1. The price undertaking works so as to level off the two markets, and as a result domestic prices go up, foreign prices go down, and firms profits decrease. Because of the price increase in the domestic market, domestic consumer surplus decreases. These two facts together (profits and consumer surplus decrease) explain the welfare result.

Proposition 3 pointed to there being many antidumping cases in developing countries against higher-quality products from the rest of the world. This is simply not the case in the data:

This condition does not only depend on cost differences but on cost levels. Given our small investment costs assumption, s^{34} risk-dominates equilibrium s^{12} .

Though the number of AD initiations is large, imports concerned represent a small fraction of trade of developing countries. Proposition 5 offers an explanation for this outcome: An AD law would simply be welfare reducing, which makes the tolerance of dumping socially desirable.

6.3.2. Strategic exit of the foreign firm. Suppose now that the parameters of the model are such that, after a price undertaking, the domestic firm continues to pick the low-quality product and exports it to the foreign country, whereas the foreign firm chooses the high-quality product and ceases to export it to the home country. Then:

PROPOSITION 6. *If the domestic government introduces a PU and the Nash equilibrium that follows is such that the foreign firm continues to produce high quality but ceases to export it to the home country, then the PU results in (i) an increase in the (hedonic) price of low quality in the domestic economy (prices in the foreign market remain constant), (ii) a decrease in domestic consumer surplus, (iii) an increase in profits of the home firm, and (iv) a decrease in domestic welfare. As a result, a pro-industry government ($\beta_1 = 0, \beta_2 = 1$) has an incentive to introduce a PU.*

The intuition behind these results is as follows: Since the foreign firm exits the domestic market so as to avoid the PU, prices in the foreign market become equal to the free trade prices. In the domestic market, however, the home firm charges the monopoly price and therefore its profits increase and domestic consumer surplus decreases. As is usual in situations with market power, the increase in profits does not offset the fall in consumer surplus, and social welfare decreases. As a result, a PU that causes the exit of the foreign firm from the domestic market can only be the outcome of successful lobbying by the domestic firm.

6.3.3. Strategic exit of the home firm. Suppose the parameters of the model are such that the equilibrium that ensues after the home government imposes a PU has the home firm exiting the foreign market, whereas the foreign firm continues to export its product to the domestic country. Then:

PROPOSITION 7. *If the domestic government introduces a PU and the home firm exits the foreign market, then the PU results in (i) an increase in the (hedonic) prices of low and high quality in the domestic economy, (ii) a decrease in domestic consumer surplus; (iii) an increase in profits of the home firm if*

$$(28) \quad \lambda m(1+m)^2(4\mu-1)^2 - [4\lambda(\mu-1) + m(4\mu-1)]^2(1+\lambda m) > 0,$$

and (iv) a decrease in domestic welfare. As a result, a pro-industry government ($\beta_1 = 0, \beta_2 = 1$) has an incentive to introduce a PU when (28) holds.

The home firm may take advantage of the fact that a PU is in place by strategically exiting the foreign market. By doing so, it induces the foreign firm to raise its price in its local market and, by the PU restriction, in the home market too. It turns out that profits of the home firm may or may not increase. Since the price it charges domestically increases, profits tend to increase; however, exiting from the foreign market altogether lowers its profits too. Only when (28) holds will home firm profits go up. Domestic consumer surplus decreases and overall welfare too.

6.3.4. Quality reversal and intra-industry trade. Let us now consider the situation where the parameters of the model are such that a PU leads to a quality reversal in the marketplace, that is, the shift of quality leadership from the foreign to the domestic firm.

PROPOSITION 8. *If the domestic government introduces a PU and the home firm chooses to produce the high-quality product and export it to the foreign country, whereas the foreign firm*

FIGURE 2
PERCENTAGE WELFARE GAIN UNDER QUALITY REVERSAL EQUILIBRIUM s^{33}

produces the low-quality product and exports it to the home country, then the PU results in (i) intra-industry trade with no negative effect on world trade, (ii) an increase in the domestic (hedonic) prices of all qualities, (iii) a decrease in domestic consumer surplus, (iv) a substantial increase in profits of the home firm, and (v) an increase in the welfare of the domestic country. As a result, both a pro-industry and a pro-welfare government have an incentive to introduce a PU. World welfare decreases though.

