TRADE LIBERALIZATION AND THE ROLE OF NON-TARIFFS BARRIERS TO INTERNATIONAL TRADE

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ABSTRACT

The dissertation studies two Non-tariffs Barriers to International Trade (NTBs) as they relate to trade liberalizations. Chapter 1 develops a theoretical model to explain the observed heterogeneity in the adoption of antidumping laws by small developing countries in an environment of multilateral tariff reduction. The analysis is based on a three-stage game of trade policy determination with imperfect competition in differentiated products where the potential lobby for protection is reflected in the government's objective function and where tariffs may be bound due to multilateral trade agreements. This framework implies that the implementation of this administrative protection device is the government's best response when multilateral bound tariffs reach a sufficiently low threshold. The heterogeneity in the adoption decision is explained by the relative size of the domestic market, the degree of product differentiation, and political economy motives.

In chapter 2, I develop a new World Bank database of European standards for electronic products to study the impact of harmonization of product standards on European Union imports. We employ a gravity model to conclude that European Union standards for electronic products that are harmonized to international standards have a positive and significant effect on trade.

Chapter 3 further investigates this finding by decomposing the effect that harmonization entails into the intensive and extensive margins of trade. Using a highly detailed dataset that links U.S. international trade transactions to U.S. firms and a new industry-level database of EU product standards, I find that harmonization increases U.S. exports to the EU and that this increase is due to more U.S. firms entering the EU market -the extensive margin of trade. New entrants to the EU region are drawn mainly from the most productive set of firms already exporting to less stringent markets before harmonization -The extensive margin of trade composition. I also find that harmonization decreases export sales at existing exporters -the intensive margin of trade. These

findings are consistent with a model featuring the role of product standards heterogeneity across market destinations and productivity heterogeneity across firms.

The research and writing of this thesis is dedicated to my lovely wife, my supportive parents, and my wonderful son. Natalia, thank you so much for all your friendship, love, understanding, and support along this long journey. I know I would not have made it without you. I hardly know what to say to my parents, specially my mom: *Esto es por y para ustedes papás!* Least but not last, Juanse you gave me the last push to finish; I love you and I cannot wait to start sharing the incredible journey of your life.

Many thanks,

JOSE DANIEL REYES

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1.1 Introduction

The international trading system placed by the General Agreement on Tariffs and Trade (GATT), and its successor the World Trade Organization (WTO), has resulted in a multilateral tariff reduction around the world. However, concurrently with this trade liberalization episode, Non-Tariff Barriers (NTBs) have surged as a mechanism to protect domestic industries. Among these NTBs, antidumping (AD) has been the preferred protectionism tool. It was originally used primarily by developed countries and later spread out among developing countries (Miranda et. al. (1998), Prusa (2001) and, Zanardi (2004)). The application of the AD procedure, and the subsequent imposition of duties, requires a national AD legislation that must be aligned with the Uruguay Round AD Agreement that entered into force on January 1st 1995.

This paper provides the first theoretical framework to understand the underlying motives that lead developing countries to adopt an AD legislation. The main purpose is to explain the observed heterogeneity in the adoption decision among developing countries in an environment of multilateral trade liberalization. One of the most important insights of the AD literature is that the mere presence of AD legislation can affect the behavior of firms even if no AD duty is ever imposed (Blonigen and Prusa (2001)), thus this model is not about the determinants of the use of AD protection —a murky issue in reality— but is instead about the underlying motives that influence the decision of a country to adopt an AD law in the first place.

AD is an exception to the GATT/WTO principle of non-discrimination. Provided that there is dumping, which is generally defined as exporting below "normal value"[2], and that it causes or threatens material injury to the domestic industry, a country is entitled to levy discriminatory

[1]I am grateful to my main advisor Rod Ludema for guidance and encouragement. I especially thank Maurizio Zanardi and Joao Macieira for helpful comments. This paper has also benefited from discussions with Meredith Crowley, Justin Pierce, Jorge Fernandez and seminar participants at the 2010 Eastern Economic Association Conference. The usual disclaimer applies.

[2]The article VI of the GATT defines normal value as an export price lower that the price charged by the exporter in its own market or as pricing below production cost plus selling, general, and administrative expenses, and profits.

duties on imports. Even though this legal apparatus was intended to deter predatory pricing in international trade, there is a consensus in the AD literature that it has degraded to be a quick and easy way to grant protection from import competition without violating WTO rules. Hence, dumping and injury determination has little connection with the intended economic motives to stop "unfair" trade. As Blonigen and Prusa (2003) argues, AD duties are simply the modern form of protection.

While the developed world has had AD legislation in place for a long time, the past three decades have witnessed an increase in the adoption of AD laws in developing countries. In fact, by the end of the negotiations in the Tokyo Round in 1980, almost all developed countries had enacted AD legislation[3] whereas only 15 developing countries had done so. Figure 1 illustrates the heterogeneity between developing countries in terms of the adoption decision after 1980 and highlights the multilateral trade rounds. Using these data, Vandenbussche and Zanardi (2008) is the only empirical paper that analyzes the determinants of this proliferation of trade protection laws and the observed heterogeneity of the time of the adoption. They employ a duration analysis to find that retaliatory motives, past trade liberalization and, the size of the chemicals sector and the extent of steel imports are positively correlated with the probability of adopting AD legislation.

This paper links the optimal tariff literature with the optimal AD policy literature under the possibility of exogenous multilateral binding tariffs. The analysis is based on a three-stage game of trade policy determination in a small developing economy with imperfect competition in differentiated products. The government chooses whether or not to adopt an AD legislation and sets the domestic tariff, which may be exogenously bound due to multilateral trade agreements, in the first and the second stage, respectively. In the third stage, duopoly competition occurs in a Cournot fashion between the domestic firm and the foreign firm. When setting tariffs, the government takes into account the lobbying pressure for protection that domestic firm can bring to bear.

This simple theoretical framework explains three key elements in the adoption decision in developing countries. First, dumping is a natural strategy of the foreign firm in the sense that it

[3]Spain and Iceland enacted AD legislations in 1982 and 1987, respectively.

always takes place due to three features of the model (proposition 1): cross-country differences in size, the degree of product differentiation, and the extent of tariff protection. Second, progressive multilateral tariff reduction entails the existence of a threshold tariff where the government decides to adopt AD legislation in order to protect the domestic industry from import competition (proposition 2). Third, the observed heterogeneity in the adoption decision is explained by three idiosyncratic factors (proposition 3): political economy motives, the relative size of the domestic economy, and the degree of product differentiation. Countries with high lobbying pressure, relatively large economies, and highly competitive domestic markets, enact AD legislation sooner.

The theoretical AD literature has converged mainly around the determinants of dumping and the process of imposition of AD duties in developed countries[4]. As data on AD duties in developing countries have become available[5], there is a rising interest in empirically studying these topics on developing countries. At the theoretical level, Moraga-González and Viaene (2004) is the only article that addresses the incentives of foreign firms to undertake dumping in developing and transition economies. The authors use a two-country model where trade occurs among oligopolistic firms, which differ in terms of efficiency, in a single quality-differentiated product and countries differ in the distribution of consumer preferences. In this context, dumping always arises and governments have incentives to levy tariff on high-quality imports. They argue that since the implications of this policy —namely the impact on the pricing behavior of exporting firms and the ineffectiveness of the arbitrage of goods— do not stop dumping by the foreign firm, governments must adopt AD laws to counteract the effect of their trade policy. Although this paper provides a complete characterization of the occurrence of dumping in developing countries, the argument for the adoption decision is not the result of comparing the economic gains and losses of market participants of enacting the law but it is just a conjecture from the analytical model. Lastly, the model does not take into account the role of trade liberalization in the adoption decision.

Moore and Suranovic (1994) examines the welfare effects of using AD duties in a trade-liberalizing country. They propose a general equilibrium model with one import and one export

[4]Blonigen and Prusa (2001) provides a review on the relevant AD literature.

[5]Bown (2007) and Zanardi (2004) provides data on the use of AD duties and on the year of adoption on AD legislation among developing countries, respectively.

sector, where tariffs are reduced and an AD duty is simultaneously introduced. The welfare impact depends on the size of the tariff liberalization, the probability that the industry gets AD protection, the size of the AD duty, and the resource cost filling and adjudicating the AD petition. Using a numerical simulation, they generate liberalization scenarios that result in national welfare losses. This article does not address the existence of dumping and assumes that AD protection is triggered by the harm that trade liberalization causes on the domestic firm. There is no explanation of the theoretical motives of enacting AD legislation in the first place.

Anderson et. al. (1995) provides a theoretical explanation about the underlying motives to adopt AD legislation in developed countries. The authors employ a differentiated products oligopoly model to characterize firm rivalry in a two-stage model where governments choose whether or not to impose antidumping laws in the first stage. They assume that markets are separated by a barrier to trade of the same size in each direction, which can be either a transport cost or a tariff. They find that the non-cooperative equilibrium is to not enact AD legislation if governments unilaterally maximize domestic welfare. However, welfare may improve if laws are enacted when the barrier to trade involves a transport cost, but not if the barrier is a tariff. Their analysis differs from my model in at least two dimensions: First, they consider the bilateral decision of adopting trade protection laws in developed countries whereas I focus on the unilateral decision of a developing country. Second, they do not consider the role of trade liberalization in the adoption decision.

This paper is organized as follows. The next section presents a formal overview of the model. In section 3 I analyze trade protection under segmented markets and integrated markets. The equilibrium choice with homogeneous goods and the role of trade liberalization are presented in section 4. In section 5 I explore the determinants of the time pattern of adoption. Concluding remarks are offered in section 6.

1.2 The model

Consider a two-country, two-good model with two identical firms producing a differentiated good. Markets are segmented. Firm 1 is located in the home country whereas firm 2 is located in the foreign country. Countries differ in their market size. The developing country (home) has a

market of size a whereas the developed country (foreign) has a market size of a^*, ($a \leq a^*$). Foreign firm is a monopolist in its local market, but competes with a domestic firm in the home country's market[6]. Let x_i be the quantity of the product manufactured by firm i, $i = \{1, 2\}$, to be sold in the home country. Likewise, x_2^* is the quantity of the product manufactured by firm 2 to be sold in the foreign country. Home (foreign) representative consumer's utility is a quadratic function of the available products in the market x_i, $i = \{1, 2\}$, (x_2^*) and linear in a numeraire good m (m^*).

$$u(x_1, x_2) = a(x_1 + x_2) - \frac{1}{2}(x_1^2 + x_2^2 + 2cx_1x_2) + m \tag{1}$$

$$u(x_2^*) = a^*x_2^* - \frac{1}{2}x^{*2} + m^* \tag{2}$$

Therefore, there are no income effects on the monopolistic sector, and I can perform partial equilibrium analysis. The degree of product differentiation is given by the parameter c, where $0 \leq c \leq 1$. The maximum degree of product differentiation corresponds to $c = 0$ (independent goods) while the minimum degree of product differentiation corresponds to $c = 1$ (homogeneous goods). These utility functions generate the following linear inverse demand function for product i:

$$p_i = a - x_i - cx_j \ ; \ i, j = \{1, 2\} \ ; \ i \neq j \tag{3}$$

$$p_2^* = a^* - x_2^* \tag{4}$$

Given that the slope coefficients of the two inverse demand equations are identical, I use the intercept to designate differences in market sizes[7].

I consider the subgame perfect Nash equilibrium of a three-stage game. The status-quo of the game is segmented markets (i.e. no AD law in place). In the first stage the domestic gov-

[6]Shutting down exports in the developing country greatly simplifies the analysis. A model with bilateral trade would require a large difference in market sizes, a high degree of product differentiation, and a binding antidumping legislation in the developed country.

[7]Even though there are other ways to represent differences in market sizes, I prefer this over others (e.g. constant price elasticity) because it implies that, for a given quantity, the larger market will have a higher price.

ernment (DG) decides whether or not to adopt an antidumping legislation. An antidumping law is modeled as an extra constraint imposed on the foreign firm preventing it from discriminating between markets. If the government decides to enact such a law, firm 2 chooses $\{x_2, x_2^*\}$ subject to the constraint $p_2 - \tau \geq p_2^*$, and firm 2's markets will be integrated. If there is not an antidumping law, firm 2 chooses $\{x_2, x_2^*\}$ without restriction, and firm 2 will be said to segmented its markets.

In the second stage, the government sets a domestic tariff ($\tau \geq 0$), which may be exogenously bound ($\overline{\tau}$) by multilateral trade rounds. It is assumed that government maximizes social welfare, composed of the consumer surplus, the profits of the domestic firm, and the tariff revenue. The domestic profits are weighted by a factor $\lambda > 1$, which represents the lobbying pressure that domestic firm can bring to bear.

$$G = cs + \lambda\pi_1 + \tau x_2 \tag{5}$$

In this context, consumers do not lobby due to the diffuse nature of their losses[8]. This *politically realistic government objective function* may be derived either from a standard lobbying pressure group model [Baldwin (1987)] or from the median voter model of Mayer (1984) [Feenstra and Lewis (1991)]. The variable λ measures the DG's valuation of a dollar of domestic firm's profits relative to its valuation of a dollar of consumer welfare (the sum of consumer surplus and the tariff revenue)[9].

In the last stage, the domestic firm (DF) and the foreign firm (FF) compete in the domestic market in a Cournot fashion, taking the government trade policy as given[10]. Before the foreign firm makes output decisions, it choosees whether to stay or to exit the home market. Firms are identical and have constant marginal production costs, which, for simplicity, are assumed to be zero.

This model sketches a broad, but tractable picture of the effects of AD legislation which is consistent with most AD cases. First, AD law is considered as an anti-discriminatory device

[8]For a model where consumers lobby in a similar framework, see Rosendorff (1996).

[9]In autarky, it is assumed that $\lambda = 1$ since firms would not lobby for protection.