In this case, the constraint on the foreign firm raises the prices paid for low quality in the domestic and the foreign countries. Prices of high quality follow suit. Domestic consumer surplus under s^{33} decreases for two reasons. First, home consumers pay a higher price for all product variants. Second, fewer consumers demand the low-quality good since the hedonic price p_ℓ/q_ℓ increases. However, the reversal has a substantial impact on domestic firm profits, which more than offsets the negative impact on consumers and ultimately results in an increase in social welfare.

Figure 2 illustrates the percentage gain in (unweighted) welfare resulting from the quality reversal as a function of m and λ , compared to free trade. Parameters are $\theta = 1$, $\mu = 6$, $q_\ell = 0.05$. The light-shaded area gives the percentage gain for all possible (m, λ) combinations; the darker area gives the percentage gain obtained when parameters are such that the equilibrium exists. The figure first shows that for this equilibrium to exist, countries' income differences have to be relatively small; in addition, the figure reveals that the effect of a PU on welfare is very large. Therefore, under the conditions in Proposition 8 the domestic government has a strong incentive to impose a PU.

6.3.5. *Quality reversal and exit of the foreign firm.* Finally, assume the parameters of the model are such that after the imposition of a PU the home firm chooses to produce the

TABLE 6
TYPES OF ANTIDUMPING MEASURES¹

AD measure	Argentina	S. Africa
PU ²	69.1	0.0
AD duty ³	30.9	100.0

¹Percentages. ²Price undertakings include cases where a duty is imposed if the price falls under a specific level. ³Duty includes specific and ad valorem duties.

SOURCE: Own calculations based on the Global Antidumping Database (Bown, 2010)

high-quality product and exports it to the foreign country, whereas the foreign firm picks the low-quality products and ceases exporting to the home country. Then:

PROPOSITION 9. *If the domestic government introduces a PU and the foreign firm chooses to produce low quality and refrains from exporting it to the home market, whereas the domestic firm picks high quality and exports it to the foreign market, then the PU results in (i) an increase in the domestic (hedonic) price of high quality, whereas foreign prices remain constant; (ii) a decrease in domestic consumer surplus; (iii) an increase in the profits of the home firm; and (iv) an increase in social welfare provided that*

$$(29) \quad 8(\mu - 1) + \lambda m(8\mu - 11) > 0.$$

As a result, a pro-industry government has an incentive to introduce a PU; a pro-welfare government has also incentives to introduce a PU provided the parameters of the model satisfy (29). World welfare decreases though.

Since the home firm is the only seller in the domestic market, it is clear that the domestic price of high quality is higher than under free trade. In the foreign market, since the foreign firm is not constrained by the PU, prices are exactly the same as under free trade. As a result, it is clear that the domestic firm obtains higher profits but consumers obtain a lower surplus. The welfare effect is, however, ambiguous. Although consumers lose, the home firm revenues increase a lot since after the policy it becomes the high-quality producer.

7. EXTENSIONS

In this section, we extend the model in two important ways. First, we examine the issue of *free price undertakings*. Second, we allow firms to select product quality from a continuum, so quality *levels* become endogenous.

7.1. Free Price Undertakings. Proposition 4 would point to there being an equal use of AD instruments. This is simply not the case in the data, as Table 6 shows. Whereas Argentina has applied a PU in 69.1% of imposed measures, South Africa relies exclusively on antidumping duties (Bown, 2010). What are the factors that are conducive to this unequal use of AD instruments? We explain this inequality in terms of the difference between FPUs and PUs and refer to our welfare function in (4). FPUs are unconstrained government-tolerated price agreements between the firms involved in a dumping case. Hence, firm prices will typically be collusive; moreover, because FPUs are generally sponsored by the government, they typically escape antitrust control. As they give firms the possibility to collude in the home market, FPUs are preferable to PUs for firms. In contrast, a welfarist government will not prefer FPUs over PUs since consumer surplus will decrease as a result of the collusive prices. Hence, only governments conferring greater importance to firm profits than to consumer surplus will select FPUs, as opposed to AD duties or the equivalent PUs.

Suppose the domestic and foreign firms choose their prices in the domestic market in order to maximize their joint profits subject to the constraint that the dumping margin at home is removed and no new dumping is created abroad. The solution involves the monopolization of the domestic market, and it is straightforward to show that, depending on the magnitude of λ , there are two possible sets of equilibrium prices. Suppose first that λ is relatively large, particularly $\lambda > 4(\mu - 1)/(4\mu - 1)$. In this case, the constraint $p_h \geq p_h^*$ is not binding and the domestic and foreign firms maximize joint profits by selling only high quality in the domestic market at the monopoly price of $p_h = \lambda\bar{\theta}\mu q_\ell/2$ while, abroad, the prices continue to be the free trade equilibrium prices given in (6). The corresponding joint profits in the home country are equal to $m\lambda\bar{\theta}\mu q_\ell/4$ while the profits of the firms in the foreign country are $\tilde{R} = \frac{\bar{\theta}\mu(\mu-1)}{(4\mu-1)^2}$ and $\tilde{R}^* = \frac{4\bar{\theta}\mu^2(\mu-1)q_\ell}{(4\mu-1)^2}$. Suppose now that λ is small instead, in which case the solution above does not eliminate the dumping margin at home, and firms have to maximize joint profits under the binding constraint $p_h = p_h^*$. In this case, again, only high quality is sold in the domestic market at a price of $\lambda\bar{\theta}q_h/2$, whereas low quality sells at a price $\lambda\bar{\theta}q_\ell/4$ in the foreign country. Firms obtain joint profits in the home country equal to $m\lambda\bar{\theta}\mu q_\ell/4$ whereas profits in the foreign country are equal to $\tilde{R} = \frac{\lambda^2\bar{\theta}\mu q_\ell}{16(\mu-1)}$ and $\tilde{R}^* = \frac{\lambda\bar{\theta}\mu(2(2-\lambda)\mu-(4-\lambda))q_\ell}{8(\mu-1)}$.

The monopoly profit is always above the sum of the duopoly profits no matter the equilibrium that would ensue in case of a disagreement. Hence, for some of the Nash equilibria we have derived above, it is obvious that there exist multiple monopoly profit allocations that will be acceptable for both firms. In order to pin down a specific profit split we can invoke the Nash bargaining solution. To illustrate, let us suppose, for example, that the disagreement (or threat) point is the equilibrium s^{12} , in which case firms obtain payoffs $\{R(s^{12}), R^*(s^{12})\}$. Note that this equilibrium would only ensue if the government were pro-industry. Denote by $\Pi_m = m\lambda\bar{\theta}q_h/4$ the joint profit firms would obtain in the domestic market if they collude. In that case, the monopoly split $\{\pi_m, \pi_m^*\}$ is a bargaining Nash equilibrium if and only if it solves the following problem:

$$\max_{\{\pi_m, \pi_m^*\}} (\pi_m + \tilde{R} - R(s^{12})) (\pi_m^* + \tilde{R}^* - R^*(s^{12}))$$

subject to

$$\pi_m + \tilde{R} \geq R(s^{12})$$

$$\pi_m^* + \tilde{R}^* \geq R^*(s^{12})$$

$$\pi_m + \pi_m^* \leq \Pi_m.$$

The same analysis can be done for the four other equilibria as well. Therefore:

PROPOSITION 10. *When $\beta_1 = 0$ in (4), the home government prefers an FPU undertaking because it always generates higher profits for the local firm.*

FPU always result in higher profits for the domestic firm, at the expense of local consumers. Governments concerned only about firm profits will therefore prefer private settlements over AD duties.

The literature has advanced other (dis)advantages of the use of PUs versus AD duties. Nakagawa (2006) mentions that the costs of implementing AD duties are nontrivial, while price undertakings are cheaper to adopt and monitor. Prusa (1992) indicates that the final injury determination is typically quite uncertain, in which case firms prefer a PU over AD duties. In contrast, Zanardi (2004) argues that coordination costs of a PU can be so high that an AD duty is preferable. The exchange rate regime should matter as well since the exchange rate pass-through of oligopolistic firms depends on the type of product and on the underlying market structure (Dornbusch, 1987). With a high exchange rate volatility, the timing of investigations

matters and information acquisition becomes costly under a PU. Moreover, the likelihood of deviations from pricing rule (15) is high, in which case AD duties would be collected.²²

7.2. Endogenous Quality. In the previous analysis, we chose to work with exogenous quality levels in order to illustrate the main insights in the simplest setting. The main purpose of this extension is to demonstrate that our earlier results are not undermined when quality levels are chosen by the firms. Even though it would be possible to replicate the entire analysis with endogenous quality levels, let us focus here on two issues. First, we illustrate how the free trade equilibrium is obtained when qualities can be chosen from a continuum. Then, we show that for some parameters the domestic government would find it desirable to impose a PU in order to induce a quality reversal.