[10]A duopoly model with differentiated goods and linear demands was firstly introduced by Dixit (1979). Singh and Vives (1984), Bian and Gaudet (1997), Bernhofen (2001), Zanchettin (2006), among others, employ it to study the role of product differentiation on market outcomes.

decreasing inter-firm rivalry to the benefit of domestic firm. Second, even though AD duties are not observed in this model it is well known that a significant share of investigations ends up with price or quantity undertakings and no duties[11]. Third, with an AD law in effect, firms respect the constraint due to the threat of an investigation and being hit by a duty. Anderson et. al. (1995) and Anderson and Schmitt (2003) use a similar model to analyze the effect of AD legislation in developed countries. The three-stage game is depicted in figure 2.

1.3 Protection Under Segmented and Integrated Markets

The domestic government's equilibrium is obtained by solving this game through backward induction. In this section, I solve the last two stages of the game without AD law and with AD law.

1.3.1 Segmented markets

When markets are segmented equilibrium prices can be determined separately for each market. The foreign firm maximizes its profits in the two markets independently, i.e., third-degree price discrimination. Superscript S denotes equilibrium variables with no AD law.

Third stage: Competition between the domestic and foreign firm

The profit of firm 1 in the domestic market is $\pi_1 = (a - x_1 - cx_2)x_1$ whereas the profit of firm 2 in both markets can be written as $\pi_2 = (a - x_2 - cx_1)(x_2 - \tau) + (a^* - x_2^*)x_2^*$.[12] Solving for the Nash equilibrium quantities, I obtain:

$$x_1^S = \frac{a}{2+c} + \frac{c\tau}{(2-c)(2+c)}; \quad x_2^S = \frac{a}{2+c} - \frac{2\tau}{(2-c)(2+c)}; \quad x_2^{*S} = \frac{a^*}{2} \tag{6}$$

The degree of product differentiation in the industry is inversely related to the intensity of competition among firms[13]. Consequently, a higher degree of product differentiation (i.e. a lower value of

[11] See Prusa (1992) and, for the Latin American case, Finger and Nogués (2006).

[12] Note that the solution of this problem would be the same as the solution of the maximization of the two markets separately.

[13] See Bernhofen (2001) for a detailed explanation on the the effect of the degree of product differentiation on the volume of trade and on the composition of the gains from trade under imperfect competition.

c) increases the market power of each firm. In the polar case of maximum product differentiation ($c = 0$) both firms are monopolists in the domestic market ($x_1^S = \frac{a}{2}$ and $x_2^S = \frac{a-\tau}{2}$). Note that the restriction $\tau < \widehat{\tau^S} = \frac{a(2-c)}{2}$ is required for there to be intraindustry trade. If $\tau \geq \widehat{\tau^S}$, there is a monopoly in the domestic firm's market with foreign firm excluded by too high export cost.

According to the WTO law, if a firm 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. Using this standard definition, this model predicts dumping by the foreign firm into the domestic market. That is firm 2 uses third-degree international price discrimination.

Proposition 1. *Segmented markets produce unilateral dumping since* $p_2 - \tau \leq p_2^*$.

Proof. Define the dumping margin as $\gamma = p_2^* - (p_2 - \tau)$. Replacing equation (6) into equations (3) and (4) I obtain:

$$\gamma^S = \frac{a^* - a}{2 + c} + \frac{a^* c}{2(2 + c)} + \frac{2\tau}{(2 + c)(2 - c)} \tag{7}$$

Since $a \leq a^*$, $0 \leq c \leq 1$, and $\tau \geq 0$, then $\gamma^S \geq 0$ ■

The first term in the dumping margin is the "market size difference effect", which is non-negative because the foreign market is at least as large as the domestic market. The second effect is the "product differentiation effect", which is non-negative because goods are strategic complements. The third term is the standard "Brander-Krugman effect", which is non-negative because government values producer surplus at least as much as consumer surplus, so it nevers assign import subsidies[14].

Second stage: Domestic tariff determination

In this stage the domestic government chooses the politically optimal tariff given its previous choice of no enacting an AD law. Evaluating equation (5) at its optimal levels with segmented

[14]See Brander and Krugman (1983).

markets and computing the optimal tariff I obtain.

$$\tau^S = \frac{a(2-c)[c(2\lambda-1)+2]}{12-c^2(2\lambda+1)} \tag{8}$$

The optimal tariff is increasing in the government's relative valuation of domestic profits (λ). This parameter is determined by the lobbying activities of the domestic industry seeking protection from import competition. Therefore, more lobbying pressure implies that the government is willing to sacrifice consumer welfare in exchange for larger domestic profits and sets a higher tariff[15].

The optimal equilibrium tariff is decreasing in the degree of product differentiation. The closer substitutes the goods are, the more negative the impact of import competition on domestic firm profits . Hence, for a given value of λ, the government sets a higher tariff the more similar the goods are[16].

1.3.2 Integrated markets

When markets are integrated, the foreign firm's prices are tied in such a way that the dumping margin is eliminated. Hence, the domestic government sets a binding constraint on the foreign firm's maximization problem that requires the elimination of the difference between FOB prices across markets ($\gamma = 0$). Superscript I denotes equilibrium variables with AD law.

Third stage: Competition between the domestic and foreign firm

The profit function of firm 1 is the same as with segmented markets. Firm 2's maximization problem is now subject to the constraint $p_2 - \tau \geq p_2^*$ or $a - x_2 - cx_1 - \tau \geq a^* - x_2^*$. The concavity of the profit function ensures that this restriction will hold with equality. Since an AD law entails the equalization of net prices across markets, firm 2 may either still serve the domestic market without dumping or else withdraw from its export market.

[15] Formally, $\frac{\partial \tau^S}{\partial \lambda} = \frac{4ac(2-c)[6+c(1-c)]}{(c^2-12+2\lambda c^2)^2} \geq 0$.

[16] Formally, $\frac{\partial \tau^S}{\partial c} = \frac{4a(\lambda-1)(c^2(1+2\lambda)+12-8c)}{(c^2(1+2\lambda)-12)^2} \geq 0$.

Solving the case where the foreign firm still serves the domestic market with an AD law, I obtain the following equilibrium quantities.

$$x_1^I = \frac{a(4-3c)+ca^*+3c\tau}{8-3c^2}; \quad x_2^I = \frac{3a(2-c)-2a^*-6\tau}{8-3c^2}; \quad x_2^{*I} = \frac{2a^*(3-c^2)-a(2-c)+2\tau}{8-3c^2} \tag{9}$$

An AD law reduces the foreign firm's equilibrium output in the domestic market and increases it in the foreign market. Domestic firm output increases in the domestic country as long as $c > 0$. The more homogeneous the goods are, the larger the increase in domestic output is. Figure 3 compares the equilibrium solutions between segmented markets and integrated markets under different degrees of product differentiation. Not surprisingly, AD legislation raises domestic prices and decreases foreign prices, whereas firm 1's profits increase and firm 2's profits decrease. The prohibitive tariff with integrated markets is $\widehat{\tau^I} = \frac{a(2-c)}{2} - \frac{a^*}{3}$ (note that $\widehat{\tau^I} = \widehat{\tau^S} - \frac{a^*}{3}$).

If constraint to tie markets, foreign firm may wish to give up entirely on the export market in order to raise its domestic price. I assume the decision to enter or exit the home market is made prior to output decisions. Thus, if the foreign firm exits the home market, both firms become monopolists in their respective local markets.

An equilibrium with two firms in the domestic market requires that the foreign firm has no incentive to deviate from this situation. This implies that firm 2's profits under integrated markets and trade must be at least as large as firm 2's profits when it is a monopolist in its own market. Given that $\pi_2^I = 2\left[\frac{a^*(2-c^2)+a(2-c)-2\tau}{8-3c^2}\right]^2$ and $\pi_2^m = \frac{a^{*2}}{4}$, the condition for exit can be written as:

$$\tau > \tau^{ex} = \frac{a(2-c)}{2} - a^*\left[\sqrt{2}-1-\frac{c^2}{8}(3\sqrt{2}-4)\right] \tag{10}$$

If the domestic tariff is too high ($\tau > \tau^{ex}$), firm 2 would prefer to exit the market in the presence of antidumping legislation. Note that τ^{ex} is decreasing in a^*, the market size of the foreign country, and increasing in a, the market size of the domestic country. That is, firm 2 is more likely to exit

the home market the smaller that market is relative to the foreign market. In order to ensure that there exists some non-negative domestic tariff ($\tau^{ex} \geq 0$) that entails an equilibrium with two firms in the domestic market, I restrict the relative size of the foreign economy as follows.

$$1 \leq \frac{a^*}{a} \leq \frac{4(2-c)}{8(\sqrt{2}-1) - c^2(3\sqrt{2}-4)} \tag{11}$$

If the relative foreign market size is greater than this upper bound, firm 2 quits the domestic market for any tariff. Hence, an AD legislation necessarily involves a monopoly in the domestic country. Note that the binding tariff for the foreign firm to stop selling in the domestic market is the exit tariff (τ^{ex}), not the prohibitive tariff ($\widehat{\tau}^I$).

Lemma 1. *Under integrated markets and both firms serving the domestic market,* $\tau^{ex} < \widehat{\tau}^I$

Proof. Suppose $\tau^{ex} \geq \widehat{\tau}^I$. Thus $\frac{a(2-c)}{2} - a^*\left[\sqrt{2}-1-\frac{c^2}{8}(3\sqrt{2}-4)\right] \geq \frac{a(2-c)}{2} - \frac{a^*}{3}$. Solving for c: $c \geq \left[\frac{8}{3\sqrt{2}-4}(\sqrt{2}-1-\frac{1}{3})\right]^{\frac{1}{2}} = 1.633$, which is a contradiction because $0 \leq c \leq 1$. Thus, $\tau^{ex} < \widehat{\tau}^I$ ■

The exit tariff is increasing in the degree of product differentiation. If products are very similar, the foreign firm faces more competition in the domestic market thus it would make lower profits and be willing to give up the domestic market at a lower tariff than when products are more differentiated[17].

Second stage: Domestic tariff determination

The politically optimal tariff (τ^I) in the case of AD law and both firms in the domestic market is given by equation 12. Let $\tilde{\tau^I}$ be the optimal tariff resulting from the maximization of equation 5 at its optimal levels with integrated markets[18].

[17] Formally, $\frac{\partial \tau^{ex}}{\partial c} = \frac{a^* c}{4}(3\sqrt{2}-4) - \frac{a}{2} < 0$.

[18] Note that I allow for firm 2 to exit the domestic market but I required that it must exist a non-negative tariff ($\tau^{ex} \geq 0$) for which it prefers to serve the domestic market with integrated markets.

$$\tau^I = \min[\tau^{ex}, \tilde{\tau^I}] \tag{12}$$

where

$$\tilde{\tau^I} = \frac{(a^* - 3a)}{3} + \frac{4(a^* - 3a)(2 - \lambda c^2) + 2ca(3 - 4\lambda)}{3c^2(1 + 2\lambda) - 20}$$

For homogeneous goods it is easy to show that $\tau^I = \tau^{ex}$. An increase in the degree of product differentiation involves an opposite impact on the relevant tariffs in equation 12. On the one hand, it raises τ^{ex} because a reduction in the intensity of competition among firms boosts foreign firm's profits in the domestic market. On the other hand, it decreases $\tilde{\tau^I}$ because the government chooses a lower optimal tariff since domestic firm is less affected by import competition. Therefore, the degree of product differentiation determines the solution of equation 12.

The government has no incentives to exclude foreign firm from the domestic market by setting a tariff higher than τ^I. Because domestic firms do not lobby for protection in autarky ($\lambda = 1$), consumer losses -the sum of consumer surplus and tariff revenue- offset the domestic firms benefits of shutting down foreign trade.

AD legislation has a different effect on domestic producers and consumers. Domestic firm is better off since it obtains more profits, provided that $c > 0$. Consumers, on the other hand, are worse off because domestic prices increase. Finally, tariff revenue decreases since, for a given value of the domestic tariff, the foreign firm exports less. The combined impact of these three effects on the government's objective function, in conjunction with the existence of an exogenous bound to multilateral tariffs determines the decision of whether to enact an AD legislation or not.

1.4 Trade Liberalization and the Adoption of AD Laws

Consider, now, the first stage in this three-stage game of trade protection. Here, the domestic government decides whether to switch to an AD law or not. The decision, of course, depends on which regime can deliver the highest government payoff in an environment where tariffs may be exogenously bound by multilateral trade rounds. This section presents the solution of the game for homogeneous goods.

The government faces a trade-off between the domestic firm's profits and the consumer welfare in the first stage. Firm 1 is better off with an AD law because it sells more at higher prices while consumers are worse off because they confront higher prices. The government collects less tariff revenue because imports decrease. If the government can freely choose any tariff, it will not switch to an AD regime because the negative consumer welfare effect outweighs the positive firm's profits effect[19].

Whenever tariffs are bound ($\overline{\tau}$) at a lower level than the politically optimal tariff in segmented markets (i.e. tariffs are effectively bound), domestic profits decrease because of fiercer foreign competition and consumer surplus increases due to the reduction in prices. The effect on tariff revenue is undetermined, on the one hand it increases due to higher import volumes, but on the other hand, it decreases due to the reduction in multilateral tariffs.

As a consequence of the progressive reduction of multilateral tariffs implied by different trade rounds, it is optimal for a government to switch to an AD law for a sufficiently low bound tariff (τ'). At this point the positive firm's profits effect just match the negative consumer's welfare effect of enacting an AD law. The optimal AD policy in small developing countries is characterized by proposition 2.

Proposition 2.