In this section, 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. This idea is modeled via the following specification of R&D costs: Domestic firm's costs of producing any two variants q_ℓ and q_ℓ^* are $C(q_\ell, q_\ell^*) = c \max\{q_\ell, q_\ell^*\}^2/2$; likewise, foreign firm costs of producing variants q_h and q_h^* are given by $C^*(q_h, q_h^*) = c^* \max\{q_h, q_h^*\}^2/2$, where c and c^* are the usual development cost parameters measuring R&D efficiency. This assumption serves to rule out quality strategy profiles where a firm sells different qualities locally and abroad. Because of the presence of (nontrivial) development costs, we shall now use the weighted sum of consumer surplus and firms' profits π as a measure of social welfare in every country: $W = \beta_1 CS + \beta_2 \pi$, $\beta_j \in \{0, 1\}$, $j = 1, 2$.

The derivation of the free trade equilibrium follows the steps in Section 4, with the additional choice-of-quality stage. The first step is to show that nonexporting strategies are strictly dominated. This implies that in equilibrium there is intra-industry trade. To select among the two possible quality assignments, we use again the Harsanyi–Selten criterion. The next proposition gives the result (for the proof, see our working paper Moraga-González and Viaene, 2007).

PROPOSITION 11. *With endogenous qualities, the unique (risk-dominant) free trade equilibrium of the export game involves intra-industry trade and is characterized as follows: (i) Goods sell at prices (5) and (6), (ii) market demands for firms are (7), (iii) the quality gap between the variants μ is the solution to*

$$(30) \quad \frac{4(4\mu^2 - 3\mu + 2)}{\mu^2(4\mu - 7)} = \frac{c^*}{c},$$

(iv) the home firm produces a good of quality

$$(31) \quad q_\ell = \frac{\bar{\theta}(1 + m\lambda)}{c} \frac{\mu^2(4\mu - 7)}{(4\mu - 1)^3}$$

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

$$(32) \quad q_h = \frac{4\bar{\theta}(1 + m\lambda)}{c^*} \frac{\mu(4\mu^2 - 3\mu + 2)}{(4\mu - 1)^3}$$

²² Since there are two policy instruments for choice, a PU and an AD duty, it is possible to implement a formal policy game where policy-imposing governments can freely pick between the two instruments. There would be four continuation games, each of them corresponding to a different instrument strategy profile. With an asymmetry in implementation costs, we could compute a refined equilibrium in instruments like we did in Table 3.

for its own market and for exports, and (vi) domestic firm's profits are $\pi = c^* q_\ell q_h / 8$, foreign firm's profits $\pi^* = 2c q_\ell q_h$ with $\pi^* / \pi = 16c / c^*$.

Observe that in this free trade equilibrium, variable μ is the unique solution to the third-degree polynomial in (30). It depends on firms' development costs but is independent of λ and m . As prices are similar to those of Proposition 2, Proposition 3 characterizes the conditions for dumping in this context as well.

Let us now show that the strategies s^{34} continue to constitute an equilibrium after a PU is imposed. Recall that under s^{34} , the home firm "leapfrogs" the foreign firm and produces a product of endogenous higher quality; meanwhile the foreign firm finds it profitable to exit the domestic market. Let us fix $\lambda = 0.2$, $m = 0.5$, $c = 1$, $c^* = 0.85$, and $\bar{\theta} = 100$. Solving for the free trade equilibrium, one obtains $q_h = 32.68$ and $q_\ell = 5.51$, with $\mu = 5.93$. Firms' profits are given by $\pi = 19.15$ and $\pi^* = 360.42$, with domestic social welfare $W = 73.07$.

Under the strategies s^{34} , the domestic firm picks q_h to maximize $\pi = R(s^{34}) - c q_h^2 / 2$, and the foreign firm chooses q_ℓ to maximize $\pi^* = R^*(s^{34}) - c^* q_\ell^2 / 2$, where $R(s^{34})$ and $R^*(s^{34})$ are given in (24). Taking the FOCs with respect to quality levels and solving gives $q_h = 27.87$ and $q_\ell = 5.57$, with $\mu = 5$. Firms' profits are given by $\pi = 298.92$ and $\pi^* = 17.68$, with domestic social welfare $W = 347.17$.