1. *AD legislation will never be enacted if* $\overline{\tau} > \tau'$*, where* τ' *satisfies* $G^S(\tau') = G^I(\tau^{ex})$
2. *When* $\overline{\tau} \leq \tau'$*, the government adopts an AD law.*

Proof. See appendix 1 ■

Figure 4 shows the optimal antidumping policy with trade liberalization. When tariffs are not effectively bound, the government chooses no AD law and sets the optimal tariff in segmented

[19]Since the status-quo regime is no AD legislation, the government's valuation of domestic profits (λ) must be restricted. See the Appendix 1 for details.

markets ($\tau = \tau^S$). When $\tau' < \overline{\tau} \leq \tau^S$, the best policy is to keep the segmented markets situation and to set $\tau = \overline{\tau}$. When $\tau^{ex} \leq \overline{\tau} \leq \tau'$ the government finds it optimal to enact an AD legislation and sets $\tau = \tau^{ex}$; hence the applied tariff is lower than the bound tariff[20]. Finally if $\overline{\tau} < \tau^{ex}$ the government sets $\tau = \overline{\tau}$. The gray line in the figure 5 shows the welfare corresponding to the optimal antidumping policy.

1.5 Heterogeneity in the Timing of AD Law Adoption

The theoretical model explains the adoption decision as a result of the trade liberalization process. Now, the observed heterogeneity in the adoption decision in developing countries is explained by three features: Political economy motives, the relative domestic market size, and the degree of product differentiation. Proposition 3 presents the relationship between the threshold for adoption (τ') and the relative government's valuation of domestic profits (λ), the inverse of the relative size of the domestic market $\left(\frac{a^*}{a}\right)$, and the degree of product differentiation (c).

Proposition 3.

1. τ' *is increasing in* λ.
2. τ' *is decreasing in* $\frac{a^*}{a}$.
3. τ' *is increasing in* c.

Proof. See appendix 1 ■

A higher government valuation of domestic profits, which reveals more lobbying pressure from the domestic industry, implies a sooner adoption of the AD law. When facing a trade liberalization episode, governments with better organized lobbies care more about domestic firm's losses than consumers' welfare gains. Thus, the threshold for adoption of an AD law is increasing in λ. The first panel of figure 6 shows the graphical solution for an increase in λ.

[20]The government does not set the $\tau = \overline{\tau}$ in this interval to avoid foreign firm exit and face a monopoly situation in the home market.

When obligate to tie markets, foreign firm exits the domestic country sooner for relatively smaller countries. In the segmented markets case, foreign firm's profits from the foreign market are at least as large as the profits for the domestic market[21]. Consequently, a decrease (an increase) in the relative size of the domestic market implies a decrease (an increase) in foreign firm's profits from the domestic market. Thus if foreign firm must integrate its markets in a relatively smaller country, it finds optimal to exit at a lower tariff since it would have to tie its own market price to a even lower domestic price. When facing a trade liberalization episode, domestic government delays its adoption of an AD law to prevent exit because this hurts domestic consumers. Thus, the threshold for adoption is decreasing in the relative size of the foreign market (second panel of figure 5).

Since the degree of product differentiation is inversely related to the intensity of competition, foreign firm's profits in the small country with segmented markets are decreasing in c[22]. Foreign firm's profits in the foreign market are independent of the degree of product differentiation since there is no competition in the foreign market. When foreign firm is obligated to equate the net domestic price —which is a function of the degree of product differentiation— with the foreign price —that is always set at the fully differentiation level due to the absence of competition—, the negative net effect on its profits ($\pi_2^I - \pi_2^S$) is smaller, the more differentiated the goods are[23]. The first panel of figure 7 shows the relation of net profits for both firms with product differentiation.

Antidumping legislation implies an increase in domestic prices. When products are perfect homogeneous, the home price of the domestic output increases at the same level as the home price of imports. On the other hand, when goods are fully differentiated, the home price of the domestic product is not affected by AD legislation (second panel, figure 6). For any degree of product differ-

[21]The reason for this is twofold: On the one hand, the foreign market is at least as large as the domestic market, thus -for the same degree of product differentiation in both markets- the foreign equilibrium price and quantities are at least as large as the domestic equilibrium values. On the other hand, due to our assumption of no competition in the foreign market, foreign firm behaves as a monopolist in fully differentiated goods in its country regardless the degree of product differentiation in the domestic country.

[22]Recall that c goes from maximum product differentiation ($c = 0$) to minimum product differentiation ($c = 1$). Thus, an increase in c is a reduction of the degree of product differentiation whereas a decrease in c is an increase of the degree of product differentiation.

[23]The conversely is true for the domestic firm, the positive net effect on its profits is smaller the more differentiated the good are.

entiation, consumers are worse off with the adoption of the law, since the net change in domestic prices ($p_1^I - p_1^S$ and $p_2^I - p_2^S$) is positive. Tariff revenue always decreases with an AD law since foreign firm reduces exports to the domestic market. Thus, consumer welfare (consumer surplus plus tariff revenue) is more negatively affected when goods are more alike. The last panel of figure 7 shows this relationship.

Having explained the solution of the model with homogeneous goods, I consider a progressive movement towards product differentiation and its impact on the timing of adoption. Consider a situation where the bound tariff is equal to the threshold tariff for adoption with homogeneous goods (called it $\tau'_{c=1}$), and compare this result with the first-stage solution (same bound tariff) with some degree of product differentiation[24]. Recall that the government decides to enact AD legislation at the point where the positive domestic profits' effect just match the negative consumer welfare's effect of switching to integrated markets. When goods share some degree of product differentiation, a change to integrated markets entails a smaller increase of domestic profits and a lower consumer welfare losses compare to the homogeneous goods situation (figure 6). The reduction in net domestic profits is larger than the reduction in consumer welfare losses, thus each marginal increase in product differentiation (reduction in c) signifies that consumer welfare losses outweigh the domestic firm's gains. This implies that, at $\overline{\tau} = \tau'_{c=1}$, the government chooses not to switch to an AD regime. Consequently, the optimal threshold for adoption is decreasing in the degree of product differentiation (figure 7).

1.6 Concluding Remarks

The reduction in tariffs that the world has witnessed in the last 40 years has led governments to resort to other mechanisms to constrain trade. Antidumping legislation, originally a privilege of the developed countries, is now the most widely used policy device worldwide. This paper proposes a theoretical framework to explain the observed heterogeneity in the time of adoption of antidumping laws in developing countries. The analysis is based on a three-stage game of trade policy determination with imperfect competition in differentiated goods, where tariffs are exogenously bound due to multilateral trade rounds.

[24] I assume that the change in c is marginal in such a way that $\tau^I = \tau^{ex}$ still holds.

Trade policy is the result of the government analysis to resolve trade-offs between surpluses of domestic market participants. On one hand, the boost in import competition created by tariff reductions decreases producer surplus, while increasing consumer surplus. On the other hand, an adoption of AD legislation decreases inter-firm rivalry to the benefit of the domestic firm and to the disfavor of the consumer welfare. In a trade liberalization episode where the potential lobby for protection is reflected in the government's objective function, it is shown that the implementation of AD legislation is the government's best response when multilateral bound tariffs reach a sufficiently low threshold.

This threshold for adoption among developing countries depends on three idiosyncratic factors. Countries with high lobbying pressure for protection enact AD legislation sooner because the government cares more about the negative impact that trade liberalization bears for domestic producers. A government in a relatively small domestic market delays the enactment of AD legislation to prevent exit from the foreign firm due to the requirement of integrated markets. Finally, since the degree of product differentiation is inversely related to the intensity of competition in the domestic market and, thus, to the level of domestic profits, AD laws are approved sooner when trade is performed in more homogeneous goods.

2 Beyond the Information Technology Agreement:Harmonization of Standards and Trade in Electronics.[25] [26]

2.1 Introduction

The expansion of trade in electronics goods has contributed in a major way to productivity growth, human welfare, and societal change.[27]Global trade in the information technology (IT) and electronic products has doubled over the period 1997 to 2005, totaling over $1.4 trillion (WTO 2007). Following the growing trend of fragmentation or relocation of production processes across countries, developing countries have increasingly participated in the production and assembly of electronic products. Investment aiming at expanding the sector in developing countries also generates positive spillovers in terms of technology transfer and innovation.

Ways to promote trade and lower costs for producers and consumers is at the forefront of policy debate and discussion. Removing non-tariff barriers to trade and building on models of success, such as the Information Technology Agreement (ITA)[28], which cut tariffs to zero on 97 per cent of world trade of a list of information technology products defined during negotiations, is one option for consideration. Shortly after its signature, discussions resumed on broadening the ITA with a set of measures that range from enlarging its product coverage to addressing non-tariff measures -including product standards- [29]. Standards may not be developed in intend as protectionist de-

[25]Joint with Alberto Portugal-Perez and John S. Wilson.

[26]The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the views of the World Bank, its Executive Directors, or the countries they represent. We have benefited from discussions with Suzanne Troje, John Godfrey, and Ben Shepherd. Without implicating them, we would like to thank Daniel Lederman, Jaime de Melo, Marcelo Olarreaga, Mario Piacentini, Frederic Robert-Nicoud, an anonymous referee, and participants at seminars at the University of Geneva and the European Academy of Standardization in Paris for helpful suggestions on earlier versions of this article. Hanna Luchnikava and Marco Antonio Martinez provided excellent research assistance.

[27]Increasingly powerful electronic and digital equipment enables lower cost accounting and management systems that increase productivity in offices around the world, for example. Access to radio and television programs in schools allow people in remote villages the opportunity to access to a world of information and knowledge. Handheld computers provide real time data and monitoring of costs for goods in transit, access to medical records to speed diagnosis of patients in hospitals, and allow farmers in developing countries minute to minute information on crop prices. These are some of the benefits that electronic products provide - driven by innovation, lower costs of production, and trade.

[28]The Information Technology Agreement (ITA), negotiated in 1996, is a remarkable example of an agreement that successfully achieved sectoral liberalization under WTO's auspices. At the origin, IT-producing nations agreed to bind their MFN tariffs at zero for a specific list of IT goods that included computers, semiconductor manufacturing equipment, and electronic instruments. The agreement stated that zero tariffs were to be reached by 2000, although some developing nations had a longer phase-in period (2005 being the latest possible date).

[29]On 2000, the Committee of Participants on the Expansion of Trade in Information Technology Products (ITA

vices. Examples abound on how they have a positive impact on daily life by avoiding, for instance, health and safety concerns, inefficiencies, and thus greater costs to economic agents.

From the exporters' perspective, they may impose additional costs as it may be necessary to alter production processes to adapt products to such standards in the importing country. Moreover, a producer willing to export to several markets may be confronted to idiosyncratic standards specific to each markets, and compliance with them may further inflate his costs. In addition, certification aiming to confirm compliance with this set of rules can generate additional costs to the exporters. Higher costs may discourage exports and reduce the range of products exported (cost effect). On the other hand, standards can potentially reduce exporters' costs by conveying information on several product requirements such as industrial requirements, compatibility or interoperability, consumer tastes, and safety, which would be more costly to collect in their absence (informational effect).

The international harmonization of product standards to facilitate trade in electronic products is a policy option that deserves further attention. Using a new database of European standards for electronic products collected by the World Bank, we estimate the net impact of internationally-harmonized European standards on EU imports of electronics. The data set includes European standards for electrical, electronic and related products over the period 1990-2006. We quantify the differentiated effect on trade of European standards that are internationally harmonized against those that are not. Our main finding is that internationally-harmonized EU standards expand EU imports of electronic products. Conversely, European standards that are not aligned with international norms have a lower effect on EU imports, or even a negative one. Developing countries in East Asia are the major exporters of electronic products to the EU and, thus, are major beneficiaries of international harmonization of standards.

To our knowledge, this is the first study to assess the impact of international harmonization of EU standards on trade flows for electronics products. In the closest article related to this research,

Committee) agreed on its "Non-Tariff Measures Work Programme" (contained in WTO document G/IT/19). This document aimed to identify NTM which were impediments for trade and to examine the economic and developmental impact of such measures on trade in ITA products.

Moenius (2006b) studies the role of international harmonization of standards on trade flows of products that depend on electricity. He proxies international harmonization with counts of bilaterally shared standards. We take advantage of the features of our dataset to widen this definition; we consider internationally harmonized standards as those aligned with worldwide practices defined by global standard institutions.

Is the impact of international standard harmonization in electronics different compared to other sectors, say textiles and apparel? Our results contrast with Czubala et al. (2009), who found that international harmonization of EU standards has a negative net effect on imports, although milder than the effect exerted by the EU standards that are not internationally harmonized. A possible explanation for this differentiated effect resides on the informational content that standards convey for more complex products is relatively more valuable, and its benefits seem to outpace its compliance costs.

The paper is structured as follows. Next section briefly explains the standards development system in Europe as it relates to electronics products. It also provides an overview of the literature on standards harmonization and trade. The third section describes the new World Bank database on electronic standards. We present our empirical model and estimates in section four. Finally, we conclude by discussing policy implications for consideration based on our results and by providing a summary of questions for further research.

2.2 Product Standards, Harmonization and the Electronic Sector

Product standards and technical regulations set out product characteristics, related processes and production methods. The World Trade Organization (WTO) differentiates them by its compliance degree: a technical regulation is mandatory, while a product standard is voluntary. In practice, this distinction is blurred, as public agencies often use standards to achieve regulatory goals (Hanson 2005).

Standards affecting electronic products cover a wide range of product specifications. They include, for example, safety requirements for sewing machines (EN 60204-31) and measures of elec-

tromagnetic emissions from integrated circuits (EN 61967)[30].

This section describes the institutional setting of product standardization in Europe, including reference to the international system for standardizing electronic products. We also summarize the literature on the effects of internationally harmonized standards on trade flows.

2.2.1 Institutional Standard-Setting Processes

Product standards have been part of trade policy forums for several decades. Concurrently with the GATT's Technical Barriers to Trade (TBT) Agreement , the European Union adopted a "New Approach to technical harmonization and standardization" in 1985, which was aiming at simplifying the movement of goods throughout the European Union (EU) and the European Free Trade Area (EFTA). New Approach Directives outline the "essential requirements" associated with the manufacturing of products, mainly related to safety, which apply either directly to final electronic goods or indirectly to electronic components. Table 1 lists the Directive areas for which CENELEC has issued harmonized standards.

Compliance with the New Approach Directives' is compulsory for the free movement of products within the EU. The system in place does not, however, specify how specific objectives, such as consumer protection through product safety, should be achieved. This role is fulfilled by European standards published by supranational standardization bodies, such as the European Committee for Standardization (CEN) or the European Committee for Electrotechnical Standardization (CENELEC). The latter institution prepares and publishes standards relevant to the electronic sector. These standards are "harmonized" EU standards and member countries are obliged to adopt them and withdraw any national standard that might conflict with them.

If a manufacturer chooses to produce a product according to these harmonized standards, the product carries the "CE" marking, which implies compliance with the "essential requirements". On

[30]Even though standards pursue an important number of benefits, such as facilitating exchange of information between producers and consumers, interoperability of products, and promotion of environmental protection and safety, they can also be means of hidden protection. Matutes and Regibeau (1996), Blind (2004), and Swan (2000) provide a discussion on the positive and negative effects of product standardization.

the other hand, manufacturers may use other technical specifications when manufacturing a product provided there is documentation certifying that the product meets the "essential requirements" formulated in the European Directives. Nevertheless, anecdotic evidence suggests that the prohibitive costs of the latter option push exporting companies to favor compliance with harmonized standards (see for instance Hanson (2005)). By 2006, the number of harmonized standards linked to compliance with New Approach Directives account for 27.3 percent of the total stock of standard published by CENELEC[31]The remaining standards are market driven and are not referenced in relation to compliance with the New Approach Directives.

The decision making process to create a standard in CENELEC consists of three stages elapsed in general over three years. The first stage involves producing a draft standard prepared by a CENELEC technical committee from a project proposal by one of four possible bodies: CENELEC's own technical bodies, CENELEC's Cooperating partners[32], the International Electrotechnical Commision (IEC), or the national committees themselves. The second stage involves an enquiry procedure among CENELEC members[33] to comment on the draft. After the comments are incorporated into the document, a final draft is sent for vote. At this third stage, and approval of a standard requires that a majority of the national committees voted in favor of the document and that at least 71 percent of the "weighted" votes cast are positive[34].

At the global level, the International Electrotechnical Commission (IEC) is the organization that prepares and publishes international standards for electrical, electronic and related technologies. Table 2 reports the procedures to formulate IEC standards. It follows a similar procedure to standards formulated under CENELEC.[35]In some instances there is a join effort between IEC and

[31]CENELEC facts and figures as of January 2008.

[32]A cooperating partner is an independent European or international organization representing, with a sufficient degree of representativity within its defined area of competence, a sector or subsector of the electrotechnical field. Examples of such bodies are: The European Committee for Cooperation of the Machine Tool Industries (CECIMO); The European Coordination Committee of the Radiological, Electromedical and Medical IT Industries (COCIR); and The European Electronic Component Manufacturers Association (EECA), among others.

[33]Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Spain, Slovakia, Slovenia, Sweden, Switzerland and United Kingdom.

[34]Members' votes are weighted according to the size of the country they represent.

[35]The main difference with CENELEC is that the IEC voting procedure occurs not only at the approval stage but also at the enquiry stage between qualified members.

the International Organization for Standardization (ISO) to publish standards related to this sector.

CENELEC standards can be divided into three groups according to their relationship to international principles (IEC standards): i) standards identical to international norms, ii) standards based on international norms but modified with some specifications added for the European market, and iii) purely European standards. For this study, we differentiate between CENELEC standards identical to IEC standards (internationally harmonized) from those that are not (non-internationally harmonized). By 2007, 70.1 percent of CENELEC standards (3,704) were internationally harmonized whereas the remaining 22.7 percent were not (1,200)[36].

For example, EU standard EN 61300 is an internationally harmonized standard in electronics that is identical to IEC 61300, which outlines the general requirements for optical fiber interconnecting devices and passive components. By opposition, standard EN 50049-1/A2, which delineates the interconnection requirements for domestic or similar electronic equipment, is a purely European standard since there is not an international norm equivalent to it.

2.3 Internationally Harmonized Standards and Global Trade

The literature about the effect of harmonization standards on international trade is limited[37].Until recently, the literature was concentrated on examining the commonly held view that block-harmonized standards encourage international trade and that country-specific standards are barriers to trade. In this regard, Moenius (2004) finds that bilateral share standards are favorable to trade while country-specific standards reduce imports for non-manufactured goods and increase imports for manufactured goods in Europe.

In a similar study focusing on agricultural products, Moenius (2006a) refutes that country-specific standards always block trade since they provide essential information about markets and

[36]CENELEC facts and figures, as of January 2008.

[37]The role of product standards -or more generally, technical barriers to trade (TBT)-, on international trade is also recent. At the theoretical level, Baldwin (2000) and Ganslandt and Markusen (2001) propose an analytical framework to understand the role of TBT on international flows. At the empirical level, Wilson and Otsuki (2004), Blind and Jungmittag (2005), and Chen et al. (2006) have estimated the impact of product standards or the effect of their liberalization. WTO (2005) provides a complete overview on the relation of product standards and international trade.

that European harmonized standards always expand trade as they also reduce the variety of goods being traded. In conclusion, Moenius work suggests that "importer standards tend to hinder trade in simple goods (including agricultural products) and promote trade in complex goods (like machinery)"[38].

The first article to consider the differentiated trade impact of "idiosyncratic" national standards versus international standards is Swann et al. (1996). Using data from 1985 to 1991, the authors regress British net exports on count data of country-specific standards and international standards in United Kingdom and Germany for 88 manufacturing industries. The results indicate that UK-specific standards have a stronger positive effect on British net exports than international standards.

Otsuki et al. (2001) is the first case study to directly address the role of internationally harmonized standards as opposed to purely European standards on trade flows. They employ a gravity model to estimate the impact of European aflatoxin standards on imports of groundnut products from Africa during 1988-1998. Results suggested that European standards set at the most restrictive level would involve trade flows significantly lower than when international standards are adopted.

Regarding the role of EU directives in trade, Chen and Matoo (2008) find that such agreements increase trade among EU members but not necessarily with non-members. The authors used a detailed panel dataset that identifies the industries influenced by each Directive to concluded that developing countries may be the worst affected since their firms are likely to be less prepared to comply with stricter standards. Although this article does not directly address the role on international harmonization in standards, it sheds light on the differentiated impact of EU standardization on third countries. In a closely related article, Baller (2007) also finds evidence that the effect of harmonization on third countries is positive for industrialized countries and mixed for developing countries.

Using a new World Bank database of EU product standards in the textiles, clothing, and

[38]Moenius (2006a), page 3.

footwear sector (EUSDB database), Czubala et al. (2009) consider the impact of international harmonization as opposed to purely European standardization at the intensive margin. The authors use a gravity model to examine the role of EU standards on African exports during the period 1995-2003. They find robust evidence on the negative impact of standards on trade, however, they find that internationally harmonized standards are less trade restrictive than purely European standards. The policy implications of this result suggest that it is indeed appropriated for the TBT Agreement to champion the use of international standards whenever possible and that it is no just technical regulations that can have a significant impact on trade.

Building on Czubala et al (2009), Shepherd (2007) examines the impact of internationally harmonized standards on the extensive margin of trade at the sectoral level. He suggests that although product standards have a negative impact on partner country export variety, international harmonization acts as a mitigating factor. The result is consistent with numerical simulations on a three-country version of Melitz (2003) model in which harmonization is beneficial at the extensive margin. The empirical results indicate that a 10 per cent increase in the total number of standards reduces export variety by 6 per cent meanwhile a 10 per cent increase in the proportion of internationally harmonized standards leads to a 0.2 per cent increase in export variety.

Finally, Moenius (2006b) is the only paper having focused on products that depend on electricity. He studies the different impacts of country-specific standards and standards shared by the exporting and the importing country. The author defines the latter as international harmonized standards and, in a gravity framework, concludes that both types of standards promote trade flows. He also finds that national standardization dominates bilateral standardization and that electricity-dependent products benefit more from international standardization than manufacturing products. We take advantage of the features of the new World Bank dataset to widen this definition; we consider internationally harmonized standards as those aligned with worldwide practices defined by IEC.

2.4 The World Bank EU Electrotechnical Standards Database (EUESDB)

The European Union Electrotechnical Standards Database (EUESDB) compiles European Standards for electrotechnical products[39] over the period 1990-2007, and maps them to the Standard International Trade Classification (SITC). The database provides counts of the number of standards and their relation with international principles. This section presents the methodology as well as some description of the standardization activity in electronic goods.

In an effort to increase the availability of empirical data on standards, the EUESDB is based upon the methodology proposed in Czubala's (2009) in assembling the European Union Standards Database in textiles, clothing, and agricultural products. Accordingly, the Perinorm database (www.perinorm.com) is used to extract the standards published by CENELEC. This approach has been employed previously in studies by Swann et al. (1996) and Moenius (2000, 2004, and 2006).

Perinorm is a subscription-only database of national, European and International product standards developed by the British Standard Institute (BSI), the Association Franaise de Normalisation (AFNOR) and the Deutsches Institut fr Normung (DIN). It contains more than 1.1 million records from 23 countries, in addition to international bodies such as ISO and IEC and supranational organizations such as CEN and CENELEC. At this stage, EUESDB does not include data on national standards from individual EU member states[40].

Each record in the Perinorm dataset corresponds to a single national, regional, or international standard. Each observation has information on its title, the history of versions, its international relationship, its classification, the original language, the issuing body, the publication date, the withdraw date (if applies) and a brief description of it. Only those documents classified as European standards (coded as "EN") in Perinorm are included in the count database.

[39] According to the IEC (http://www.iec.ch), the term electrotechnical refers to electrical, electronic and related technologies.

[40] There are three reasons for this omission: First, a considerable number of national standards are in fact supranational standards implemented at the national level. Second, data availability varies considerably across EU member countries. Third, as supranational standards are relatively recent, it is more feasible to obtain accurate stock data for them than for national standards.

We use that information to build an inventory of the "stock" of active standards[41] for a given product-year in the electrotechnical sector. As Perinorm classifies standards according to the International Classification of Standards (ICS), standards are matched to products using Blind's (2004) concordance between ICS classification and SITC revision 2 classification[42]. A standard is considered to be in force for a given year if it was published before or during the year in question and (if applicable) if it was withdrawn after the same year. Amendments to existing standards are counted as additional standards. The withdraw date defines when a standard is no longer active.A standard is considered internationally harmonized if it is "identical" to an existing IEC standard. For instance, European standard EN 61965 delineates the mechanical safety of cathode ray tubesCathode ray tubes are electronic vacuum tubes that use focused electron beams to display images. They are most famous for their use in such things as televisions, computer and radar displays, and automated teller machines.. It was introduced in 2002 and modified in 2003, so it appears as active standard from 2002 on. It is considered as internationally harmonized since it implements IEC standard IEC 61965. This standard applies to SITC 776 which included thermionic, cold and photo-cathode valves, tubes and parts.

Two factors raise international harmonization: the introduction of new harmonized standards and the removal of purely European standards. Indeed, between 2005 and 2006, CENELEC implemented 96 IEC standards, whereas it withdrew 16 non-harmonized standards.

It is worth noting the limitations of the data set. Even though the count variable is a proxy of the number of standards an exporter should comply with, it is not possible to identify the level of technical complexity among those standards affecting a given product. Previous attempts to include the number of pages of each standard as a proxy for its technical complexity proved unworkable, we believe, as Perinorm records the number of pages of each standard in its original language, which may differ among standards.

[41] The primary variable of interest is the total number of standards with which an exporter's product should comply during a particular year.

[42] An advantage of this automatically mapping over the manual mapping used in Czubala et al. (2007) is its transparency and automation. On the other hand, the manual mapping has the benefit of allowing a finer level of product-detail. This advantage might be partly offset by the considerable room for the exercise of the analyst's judgment.

From the complete stock of electrotechnical standards, we extracted those standards directly related to electronic goods from 1990 to 2006. In an attempt to consider groups of homogenous goods where standards entail similar technical requirements among products, we distinguish between three groups of electronics: i) Electronic components; ii) consumer electronics and telecom; and iii) Information technology products. Lall et. al (2004) use a similar categorization to study industry fragmentation in electronic products. Table 3 reports the SITC categories within each group.

Table 4 and figure 8 show the evolution of total number of product standards in each category.

The share of internationally harmonized standards (IEC standard) has increased in the sample period for electronic products as shown in table 5 and figure 9.T his pattern differs among subsectors. In 1990, categories 1 and 2 began with a high share of international harmonization (almost 90 percent), partly due to the small number of standards in those categories. While the EU standardization process increased over time, the share of internationally harmonized standards temporarily decreased reaching its lowest level in 1993 for category 1 (36 percent) and in 1996 for category 2 (69.2 percent). From that point on, the share of international harmonization has remained constant for category 2 whereas it has increased in category 1 to reach 70 percent in 2006. Category 3 has a lower initial value (30 percent) in 1990, it reached it lowest point in 1992 (20 percent) to begin increasing until reach a level of 23 percent in 2006 (figure 10).

It is worth mentioning that the percentage of international harmonization tends to converge on the 70 per cent to 80 per cent range for the stock of standards of each sub-sector. This pattern may be the result of the implementation of the Dresden Agreement in 1996, which lays down a set of parameters to expedite the collaboration between IEC and CENELEC in the preparation and publication of international standards.