These results clearly show that imposing a PU is incentive compatible provided that the equilibrium that ensues is s^{34} . To see whether deviations are profitable, we ask whether any of the firms wishes to pick another quality level and export strategy. Given the strategy of the foreign firm, q_ℓ & NE, it is readily seen that the home firm does not wish to deviate because by doing so its profits unambiguously fall. To see whether, given the strategy of the home firm, q_h & E, the foreign firm wishes to deviate, we first consider the case where it deviates to strategy $\{q_\ell$ & E $\}$. In this case, it would obtain a deviating payoff equal to $\pi^{*d} = R^*(s^{33}) - c^* q_\ell^2 / 2$, where the expression for $R^*(s^{33})$ is given in (23) and q_h is fixed to 27.87 in the deviation. Maximizing profits with respect to q_ℓ gives $q_\ell = 3.96$ and a deviating profit equal to $\pi^{*d} = 8.01$. As a result, the deviation is not profitable.

Finally, we check whether the foreign firm wants to deviate to $\{q_h$ & E $\}$, in which case it jumps over the quality of the home firm in the putative equilibrium. In that case, it would obtain a deviating payoff equal to $\pi^{*d} = R^*(s^{11}) - c^* q_h^2 / 2$, where $R^*(s^{11})$ is given in (20) and q_ℓ would be fixed to 27.87 in the deviation. Maximizing profits with respect to q_h gives $q_h = 0$ and a deviating profit equal to $\pi^{*d} = 0$. As a result, the deviation is not profitable.

With these calculations, we conclude that for the chosen parameters (which clearly fall in the s^{34} -labeled region of Figure 1), the equilibrium described by Proposition 9 remains true for the cases when firms are allowed to choose their quality levels.

8. CONCLUSION

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 always takes place. With transport costs, reciprocal dumping may emerge. In the context of dumping of high-quality products, we have studied the incentives of the domestic firm to file a petition for an antidumping action and of the domestic government to honor it.

Our main result is that a PU may lead 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 impose a PU. A PU may also lead to the exit of the foreign firm, which favors the domestic one and thereby helps explain why there is so much lobbying by domestic firms for antidumping regulations. When AD duties are considered instead, an equivalence result between AD duties and a PU is obtained as long as we abstract from transaction costs and collusion among firms.

Though the focus of the article has been on unilateral dumping cases, we showed situations in which reciprocal dumping would be prevalent under free trade. Moreover, we encountered cases of domino dumping, that is, situations where once a country enacts antidumping law it triggers dumping by its own firm on foreign markets. Further work could include strategic policy games between governments with opposite incentives. The welfare implications of AD law in these cases are still unknown. Finally, key questions related to the equivalence between antidumping instruments remain unanswered. A formal game between governments is one way to endogenize the choice of AD instruments and to uncover when this equivalence fails.

Of course, an important issue is to establish the empirical relevance of our results. As mentioned above, there is plenty of empirical evidence supporting the main features of the model analyzed here. Also, it is well known that governments have traditionally used and continue to use an array of trade and industrial policy instruments to support local producers. For members of the WTO, market protection via tariff barriers is nowadays limited; in contrast, antidumping measures whose application is governed by the WTO are not. The main hypothesis of this article is that antidumping 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 antidumping measures with recent databases like the “Analytical Database on International Trade (BACI)” of CEPII,²³ which explicitly accounts for intra-industry trade in vertically differentiated products, may allow for the empirical testing of the various conclusions of the model.

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix S1.

REFERENCES

- ANDERSON, E. J., “Domino Dumping I: Competitive Exporters,” *American Economic Review* 82 (1992), 65–83.
- , “Domino Dumping II: Antidumping,” *Journal of International Economics* 35 (1993), 133–50.
- ANDERSON, S., N. SCHMITT, AND J.-F. THISSE, “Who Benefits from Antidumping Legislation?” *Journal of International Economics* 38 (1995), 321–37.
- ANDERTON, B., “Innovation, Product Quality, Variety and Trade Performance: An Empirical Analysis of Germany and the UK,” *Oxford Economic Papers* 51 (1999), 152–67.
- AOKI, R., AND T. J. PRUSA, “Sequential versus Simultaneous Choice with Endogenous Quality,” *International Journal of Industrial Organization* 15 (1997), 103–21.
- BASTOS, P., AND J. SILVA, “The Quality of a Firm's Exports: Where You Export Matters,” *Journal of International Economics* 82 (2010), 99–111.
- BECKER, G. S., “A Theory of Competition among Pressure Groups for Political Influence,” *Quarterly Journal of Economics* 98 (1983), 371–400.
- BILS, M., AND P. J. KLENOW, “Quantifying Quality Growth,” *American Economic Review* 91 (2001), 1006–30.
- BLONIGEN, B. A., AND T. J. PRUSA, “Antidumping,” in E. K. Choi and J. Harrigan, eds., *Handbook of International Trade* (Oxford, UK and Cambridge, MA: Blackwell Publishing, 2003), 251–84.