2.5 Model and Estimation Results.

In this section, we present the empirical model to be used to estimate the impact of internationally harmonized and non-harmonized EU standards on imports. Then, we discuss the econometric

strategy as well as our estimates. Since we attempt to make the basic mechanisms underlying the model as clear as possible, we keep the theoretical presentation highly stylized.

2.5.1 Empirical Model.

To examine the differentiated impact of internationally harmonized and non-harmonized standards on EU imports of electronic goods, we use a standard gravity model of international trade applied to data on EU-15 imports from the rest of the world[43]. Individual EU standards in electronics often tend to be applied across numerous product lines, which make it convenient to aggregate the trade data to a higher level of generality.

As starting point, we take the micro-founded gravity model formulation of Anderson and Van Wincoop (2003, 2004) and adapt it to the electronics sector:

$$ln(M_{ijt}^k) = ln(E_{jt}^k) + ln(Y_{it}^k) - ln(Y_t^k) + (1-\sigma_k)ln(t_{ijt}^k) - (1-\sigma_k)ln(P_{jt}^k) - (1-\sigma_k)ln(\pi_{it}^k) + \epsilon_{ijt}^k \quad (13)$$

where: M_{ijt}^k = Country j imports from country i in category k for year t; Y_{it}^k =Production of country i in sector k for year t; E_{jt}^k =Expenditure of country j in category k for year t; Y_t^k =Aggregate (world) output in category k for year t; σ_k =Elasticity of substitution in category k; t_{ijt}^k =Trade costs facing exports from country i to country j in category k for year t; ω_{it}^k =Country $i's$ output share in category k for year t; ω_{jt}^k = Country $j's$ expenditure share in category k for year t; and ϵ_{ijt}^k =Random error term, satisfying the usual assumptions.

We modify the bilateral trade costs component, t_{ijt}^k, in the standard model 13 as to explicitly include our standards count variables. Ideally, the model would require data on the direct costs of compliance with standards for the categories we use. Unfortunately, such data is not available at the categories level, let alone at the firm level, and we are forced to resort to count-variables as proxies that capture the effects of standards. Indeed, other empirical papers resort to standards

[43] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, , Sweden, and United Kingdom.

count, see for instance Czubala et al. (2009) for EU standards on apparel and textiles, as well as by Swann (1996) and Moenius (2000, 2004, and 2006).

Our standards count variables make a distinction between the number of EU standards internationally harmonized with IEC standards (IH_std^k) in product category k and the number of EU standards not internationally harmonized (NIH_std^k) By defining the standards count variable at the product category, we allow for uneven effects of standards on trade across categories, as the number of standards per product-category k diverges. We also include in the trade cost function $Tappl_{ijt}^k$, an import-weighted average of applied tariffs to category k levied by EU importers to exports from country i, as explained below.Finally, the trade cost function also includes, as is usual in this literature, the distance between pairs of trading countries (dist) as proxy for transport costs, as well as dummy variables to take into account important geographical and cultural links such as colonial links (Dcolony), and a common official language (Dcomlang). We also control for the differentiated impact of exports from the ten European countries that formally acceded to the EU in 2004, by including a dummy (DEU_memb) that equals one when exporter i is one of the ten countries in 2004 or a subsequent year, and zero elsewhere. Furthermore, as part of EU-accession, the ten countries had also benefited from zero-tariff preferences in the EU for several sectors - including manufacturing- since 1998, prior becoming full EU-members. Therefore, zero-tariffs were applied by EU-15 countries on the export of electronic products of these countries from 1998 onwards[44], as captured by the applied tariff variable in the estimates.

Assuming linearity, we therefore specify:

$$ln(t_{ijt}^k) = \sum_{k=1}^{3} \theta_k ln(IH\_std_t^k) + \sum_{k=1}^{3} \varphi_k ln(NIH\_std_t^k) + \varsigma_1 Tappl_{ijt}^k + \varsigma_2 dist_{ij} + \varsigma_3 Dcolony_{ij} + \quad (14)$$

$$\varsigma_4 Dcomlang_{ij} + \varsigma_5 DEU\_membij$$

As to implement the estimation procedure, Anderson and Van Wincoop (2003, 2004) suggest that

[44]For an account of EU enlargement issues, see for instance Breuss (2002).

the model can be simplified by replacing the "multilateral resistance" terms with appropriate fixed effects. In this case, a strict interpretation of their structural model in a panel context would require fixed effects in the importer-sector-time, exporter-sector-time, and sector-time dimensions. However, this approach is difficult to implement as it requires estimation of a large number of parameters, a problem accentuated in our case by the large number of countries. For our baseline model (3), we therefore prefer a simpler formulation using fixed effects only in the exporter σ_j importer δ_i and product-year $(\psi_k * \phi_t)$ dimensions. The last term has the advantage of controlling for obsered and unobserved time-varying effects specific to each category of electronics that are likely to influence trade, such as technological innovation. The importer and exporter fixed effects control for country-specific observed and unobserved factors.

plugging 15 in 13 and replacing the "multilateral resistance" terms with appropriate fixed effects, we obtain:

$$ln(M_{ijt}^k) = \delta_i + \sigma_j + \psi_k * \phi_t + \sum_{k=1}^{3} \theta_k ln(IH\_std_t^k) + \sum_{k=1}^{3} \beta_k ln(NIH\_std_t^k) + \gamma_1 ln(\tau_{jt}) + \gamma_2 dist_{ij} \quad (15)$$

$$+\gamma_3 Dcolony_{ij} + \gamma_4 Dcomlang_{ij} + \gamma_5 DEU\_membij + \epsilon_{ijt}^k$$

Data

Our panel covers three categories of electronic products described in Table 3 imported by the EU-15 countries from 131 countries exporting countries[45] over the period 1990-2006. Export and tariff data were compiled through WITS from COMTRADE and TRAINS, respectively under the SITC revision-2 nomenclature. Core gravity variables, such as bilateral distances, colonial and common language dummies, were obtained from the CEPII web-site[46]. Data on standards was explained in section 2.3.

[45] The sample size for 131 exporting countries, 15 importing countries, 3 electronic categories, and 17 years is 100,215.

[46] http://www.cepii.fr/anglaisgraph/bdd/distances.htm

Exports to the EU in electronics have increased over time. In average, information technology products represent 50 percent of electronic exports to the EU meanwhile consumer electronics and electronic components represent 32 percent and 18 percent, respectively. Table 6 shows EU import composition by exporter regions. East Asian and Pacific countries are clearly the major source of EU imports, with exports accounting for more than 80 percent in each category.

EU tariffs for electronic products decreased continuously as the electronics sector experienced a period of sustained liberalization. This pattern coincides with the implementation of the Information Technology Agreement (ITA), a sectoral tariff-cutting multilateral agreement negotiated by an important number of WTO member countries in 1996 for several IT products.[47]

Econometric Strategy

The econometric strategy was guided by the trade-offs resulting from the presence of a large number of observations with zero-exports in the data: about 57 percent of observations. To deal with zero-exports, estimations were carried out with several econometric methods, using a logarithmic transformation in the dependent variable to avoid giving too much weight to observations with a high-volume of exports. However, the use of logarithms brings in a truncation problem for observations with zero-exports. The standard solution in the literature (see for instance Frankel et al. (1997)) consisted of shifting all export values by one dollar before applying the logarithmic transformation, so that the dependent variable in 15 $ln(1 + M_{ijt}^k)$. This increases the mean of exports by one unit without affecting its variance. In addition, with this correction, product categories with zero exports are linked to zero values of the dependent variable. Then, Tobit estimation may appropriately account for the censorship of the dependent variable. However, as shown by de Melo and Portugal-Perez (2008), coefficient estimates can be very sensitive to this (arbitrary) choice of adding one dollar. Therefore, it is prudent to explore alternatives.

Eaton and Tamura (ET 1995) proposed to estimate a variation of the Tobit model in which the independent variable is $ln(a_v + M_{ijt}^k)$ and the maximum likelihood (ML) function is modified

[47] ITA set tariffs for all products listed in its Declaration at a zero-level after an implementation period. As to the three categories we consider, almost half (47 per cent) of their number of tariff lines were affected by ITA, accounting for 25 per cent of total EU imports volume in these categories.

to endogenize the choice of the a_v parameter. Then, the ML estimator includes an estimate of the value of among the set of estimates which means that the dependent variable will be censored at the value (see de Melo and Portugal-Perez (2008) for technical details on the Eaton Tamura (ET) tobit Model).

Along the same lines, Santos Silva and Tenreyro (SS-T) (2006) propose a Poisson Pseudo Maximum Likelihood (PPML) model to deal with heteroskedasticity in constant-elasticity models, such as log-linear gravity models. Using Monte-Carlo simulations, they show that that the PPML produce estimates with the lowest bias for different patterns of heteroskedasticity. However, Martin and Pham (2008) noticed that the data-generating process used by SS-T did not produce zero-values properly. When correcting the data-generating process to obtain a sample with an important amount of zero-value observations -a situation closer to ours - Martin and Pham find that the ET-Tobit estimates have a lower bias than those obtained with the PPML estimator.

The above formulation captures the impact of trade costs on bilateral trade volumes. However, the impact that we are capturing is conditional on trade taking place between the two countries, i.e. on $M_{ijt}^k > 0$. Zero or missing trade flows are excluded from the effective sample in 15, which has been shown to bias the resulting coefficient estimates (e.g., Helpman et al., 2008). Moreover, equation 15on its own does not allow us to say anything about the second part of our working hypothesis, which has to do with export propensity. Ideally, one would want to implement a two-stage procedure in which a decision to export a specific product is taken in a first stage (selection equation), then in a second stage a decision is taken on volume (outcome equation) as in Helpman, Melitz and Rubinstein (2008)[48]. Indeed, we also estimate a Heckman (1979) sample selection model. Such an approach requires an appropriate exogenous instrument that would influence only the decision to export in the first-stage and not the volume of exports in the second stage in order to comply with the exclusion restrictions of the two-stage method. At this high level of disaggregation with panel data, the only potential instrument in this data set would be the lagged decision

[48]The first stage consists of a probit regression that explains the probability that country i exports to country j (selection equation), where the dependent variable is a dummy that is equal to one if country i exports to country j. The second stage consists of a gravity equation estimated in logarithmic form that explains the volume of exports from i to j (outcome equation) and incorporates a term based on estimates of the first-stage, known as the inverse Mills-ratio, to correct for the non-random prevalence of zero trade flows and intra-sector firm heterogeneity.

to export (represented by a dummy that is equal to one if the product was exported from country i to country j in the preceding period).[49]However, since there is not much heterogeneity in this indicator, we are also inclined to retain ET-Tobit estimates.

Another issue to be addressed is the possible endogeneity of the standards count variables, $IH\_stds_t^k$ and $NIH\_stds_t^k$ in all three types of electronics, to trade flows. The number of standards in a particular sector could, in a general sense, be endogenous to imports through a political economy process. Moreover, we take into consideration exports to the EU from a large group of countries. It is therefore unlikely that sector-wide standards in electronics -which apply to both domestic production and imports from all sources- are set in response to unexpectedly large imports from a single country in a single year. As robustness checks we include alternately in our regressions lagged count variables for standards, see below in table 8. Although we do not expect major problems with endogeneity in this case, we leave for future research alternative ways of dealing with it.

2.6 Econometric Results

We first report the results for the baseline equation using the different estimation techniques discussed above in the empirical strategy. Then, we carry out robustness checks using the ET-Tobit and Heckman selection estimators, our preferred ones.

Baseline Results

Table 7 reports the estimates from equation 15 obtained under several estimation methods. Column 1 reports the OLS method with the logarithm of exports, $ln(M)$,as dependent variable. Columns 2 and 3 report Tobit-type of estimates for 15.The "standard" Tobit estimates in column 2 account more appropriately for the censorship of the dependent variable. Now the dependent variable is the log of imports plus one dollar, implying that av=1. However, as discussed before, all coefficient values, are very sensitive to the choice of av used to avoid truncation. Column 3 goes one step further and reports the ET-Tobit estimates that also estimates the value of av that fits best the

[49]Helpman, Melitz, and Rubinstein (2008) employ a two-stage Heckman estimation procedure in cross-section estimates. In order to comply with the exclusion restriction condition, they use separately two instrumental variables in the first-stage probit excluding them from the second-stage: a common religion variable and a variable on the regulation costs of firm entry in a country.

data. Column 4 and 5 report estimates for the outcome and the selection equations of the Heckman selection model. Finally, column 5 reports estimates when applying the Poisson Pseudo Maximum Likelihood (PPML) model recommended by Santos Silva and Tenreyro (SS-T) (2006) to deal with heteroskedastic errors in log-linear gravity models.

Most coefficients are significant with reasonable magnitudes and expected sign across estimation methods. Among the standard gravity variables, distance is negative and statistically significant, while a colonial relationship (statistically significant) and common official language (statistically significant) are both positive. The coefficient of the applied tariff is negative and significant except in the last column for the PPML, confirming the negative impact tariffs have on imports. A possible explanation for the sign reversal when using the PPML method lies on the fact that the dependent variable is in level rather than logarithmic form, giving more weight to extreme observations and, the loss in precision being attributable to giving probably too much weight to very noisy data at the level at which product categories are defined.

We find that all estimated coefficients for the count of internationally harmonized standards in each category of electronics goods are positive and significant across all columns. The results are less homogenous for non-harmonized variables. Although coefficients for non-harmonized standards in category 3 are all positive, the non-harmonized standards coefficients in categories 1 and 2 have different signs across estimation methods. However, when non-harmonized standard coefficients are positive, their magnitude is always smaller than corresponding coefficients for harmonized standards[50], as confirmed more formally when carrying out hypothesis tests (not reported here).

Robustness Checks

For next results, we only report estimates of the ET-Tobit and the Heckman selection methods, our preferred ones. As noted previously, a potential difficulty with our results is the possible endogeneity of our standards measures due to reverse causality: large export volumes to the EU may prompt international harmonization efforts. Since it is tough to find an instrumental variable at the

[50]The single exception is the coefficient for category 1 in column 5, but it is the selection equation of the Heckman selection model.

exporter-importer-category level, we deal with this issue by exploiting an institutional regularity, first noted by Moenius (2004). Standard institutes review their standards every five years so they remove standards that were introduced based on short-run considerations. Consequently, we re-run our baseline specification using two and five period lags of our standards count variables. Table 8 presents the results. Qualitatively, they are identical to our baseline results: harmonized standards exert a positive impact on trade values and export propensity, where as non-harmonized standards have a mixed result; although in cases where the impact is positive it is smaller than for harmonized standards. With five lags, coefficients of standards tend to be significant at least at the 10 per cent in fewer cases. If anything, attempting to account for endogeneity by using lag-variables tends to strengthen our initial results.

We report estimates for further robustness checks in table 9; for brevity, we only report the outcome equation results of the model estimated as a Heckman selection model. Column 1 reports estimates on a sample that excludes the 10 countries having joined the EU in 2004, whereas column 2 reports estimates on a sample that reduces the time horizon to the period 1996-2006. Estimates in both specifications are very similar. There are two main contrasts with our preferred results in table 7. First, standards count coefficients are slightly higher when the samples are reduced. Second, coefficients for non-harmonized standards in category 3 are no longer negative, but they are lower in absolute value than coefficients for internationally-harmonized standards.

We also aggregate imports across the fifteen importers, taking them as a single bloc, and estimated the model. Bilateral variables not varying over time, such as distance and colonial dummies, are dropped as we use exporter fixed effects. The estimated coefficient of our standards variable does not vary significantly, as reported in column 3 of table 9.

As we pool three categories of electronic products, an aggregation bias may arise from counting standards across a range of different products[51]. To attenuate the bias in our estimates, we estimate the model for each of the three electronic groups separately, and report estimates in columns 4 to 6. Coefficient estimates for harmonized standards remain positive and significant and of similar

[51] We thank an anonymous referee for pointing this out.

magnitude to baseline estimated coefficients. As discussed earlier, the available mapping does not allow identifying the standards applying to more disaggregated categories of goods. To test our model at a finer level, we use data from Reyes (2010), who identifies product standards for micro-circuits and semi-conductor devices (SITC categories 7763 and 7764) -a subgroup of category 1- are identified. Column 7 reports results of the model estimated to this finer category. The number of observations is smaller as fewer countries export these products to the EU.

Finally, omitted variable bias and measurement error leading to our large estimated values could have resulted from omitting the exchange rate differential between exporter and importer currency as it could also have an impact on exports. Nevertheless, when adding the ratio of importer/exporter exchange rates (with respect to the dollar), its effect was not significant (not reported here).

2.7 Concluding Remarks

This analysis centers on evaluating the impact of international harmonization of product standards on trade in electronic goods. We estimated a micro-founded gravity- model of trade to find robust empirical evidence on the positive impact of EU standards aligned with international norms on both EU import volumes of electronic products and the propensity to import. This result remains robust to alternative specifications, samples, and estimation methods.

We have also shown the differentiated impact of harmonization on three categories of electronics: electronic components, consumer electronics and telecoms, and information technology. Although a positive and robust relationship between international harmonization and trade seems to appear in all of the three categories, we found that EU-specific standards not aligned to international norms have a mixed impact on trade across sectors and estimation methods used. Yet, even when the impact of non-harmonized standards is found to be positive, the trade-effect is smaller than with internationally harmonized standards. As developing countries in East Asia are the main exporters of electronic products to the EU, they are the main beneficiaries of harmonization of standards.

Compared with previous empirical work on EU standards harmonization in textiles under-

taken by Czubala et al. (2009) -where internationally harmonized standards were shown to have a negative effect on imports from Africa, although a more mitigated adverse effect compared to non-harmonized standards- the evidence in this paper confirms the importance of international harmonization of standards on the commercialization of more complex goods, such as electronics, as well as on their production and consumption.

From the empirical point of view, our paper builds on previous work and improves it in three fundamental ways. First, we consider the differentiated impact of international harmonization across three categories of electronics as opposed to considering the average impact on the whole sector. Second, this paper considers the full set of exporters to the EU in a sector, so that selection bias does not become an issue. Third, among the estimation techniques explored, we obtain Heckman and ET-tobit estimates that adequately control for the important proportion of observations with zero-exports at the disaggregated level.

The policy implications of these results are of significant interest. The evidence makes a strong case for deepening efforts on international harmonization in electronics with a positive and significant impact on trade. In addition, new products are likely to need more standards and international harmonization may contribute to restrain an inefficient proliferation of standards. Building on the Information Technology Agreement, for example, could include talks to undertake commitments to harmonize standards in electronics products to international norms. Moreover, the WTO Technical Barriers to Trade Agreement encourages harmonization of standards and includes the Code of Good Practice to promote this objective. Concrete options to achieve wider use of international standards in support of the Agreement have specifically been discussed in the electronics sector[52], and there are a number of initiatives underway in regional trade and industry groups to harmonize standards in electronic and electrical products. The organizations with active initiatives include the Association of Southeast Asian Nations (ASEAN), the Asia Pacific Economic Cooperation (APEC), the Pan American Standards Commission (COPANT), among others.

[52]As a matter of fact, in September 2008 the EU submitted a proposal (G/IT/W/28) to review and initiate negotiations to update the ITA. On non-tariff barriers it proposed, "... agreement on substantive provisions concerning the recognition of internationally agreed standards and of methods of conformity assessment, in order to avoid multiple testing and enable greater economies of scale without compromising on product safety".

In regard to future research work, we view two areas of particular interest. First, there may be significant gains from collecting data through firm-surveys in major exporters in order to explore the effect of standards at the firm-level. Second, as the new database of EU standards in electronics reveals cross-sectoral variation in the number and type (harmonized vs. non-harmonized) of standards, further research on the political economy forces that play a role in standard setting behavior may also prove useful.

3 Product Standards Harmonization and Firm Heterogeneity in International Trade. [53]

3.1 Introduction

While numerous articles study the impact of trade liberalization in traditional trade policy instruments, few studies analyze the effect of liberalization in Non-Tariff Barriers (NTBs). This paper examines the response of U.S. manufacturing firms to a reduction of a NTB by looking at the harmonization of European product standards to international norms in the electronic sector. Heterogeneity of product standards across market destinations is a NTB because it imposes additional costs on exporters to comply with market-specific product requirements. It also increases the time required to bring a product to the market. In this paper, I provide the first firm-level evidence of the gains of liberalization in this NTB and decompose its impact into the different margins of trade.

The Agreement on Technical Barriers to Trade (TBT), signed by WTO member countries in 1995, defined product standards as *"a document approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for products or related processes and production methods, with which compliance is not mandatory."* These characteristics are mainly safety rules but they can also include other attributes such as design, size, weight, and energy performance. Example of standards are safety requirements for sewing machines, measures of electromagnetic emissions from integrated circuits, specific guards for lawn mowers, and mechanical safety of cathode ray tubes. Although the TBT agreement encourages countries to adopt international standards whenever possible, it also recognizes the rights of countries to adopt measures to the extent they consider appropriate — for example, for human, animal or plant life or health, for the protection of the environment, or to meet other consumer interests such as the prevention of deceptive practices.

[53] I am grateful to Rod Ludema for guidance and encouragement throughout the completion of this project. I am also deeply in debt with Brad Jensen for delightful discussions. I thank John Wilson for kindly sharing The World Bank EU electrotechnical product standards database with me. I also thank Andrew Bernard, Peter Schott, Francis Vella, Lindsay Oldenski, Peter Swann, Blind Knut, Justin Pierce, and Danielken Molina for their comments. The research in this paper was conducted while the author was a Special Sworn Status researcher of the U.S. Census Bureau at the Center of Economic Studies Research Data Center in Washington DC. Any opinions and conclusions expressed herein are those of the author and do not necessarily represent the views of the U.S. Census Bureau. All results have been reviewed to ensure that no confidential information is disclosed.

While the use of standards remains voluntary, the European Union has, since the mid-1980s, made an increasing use of standards in support of its policies and legislation. The European Commission sets compulsory regulatory goals by means of "New Approach Directives", which outline "essential requirements" associated with the manufacturing of products. The system in place does not, however, specify how specific objectives should be achieved. For the electronic sector, this role is fulfilled by product standards issued by the European Committee for Electrotechnical Standardization (CENELEC).[54] EU member countries are obliged to adopt these standards and withdraw any national standard that might conflict with them. If a manufacturer chooses to produce a product according to these standards, the product carries the CE mark, which implies compliance with the "essential requirements". On the other hand, manufacturers may use other technical specifications when manufacturing a product provided there is documentation certifying that the product meets the "essential requirements" formulated in the Directives. Nevertheless, anecdotal evidence suggests that the prohibitive costs of the latter option push exporting companies to favor compliance with CENELEC standards (see, for instance, Hanson (2005)). At the global level, the International Electrotechnical Commission (IEC) is the organization that prepares and publishes international standards for the electronic sector.

To examine the impact of the trade liberalization in this NTB, I use the CENELEC-IEC agreement to harmonize European product standards to international norms as a natural experiment. The Lugano Agreement, signed in 1991, and the Dresden Agreement, signed in 1996, sought to expedite the adoption of international standards in the EU as well as to facilitate the adoption of EU standards internationally. This synergy has taken the number of purely European standards as a share of all standards published by CENELEC from 50 percent in the early-1990s to 25 percent in 2008. In this context, the decrease in the share of idiosyncratic standards is a liberalization in a NTB to international trade.

[54]For example, the Low Voltage Directive (2006/95/EC) outlines "essential requirements" for electrical equipment with a voltage between 50 and 1000 V for alternating current and between 75 and 1500 V for direct current. Among other conditions, it establishes that "persons and animals are adequately protected against the danger of physical injury or other harm which might be caused by direct or indirect contact". Consequently, CENELEC issued a standard (EN 50371:2002) to demostrate the compliance of low power electronic and electrical apparatus with the basic restrictions related to human exposure to electromagnetic fields (10 MHz - 300 GHz).

Product standards are an important, albeit often overlooked, actor in the international trade arena.[55] Currently, there are two broad types of concerns: First, Product standards are sometimes more prescriptive or restrictive than they need to be to achieve the health and safety outcomes desired by the community. Second, differing requirements between countries can result in substantial additional costs for producers and mean that foreign firms are in effect shut out of the market. Regarding the former point, the Semi-Conductor Equipment and Material Association (1997) found the average cost of U.S. manufactures for certifying one type of machine in the EU was $92,000. Additionally, Hanson and McKinney (2005) conclude that smaller Pennsylvania manufactures had lost, on average, $380,000 per year in European sales due to European product standards. Concerning the latter issue, the United States Trade Representative, in the Annual Report on Foreign Trade Barriers (2007), singled out the divergence of product standards for product sold in the EU and in the U.S. as a source of additional cost for U.S. exporters as well as an extra factor increasing the required time to bring a product to market. This is not a new complaint, the same issue was raised in the report on trade barriers for 1995, 1996, 1999, and 2001.

To study the impact of European product standard harmonization on U.S. manufacturing firms, I develop and estimate a tractable general equilibrium model of international trade that includes productivity heterogeneity across firms and product standards diversity across market destinations. The model is a three-country version of the Melitz (2003) framework in which I assume that two countries have different but equally costly product standards (countries H and F) while the third country has less stringent product requirements (country R). After setting out the base case scenario without harmonization, I modify the model to allow harmonization between countries F and R and characterize the trade impact in country H. The theory provides three testable results: First, harmonization decreases export sales of $H's$ existing exporters to country F, the intensive margin of trade. Second, harmonization increases the number of $H's$ exporting firms to market F, the extensive margin of trade. Third, new entrants are mainly drawn from the most productive set of H's firms exporting to country R, the extensive margin of trade composition. These firms are

[55] Sykes (1995) and WTO (2005) present an excellent overview of product standards in the multilateral system and its impact on trade.

characterized by being smaller and less productive than the incumbent exporters to country F.

To test these results empirically I merge two newly available datasets: the Linked/Longitudinal Firm Trade Transaction Database (LFTTD), which links individual trade transactions to firms in the US, and the World Bank EU Electrotechnical Standards Database (EUESDB), which provides an inventory of the stock of active standards published by CENELEC and their link with standards issued by the IEC. The LFTTD spans 13 years from 1992 to 2004 and allows the researcher to use information from the Censuses of Manufactures (CM) of the Longitudinal Research Database (LRD) of the U.S. Census Bureau to pin down additional firm characteristics on a quinquennial basis. The EUESDB covers the period 1990-2007 and classifies product standards according to the International Classification of Standards (ICS). A key contribution of my analysis is the linking of firm level U.S. manufacturing data to industry level measures of EU product standards. Since there is currently no official concordance mapping from ICS codes to any product or industry classification system, I develop a concordance method between 5-digit ICS codes and 4-digit SIC industries for the Electronic sector.[56]

Results are largerly consistent with theoretical implications. First, I confirm that U.S. industries with relatively high harmonization and high reduction in tariff rates exhibit relatively high U.S. export value to the EU. Furthermore, I show that this impact is negative for the intensive margin of trade: the change in the value of U.S. goods that are already exported to the EU within surviving trade relationships, e.g., the same firm exporting the same product to Europe throughout the time span. Second, I find that product standards harmonization increases the probability that higher-productivity firms enter the EU market whereas tariff rates do not affect entry decisions. Third, I show that this impact is more relevant for U.S. firms that were already exporters serving developing countries than for firms entering the export activity. Overall, the empirical findings suggest that EU product standards harmonization contributes significantly to explain the export entry patterns observed in my sample of U.S. firms.