²³ See <http://www.cepii.fr/anglaisgraph/bdd/baci.htm>.

- BORRUS, M., L. D. TYSON, AND J. ZYSMAN, "Creating Advantage: How Government Policies Shape International Trade in the Semiconductor Industry," in P. R. Krugman, ed., *Strategic Trade Policy and the New International Economics* (Cambridge, MA: MIT Press, 1986), 91–113.
- BOWN, C. P., "Global Antidumping Database," Mimeo, Development Research Group, World Bank, 2010.
- BRANDER, J. A., AND P. R. KRUGMAN, "A 'Reciprocal Dumping' Model in International Trade," *Journal of International Economics* 15 (1983), 313–23.
- BRUTTON, H. J., "A Reconsideration of Import Substitution," *Journal of Economic Literature* 36 (1998), 903–36.
- CROZET, M., AND H. ERKEL-ROUSSE, "Trade Performances, Product Quality Perceptions, and the Estimation of Trade Price Elasticities," *Review of International Economics* 12 (2004), 108–29.
- DORNBUSCH, R., "Exchange Rates and Prices," *American Economic Review* 77 (1987), 93–106.
- EATON, B. C., AND N. SCHMITT, "Flexible Manufacturing and Market Structure," *American Economic Review* 84 (1994), 875–88.
- ETHIER, W. J., AND R. D. FISCHER, "The New Protectionism," *Journal of International Economic Integration* 2 (1987), 1–11.
- EUROPEAN COMMUNITY, *Twentieth Annual Report from the Commission to the European Parliament on the Community's Antidumping and Anti-Subsidy Activities*, Brussels, http://trade.ec.europa.eu/doclib/docs/2004/january/tradoc_112241.pdf, 2002.
- FALVEY, R., "Commercial Policy and Intra-Industry Trade," *Journal of International Economics* 11 (1981), 495–511.
- FEENSTRA, R. C., *Advanced International Trade: Theory and Evidence* (Princeton: Princeton University Press, 2004).
- GATT, *Trade Policy Review: The European Communities* (Geneva: GATT, 1991), Volume 2.
- GAULIER, G., AND S. ZIGNAGO, "BACI: International Trade Database at the Product-level. The 1994–2007 Version," Working Paper No. 2010-23, CEPII-Paris, 2010.
- HALLACK, J. C., "Product Quality and the Direction of Trade," *Journal of International Economics* 68 (2006), 238–65.
- , AND P. SCHOTT, "Estimating Cross-Country Differences in Product Quality," *Quarterly Journal of Economics* 126 (2011), 417–74.
- HARSANYI, J. C., AND R. SELTEN, *A General Theory of Equilibrium in Games* (Cambridge, MA: MIT Press, 1988).
- HERGUERA, I., P. KUJAL, AND E. PETRAKIS, "Tariffs, Quality Reversals and Exit in Vertically Differentiated Industries," *Journal of International Economics* 58 (2002), 467–92.
- HORN, H., "National Treatment in the GATT," *American Economic Review* 96 (2006), 394–404.
- HUGHES, J. S., S. LENWAY, AND J. RAYBURN, "Stock Price Effects of U.S. Trade Policy Responses to Japanese Trading Practices in Semi-Conductors," *Canadian Journal of Economics* 30 (1997), 922–42.
- KRISHNA, K., "Tariffs versus Quotas with Endogenous Quality," *Journal of International Economics* 23 (1987), 97–122.
- LEE, K., AND C. LIM, "Technological Regimes, Catching-Up and Leapfrogging: Findings from the Korean Industries," *Research Policy* 30 (2001), 459–83.
- LEIDY, M. P., AND B. M. HOEKMAN, "Production Effects of Price and Cost-based Antidumping Laws under Flexible Exchange Rates," *Canadian Journal of Economics* 23 (1990), 873–95.
- LU, Z., "Learning to Use WTO Rules for Protection," *China Daily* (2004), July 6.
- MAUR, J.-C., AND P. A. MESSERLIN, "Antidumping in Supercomputers or Supercomputing in Antidumping? The Cray-Nec Case," Mimeo, Institut d'Etudes Politiques de Paris, 1999.
- MORAGA-GONZÁLEZ, J. L., AND J.-M. VIAENE, "Trade Policy and Quality Leadership in Transition Economies," *European Economic Review* 49 (2005), 359–85.
- , AND ———, "Anti-Dumping, Intra-Industry Trade and Quality Reversals," Discussion Paper TI 2004-124/2, Tinbergen Institute, Netherlands (<http://www.tinbergen.nl/moraga/ADpolicy.pdf>), 2007.
- MOTTA, M., J.-F. THISSE, AND A. CABRALES, "On the Persistence of Leadership or Leapfrogging in International Trade," *International Economic Review* 38 (1997), 809–24.
- MUSSA, M., AND S. ROSEN, "Monopoly and Product Quality," *Journal of Economic Theory* 18 (1978), 301–17.
- NAKAGAWA, J., "Argentina," in J. Nakagawa, ed., *Antidumping Laws and Practices of the New Users* (London: Cameron May, 2006).
- NIELS, G. T., "A Political Economy Assessment of Antidumping Policy in Mexico," Ph.D. Thesis, Erasmus University Rotterdam, 2004.
- PANAGARIYA, A., AND P. GUPTA, "Anti-dumping Duty versus Price Negotiations," *World Economy* 21 (2002), 1003–19.
- PRUSA, T. J., "Why Are So Many Antidumping Petitions Withdrawn?" *Journal of International Economics* 33 (1992), 1–20.
- REITZES, J. D., "Antidumping Policy," *International Economic Review* 34 (1993), 745–63.