These results have an important policy implication. The U.S. National Export Initiative laid

[56]The concordance is available at http://sites.google.com/site/josedanielreyesp/

down by President Obama in March 2010 seeks to double U.S. exports over the next five years by enhancing small and medium sized firms' ability to enter export markets and by actively reducing barriers to trade. The results obtained in this paper suggest that working towards a reduction in the differences of product requirements across markets could be a supportive policy to incentive firm entry into export markets.

The remainder of the paper is structured as follows. The next section develops the theoretical model. Section 3 describes the data set and presents summary statistics. Section 4 presents the empirical strategy and report results from testing the main theoretical results. Concluding remarks are offered in section 5. Finally, appendix 2 contains theoretical derivations and appendix 3 presents details of the data set.

3.2 A Model of Product Standards Harmonization

In this section, I present a model featuring the role of product standards heterogeneity across market destinations and productivity heterogeneity across firms. The model is a straightforward extension of the Melitz (2003) framework in which I allow the fixed cost to export to vary bilaterally in a three-country version of the model. These costs arise from the adaptation of products and production processes to foreign standards and technical regulations. After setting out the base case scenario without harmonization, I modify the model to allow product standard harmonization covering two of the three countries. The impact of harmonization on the third country is then analyzed.

3.2.1 Preferences

The three markets, indexed by $i \in \{H, F, R\}$, are symmetric. Labor is the only factor of production and each country is endowed with L units of labor, which is also the measure of each market. Consumers have no taste for leisure and inelastically supply their labor at the market prevailing wage rate. Consumers derive utility from the consumption of a continuum of differentiated varieties, indexed by ω, produced under increasing returns to scale and costly trade. The preferences of a representative consumer are given by the following CES utility function.

$$U = \left[\int_{\omega \in \Omega^i} q(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}} \tag{16}$$

where Ω^i represents the mass of available goods in country i, $q(\omega)$ is the quantity of variety ω consumed, and σ is the elasticity of substitution between any two goods, $\sigma > 1$. This specification of utility gives rise to the following isoelastic demand functions.

$$q\left[p(\omega)\right] = \frac{E^i p(\omega)^{-\sigma}}{{P^i}^{1-\sigma}} = d^i p(\omega)^{-\sigma} \tag{17}$$

where $d^i = \frac{E^i}{{P^i}^{1-\sigma}}$ is a demand shifter parameter, $E^i = L$ is total expenditure by that country's consumer, and P^i is the aggregate price index of market i given by:

$$P^i = \left[\int_{\omega \in \Omega^i} p(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}} \tag{18}$$

3.2.2 Production

There is a continuum of single-plant, single-product firms, each choosing to produce a different variety ω. The cost function is represented by a constant marginal cost, c, with a fixed start up cost[57], f_d: $l = f_d + cq$. Firms also face country-specific fixed costs, f_x^i, to export their products to foreign markets, $(f_d < f_x^i)$. To sharpen the role of heterogeneity in the fixed cost to export, variable trade costs are set equal to zero.[58] The fixed costs to export reflect the investment required to establish a production process that manufactures goods which accord with product standards in country i. Firms face cost heterogeneity by assuming that c is a random draw from a common distribution $g(c)$ with cumulative density function $G(c)$ and support $[0, \bar{c}]$. Exporters confront product standards heterogeneity across market destinations by assuming that $f_x^R < f_x^F$ and $f_x^H = f_x^F$.[59] Profit maximization leads to the following pricing rule:

$$p(\omega) = \frac{\sigma}{\sigma - 1} cw \tag{19}$$

where w is the common wage rate hereafter normalized to one. The constant mark up pricing is

[57] This overhead cost is assumed to be the same across countries.

[58] The basic insights of the model does not change if I allow $\tau^i > 1$, and $\tau^R > \tau^F$.

[59] Home country and Foreign country have different but equally costly product standards.

equal across market destinations due to the assumption of no variable trade costs.

The conditional profit function for domestic firms (π_d^i) and exporters from country i to country j (π^{ij}_x) can be expressed as:

$$\pi_d^i = c^{1-\sigma}\frac{d^i}{\sigma}\left[\frac{\sigma}{\sigma-1}\right]^{1-\sigma} - f_d \tag{20}$$

$$\pi^{ij}_x = c^{1-\sigma}\frac{d^j}{\sigma}\left[\frac{\sigma}{\sigma-1}\right]^{1-\sigma} - f_x^j \tag{21}$$

where $\{i,j\} \in \{H,F,R\}$ and $i \neq j$.

Profit functions for the Home country are depicted in figure 11. In this figure, $c^{1-\sigma}$ is represented in the horizontal axis. Since $\sigma > 1$, this variable increases monotonically with labor productivity, $\left(\frac{1}{c}\right)$, and can be used as a productivity index. Profits from export are lower because $f_d < f_x^j$. Profits from export to country F are lower than profits to export to country R because $f_x^R < f_x^F$. The slope of π^F is greater than the slope of π^R because, in equilibrium, $d^R < d^F$.[60]

3.2.3 Equilibrium

The equilibrium in each economy is given by the labor market clearing condition, the zero cutoff profits condition, and the free entry condition. The labor market clearing condition ensures that total expenditure equals the total revenue of consumers $E^i = L$. Equations 20 and 21 provide the maximum marginal costs above which it is not possible to profitably supply the domestic market in country i, c_d^{i*}, and export to country j, c_x^{ij*}.

$$c_d^{i*} = \left[\frac{d^i}{f_d\sigma}\right]^{\frac{1}{\sigma-1}}\left[\frac{\sigma-1}{\sigma}\right] \tag{22}$$

$$c_x^{ij*} = \left[\frac{d^j}{f_x^j\sigma}\right]^{\frac{1}{\sigma-1}}\left[\frac{\sigma-1}{\sigma}\right] \tag{23}$$

[60] See appendix 2.

The export threshold is increasing in the demand level in every country, d^j, and decreasing in the cost to comply with product standards, f_x^j. The partitioning of firms by export status within each country is ensured by $f_d < f_x^j$. Under this assumption, firms drawing marginal cost above the maximum marginal cost c_d^{i*} will exit the industry. Those drawing marginal cost below c_d^{i*} will engage in profitable production. In addition, if the firm's marginal cost is below the export marginal cost threshold, c_x^{ij*}, the firm also exports to country i. Figure 11 depicts these thresholds for the Home country.

A free entry condition closes the equilibrium of the model. It ensures equality between the expected operating profits of a potential entrant and the entry cost f_E.

$$\int_0^{c_d^{i*}} \left[\pi_d^i\right] dG(c) + \int_0^{c_x^{ij*}} \left[\pi_x^{ij}\right] dG(c) + \int_0^{c_x^{ik*}} \left[\pi_x^{ik}\right] dG(c) = f_E \ \ \forall i \tag{24}$$

where $\{i, j, k\} \in \{H, F, R\}$ and $i \neq j \neq k$. See appendix 2 for an overview of the unique equilibrium in this economy.

From H's standpoint, F's more restrictive trade policy makes that market tougher for a firm to export to it for two reasons: first, there is the direct effect of more costly product standards which reduces a firm's profits; second, there is an indirect effect via the demand level in the market. The appendix shows that as long as the relative foreign fixed cost to export is large, only the more productive firms serve the foreign market. Productivity, thus, provides a natural hierarchy of firms, with less productive firms only serving market R (OR firms) whereas more productive firms being able to export also to market F (AF firms).

3.2.4 Product standard harmonization

Harmonization of product standards between country F and country R involves a single fixed cost, $\widehat{f_x}$, that home producers now must pay in order to access all foreign markets. The mutual recognition of standards involves a new fixed cost in between the pre-harmonization levels: $f_x^R \leq \widehat{f_x} \leq f_x^F$. Home country does not modify the stringency of domestic product standards, therefore the fix cost to export to H remains unchanged.

In this new situation, the profit function for domestic firms does not change. Accordingly, the domestic market productivity cutoffs are still given by equation 22. Since home producers now are only required to pay a single fixed cost to export to F and R, H's conditional profits from export collapse into a single equation.

$$\widehat{\pi_x^H} = c^{1-\sigma}\left[\frac{d^F + d^R}{\sigma}\right]\left[\frac{\sigma}{\sigma-1}\right]^{1-\sigma} - \widehat{f_x} \tag{25}$$

Consequently, H's marginal cost cutoff for exporting to both markets, $\widehat{c_x^H}$, is given by.

$$\widehat{c_x^H} = \left[\frac{d^F + d^R}{\widehat{f_x}\sigma}\right]^{\frac{1}{\sigma-1}}\left[\frac{\sigma-1}{\sigma}\right] \tag{26}$$

The conditional export profit from F and R to H are still given by equation 21, but the profits to export within the harmonized zone, $\widehat{\pi_x^{ij}}$, and the new marginal cost thresholds, $\widehat{c_x^{ij}}$, can now be written as follows.[61]

$$\widehat{\pi_x^{ij}} = c^{1-\sigma}\left[\frac{d^j}{\sigma}\right]\left[\frac{\sigma}{\sigma-1}\right]^{1-\sigma} - \widehat{f_x} \tag{27}$$

$$\widehat{c_x^{ij}} = \left[\frac{d^j}{\widehat{f_x}\sigma}\right]^{\frac{1}{\sigma-1}}\left[\frac{\sigma-1}{\sigma}\right] \tag{28}$$

where $\{i,j\} \in \{F,R\}$ and $i \neq j$.

These changes to the profit condition require corresponding changes to the free entry condition:

$$\int_0^{c_d^H}\left[\pi_d^H\right]dG(c) + \int_0^{\widehat{c_x^H}}\left[\widehat{\pi_x^H}\right]dG(c) = f_E \tag{29}$$

$$\int_0^{c_d^{i*}}\left[\pi_d^i\right]dG(c) + \int_0^{c_x^{iH*}}\left[\pi_x^{iH}\right]dG(c) + \int_0^{\widehat{c_x^{ij*}}}\left[\widehat{\pi_x^{ij}}\right]dG(c) = f_E \; for \; \{i,j\} \in \{F,R\} \; i \neq j \tag{30}$$

Product standards harmonization involves two opposite effects in the Home country. On the

[61] To ensure selection of firms by export status within countries F and R, I assume that nonlocal firms still face higher fixed costs when selling to the local market. Even though they share product standards, they incur in a cost to export due to conformity assessments, for example.

one hand, it gives firms access to a bigger market upon the payment of a single fixed cost. On the other hand, it entails a fixed cost to export which is higher than the pre-harmonized fixed cost to export to R. The relationship between these impacts determines the consequences of product harmonization. See appendix 2 for an overview of the equilibrium.

Some OR firms, conditional on their productivity, are now able to enter the F market because the increase in the market size outweighs the increase in the fixed cost to export. The share of OR firms that enter the F market depends on the relative stringency of the harmonized standard. If $\widehat{f_x}$ is "close" to f_x^F, only the most productive firms within the OR firms find it profitable to remain as an exporter serving both markets.[62] Figure 12 illustrates this situation. New entrants to the F market are characterized by the segment $[(\widehat{c_x^H})^{1-\sigma}, (c_x^{HF*})^{1-\sigma}]$. Conversely, low productivity OR firms drop export participation because the increase in the fixed cost to export offsets the increase in the market size; those firms are located in the segment $[(c_x^{HR*})^{1-\sigma}, (\widehat{c_x^H})^{1-\sigma}]$.

If the harmonized standards is undemanding, meaning $\widehat{f_x}$ is "near" f_x^R, then all OR firms enter the F market[5]. Furthermore, the more productive non-exporter firms are now able to become exporters to F and R because the market size effect outweighs the modest increase in the fixed cost to export. Figure 13 describes this situation. New entrants to the F market are depicted in the interval $[(\widehat{c_x^H})^{1-\sigma}, (c_x^{HF*})^{1-\sigma}]$. New exporters are located in $[(\widehat{c_x^H})^{1-\sigma}, (c_x^{HR*})^{1-\sigma}]$ whereas OR firms entering the F markets are situated in $[(c_x^{HR*})^{1-\sigma}, (c_x^{HF*})^{1-\sigma}]$.

Firm entry into the foreign market has an impact on the average sale of AF firms —the intensive margin of trade. New entrants push the the aggregate price index of market F down and reduce the optimal quantity demanded of a given firm, see equation 17. Harmonization, then, involves a negative impact for AF firms because it increases the competition in the foreign market. Even though I model product standards as a fixed cost to export they may also affect the variable cost.[63] If this is the case, harmonization may increase exports from AF firms due to the reduction in the ongoing costs. As it turns out in the empirical application, the fixed cost aspect seems to be the

[62] See appendix 2 for this condition.

[63] Such as periodic testing or higher marginal costs that stem from a low scale of production. see Baldwin (2000), Chen and Mattoo (2004), and Baller (2007).

key factor driving the trade impact of product standards harmonization.

This theoretical framework gives rise to three testable hypotheses on the impact of product standard harmonization on third countries:

1. Product standards harmonization decreases export sales at existing exporters. The intensive margin of trade.

2. Product standards harmonization increases the number of $H's$ exporting firms to market F. The extensive margin of trade.

3. New entrants are mainly drawn from the most productive set of OR firms. The extensive margin of trade composition.

The model presented above is fairly flexible in terms of the assumption on the level of stringency of international norms in country R. Note that hypotheses 1 and 2 remain unchanged if I assume that country F and country R have different but equally costly product standards to begin with. In this case, harmonization involves a different composition of the extensive margin of trade (hypothesis 3). It is represented now by entry from the most productive non-exporter firms because they can now access both markets upon the payment of a single fixed cost. Alternatively, I can relax the assumption that country R uses international norms and get the same theoretical results. In this scenario the only required assumption is that country R has lower fixed costs to export than country F and that harmonization entails some reduction on the cost to export to country F due to, for example, the elimination of standards aimed to protect domestic firms.