- SAGGI, K., AND N. SARA, "National Treatment at the WTO: The Roles of Product and Country Heterogeneity," *International Economic Review* 49 (2008), 1365–94.
- SHAKED, A., AND J. SUTTON, "Natural Oligopolies and International Trade," in H. Kierzkowski, ed., *Monopolistic Competition and International Trade* (Oxford: Oxford University Press, 1984).
- STAIGER, R. W., AND F. A. WOLAK, "Measuring Industry Specific Protection: Anti-Dumping in United States," *Brookings Papers on Economic Activity: Microeconomics*, 51 (1994), 51–118.
- TIOLE, J., *The Theory of Industrial Organization* (Cambridge, MA: MIT Press, 1988).
- UNITED STATES INTERNATIONAL TRADE COMMISSION, "Canned Pineapple Fruit from Thailand," USITC Publication No. 3417, Washington DC, 2001.
- , "Certain Folding Metal Tables and Chairs from China," USITC Publication No. 3515, Washington DC, 2002a.
- , "Lawn and Garden Steel Force Posts from China," USITC Publication No. 3521, Washington DC, 2002b.
- , "Certain Color Television Receivers from China and Malaysia," USITC Publication No. 3607, Washington DC, 2003.
- , "Matchbooks from India," USITC Publication No. 4054, Washington DC, 2008.
- VANDEBUSSCHE, H., AND X. WAUTHY, "Inflicting Injury through Product Quality: How E.U. Antidumping Policy Disadvantages European Producers," *European Journal of Political Economy* 17 (2001), 101–16.
- , AND M. ZANARDI, "Antidumping," *Economic Policy* 23 (2008), 94–138.
- , AND ———, "The Chilling Trade Effects of Antidumping Proliferation," *European Economic Review* 54 (2010), 760–77.
- VERHOOGEN, E., "Trade, Quality Upgrading, and Wage Inequality in Mexican Manufacturing Sector," *Quarterly Journal of Economics* 123 (2008), 489–530.
- WEINSTEIN, E. D., "Competition and Unilateral Dumping," *Journal of International Economics* 32 (1992), 379–87.
- ZANARDI, M., "Antidumping Law as a Collusive Device," *Canadian Journal of Economics* 37 (2004), 95–122.
- ZHOU, D., B. J. SPENCER, AND I. VERTINSKY, "Strategic Trade Policy with Endogenous Choice of Quality and Asymmetric Costs," *Journal of International Economics* 56 (2002), 205–32.