A corollary of this model is that harmonization may also explain firm entry into market R. This is the case if the harmonized standard is "close" to the less stringent standard in the pre-harmonization scenario or if both R and F regions have equally costly standards. In both cases, the increase in the market size triggers entry from the most productive non-exporters firms.

3.3 Data

This analysis uses the U.S. linked/Longitudinal Firm Trade Transaction Database (LFTTD), which links individual U.S. trade transactions to U.S. firms in the Longitudinal Business Database (LBD)[64], in conjunction with firm level information from the Censuses of Manufactures (CM) of the Longitudinal Research Database (LRD) of the U.S. Census Bureau. A key contribution of this study is the linking of firm level U.S. manufacturing data to industry level measures of EU product standards and their relationship with international norms. This section outlines the main features of the datasets.

3.3.1 U.S. Manufacturing firms Across Industries and Time

The CM is conducted every five years and the empirical part of this paper makes use of CM information from 1992, 1997, and 2002.[65] The unit of observation for the Census is a manufacturing establishment, or plant, and it contains detail information on inputs and output of all establishments.[66] For 1992 and 1997, plants are classified at the four-digit Standard Industrial Classification level (SIC4). In 2002, industry classification changed to the North American Industry Classification System (NAICS). Details of the construction of the variables can be found in appendix 3.

The empirical analysis concentrates on the Electronic sector (SIC 36). This sector was chosen because of the availability of EU product standards data. This sector consists of 36 SIC4 Industries that ranges from vehicular lighting equipment and electric lamps to semiconductors and transformers. Table 10 provides a description of the relative level of detail between industries. U.S. exports to the EU in this sector represents roughly 15.0 percent of total exports to the EU between 1992 and 2002.

Table 11 shows firms' characteristics by exporting and non-exporting firms for 1992 and 1997.[67]

[64] See Bernard et. al. (2005) for a complete description of the LFTTD and its construction. For an extensive discussion of the LBD see Jarmin and Miranda (2002).

[65] Though CM data are available for earlier periods, I cannot use them because export information on the LFTTD is not available.

[66] The CM imputes input usage data for small manufactures, referred to in the data as "administrative records". As it is customary in the U.S. microdata research —see Bernard, Redding and Schott (2010)—, these observations are excluded from the analysis.

[67] I do not present data for 2002 because the change in industry classification does not allow me to observe entry

Exporting firms are further divided into the set of firms that exports to the EU and those that export to other markets. As expected, exporters —nearly half of the firms— are bigger than non-exporters in terms of average value of shipments and average employment. Around half of exporting firms are multi-plant firms. Interestingly, and consistent with the theoretical model presented in section 2, exporters' characteristics differ in terms of the market destinations. Exporters to the EU are bigger and export more than exporters to other markets. Finally, there is firm entry into export markets across years, which —I argue— can be partially explained by the role of European product standards harmonization.

3.3.2 Trade Costs Across Industries and Time

Measuring the extent of product standardization across export market destinations is not an easy endeavor. I used The World Bank EU Electrotechnical Standards Database (EUESDB) to gauge this effect and to assess the degree of harmonization of EU standards with international norms. The EUESDB provides the first catalog of European standards in the electrotechnical sector[68] and their relationship with worldwide standards. The database provides an inventory of the "stock" of active standards[69] issued by the European Committee for Electrotechnical Standardization (CENELEC) and their link with standards issued by the International Electrotechnical Commission (IEC). Product standards are classified according to the International Classification of Standards (ICS) and the database covers the period 1990-2007.[70] See Portugal-Perez et. al. (2010) for a full description of the EUESDB and its construction.

An important contribution of my analysis is the creation of a new set of industry level measures of EU product standards for the Electronic sector. There is currently no official concordance mapping from ICS codes to any product or industry classification system.[71] I deal with this issue by proposing a concordance between 5-digit ICS codes (ICS5) and SIC4 industries. The construction

of new firms into sic4 industries for that year. This issue is not problematic for the empirical application since the model does not predict any role for product standard harmonization in domestic firm entry and exit.

[68] This sector refers to electrical, electronic and related technologies. More information can be found at www.iec.ch.

[69] The primary variable of interest in the total number of standards with which an exporter should comply during a particular year.

[70] A list of the ICS codes can be found at www.iso.org/iso/ics6-en.pdf

[71] Blind (2004) proposes a partial concordance from ICS codes to SITC codes. However, this bridge is too aggregate at the ICS level so individual SITC codes are mapped to a large number of ICS codes.

of this mapping involves a three-step procedure. First, I obtain the 10 digit HS codes (HS10) within each SIC4 industry from Pierce and Schott (2009). Second, I search the PERINORM database[72] —the source dataset for the EUESDB— and tabulate the ICS5 codes associate with the set of HS10 codes within each SIC4 industry. Third, I tabulate standards by those ICS5 codes in the PERINORM dataset and select the ICS5 codes whose standards are actually related to the industry into which they were classified in step two. "Terminology" or "vocabulary" standards are not taken into account. Table 12 presents this concordance and the description of the ICS codes within each industry.

The theoretical model suggests that the heterogeneity of product standards across market destinations is a barrier to trade. I define the non-harmonized share of standards for industry i in year t (NH_t^i) —a proxy for this NTB measure— as the number of CENELEC standards that are not "identical" to an existing IEC standard as a share of the total number of standards in each SIC4 industry. I also compute the tariff rate for industry i in year t (τ_t^i) as the weighted average rate across all 6-digit HS products within each SIC4 industry, using EU's import value from the U.S. as weights.

Table 13 reports average tariff and non-tariff trade costs across SIC4 industries for five-year interval from 1992 to 2002. European tariff rates decline across a broad range of industries over time in the Electronic sector. Indeed, over the entire period, tariffs were halved for approximately 40 percent of industries. The rate of tariff declines, however, varies substantially across industries. According to the directives laid down by the Lugano and the Dresden agreements, European product standards have progressively been harmonized to international norms. The decline in the non-harmonized share of standards also differs across industries. The highest reduction is among industries producing household appliances, including cooking equipment, refrigerators, laundry equipment, and vacuum cleaners.

In addition to being a good match to the theory, the trade costs constructed here have several advantages. First, they are derived directly from a database used by firms to document the reg-

[72] PERINORM is a bibliographic database maintained by the British, French and Germand standard-setting bodies. It is designated to facilitate industry access to product standards and technical regulations.

ulation requirements to export to the European Union. Second, they vary across industries and time. Even with these advantages, some caveats should be noted. First, the EUESDB does not provide information on which to base an assessment of the relative technical complexity of individual standards. Constructing such a measure requires highly specialized technical and commercial information that is currently not available. Second, product standards might vary across products within an industry. Mapping standards to products, however, is quite difficult and would have to be done manually.[73] Given the number of standards for electronic products this option is not currently feasible.

3.4 Empirical Analysis

In this section, I explore the firm-level relashionship between changing trade costs, export growth and firm entry decisions. I confront the model's main predictions with the data. In particular, I estimate the impact of EU product standards harmonization on U.S. export value and I decompose the effect into intensive and extensive margins. Overall, the empirical findings suggest that EU product standards harmonization contributes significantly to explain the export entry patterns observed among U.S. firms.

The theoretical results presented in section 2 are robust to different assumptions on the degree of stringency of international standards as well as to the level of adoption of international norms in region R. Accordingly, in the empirical analysis, I need to define a set of countries that use international standards if they use product standards at all. The empirical part makes use of the agreement on Technical Barriers to Trade where the World Trade Organization urges its members to use International Standards whenever possible. Given the institutional capacity required to create regional product standards, developing countries are assumed to mostly use international product standards if they use product standards at all.[74] In terms of the theoretical model, developing countries are embedded into the R region whereas Europe and the U.S. are represented by regions

[73] A manual mapping has been implemented for the textiles sector in Shepherd (2006) and used by Shepherd (2007) and by Czubala et. al. (2009).

[74] I define the developing country group as including all countries in The World Bank's high middle income and low middle income groups. I use the classification for July 2009, which is in effect until July 2010. The list can be found at http://go.worldbank.org/K2CKM78CC0. China and India are excluded because they have prolific national institutes of standardization.

F and H, respectively.

3.4.1 Export Value

The existing literature has found robust evidence on the positive impact of product standards harmonization on export volume (Shepherd (2006), Czubala et. al (2009), and Portugal-Perez et. al. (2010)). I test this result in my data by estimating a gravity-type equation where the role of firm heterogeneity is properly taken into account. Specifically, I regress U.S. export value of industry i to country j in year t (x^i_{jt}) on economic sizes (Y_{jt}), distances (D_j), and my measures of trade costs (τ^i_t and NH^i_t).[75] I also include the fraction of U.S. firms in industry i that export to country j in year t (W^i_{jt}) as a control for the self-selection of firms into export markets.[76] An industry is a SIC4 code and countries are the original EU-15 members.[77] D_j is the distance between the U.S. and country j whereas Y_{jt} is the GDP of country j in year t. Finally, γ_t and γ_i are sets of year and industry fixed effects and robust standards errors are adjusted for clustering at the country level.[78]

$$ln(x^i_{jt}) = \beta_0 + \beta_1 ln(D_j) + \beta_2 ln(Y_{jt}) + \beta_3 ln(W^i_{jt}) + \beta_4 ln(\tau^i_t) + \beta_5 ln(NH^i_t) + \gamma_t + \gamma_i + \epsilon^i_{jt} \quad (31)$$

Table 14 report the results of estimating specification 31 from 1992 to 2004. The first and third column use the propensity to export[79] as the dependent variable, so the sample comprises all industry-country-year cells including those with zero trade. The second and fourth column focus on the U.S. export value, and the sample is all observations with positive exports. Columns three and four control for the non-random selection of observations with positive export value using the Heckman two-stages procedure. The two stages are separately identified by functional form and the instrumental variable from the second-stage regression. An appropriate instrument is a variable

[75] Note that an increase in harmonization of standards (reduction in a NTB to international trade) implies a reduction in NH^i_t.

[76] Helpman et. al. (2008) estimate W^i_{jt} as a predicted component from a probit regression on the propensity to export. I compute it from the underlying firm level data. Details of the construction of the variables are in appendix 3.

[77] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and United Kingdom.

[78] Year fixed effects control for observable and unobservable characteristics that change across years and are common to countries and industries; like exchange rates and other type of European trade policy tool. Industry fixed effects control for characteristics that vary across industries but not across years or across countries.

[79] The propensity to export is a dummy variable which is equal to one if there are positive export flows at the industry-country-year level.

that is correlated with the probability of export but largely uncorrelated with the export volume. At this high level of disaggregation, the only potential instrument is the lagged decision to export.[80]

I find an important role for European product standards harmonization on both the export value and the propensity to export: the negative coeffients on NH_t^i and τ_t^i indicate that falling trade costs are followed by an increase in the propensity to export as well as in the export value within industry-country-year bins. Interestingly, product standard harmonization seems to be more important than tariffs for the propensity to export. Henceforth, I make use of detail firm level data to show that the impact of harmonization on trade flows is due to the entry of new exporters —the extensive margin— rather than an increase in the export value of established exporters —the intensive margin.

3.4.2 The Intensive Margin of Trade

An important implication of the theoretical model presented in section 2 is that harmonization decreases export sales at existing exporters in market F (hypothesis 1). I test the impact of harmonization on the intensive margin of trade by estimating equations 31 on the export volume of U.S. goods that are already exported to the EU within surviving trade relationships (i.e. firm-product pairs that remain as exporters to the EU for the complete set of years of my sample). This sample is the equivalent to the export value from AF firms in the theoretical model.

Results for the Heckman model are reported across the first three columns in table 15. As a way to present preliminary evidence on the different impact that harmonization exerts at the extensive margin of trade, columns fouth and five report the results of estimating equations 31 on the export volume constructed from the set of firm-product pairs that enter the EU market at some point after 1992 and that remain as exporters up to 2004. In order to make this group similar to the theoretical set of OR firms, I also require that the first time a pair is observed in the data is when it exports to a developing country and not to the EU region. I find, as expected, a positive and significant coefficient for the role of product standard harmonization in AF firms' export volume.

[80] The lagged decision to export is represented by a dummy variable that is equal to one if there were U.S. exports in industry i to country j in the preceding period.

This confirms the negative impact that European harmonization of product standards has at the intensive margin of trade of US exporters. Conversely, the coefficient for harmonization is negative and significant for OR firms's export value. Consistent with previous findings, harmonization increases the probability of observing trade within product-country-year bins. Now, I provide further evidence that the impact on AF firms' export volume is due to an increase in the number of new entrants to the EU market.

3.4.3 The Extensive Margin of Trade: New Exporters

While harmonization of product standards are important to increase U.S. export value to the EU, the theoretical model predicts that the extensive margin of trade (the number of exporting firms) accounts for this variation (hypothesis 2). I estimate the impact of falling trade costs on the probability that non-exporting firms to the EU become exporters to the EU via a logistic regression on my measure of changing trade costs, firm productivity and other firm characteristics. I use firms' information from the 1992, 1997, and 2002 U.S. Censuses of Manufactures. I define the change in trade costs for census year t as the log difference in tariffs over the preceding five years ($\triangle\tau^i_{t+5}$) and as the log difference on my measure of product standard heterogeneity over the preceding five years ($\triangle NH^i_{t+5}$). These regressions are given by:

$$
\begin{aligned}
&(\textit{Spec 1}) \quad Pr(E_{t+5}=1) = \quad \Phi(\beta_1\triangle\tau^i_{t+5} + \beta_2\triangle NH^i_{t+5} + \gamma_t + \gamma_i) \\
&(\textit{Spec 2}) \quad Pr(E_{t+5}=1) = \quad \Phi(\beta_1\triangle\tau^i_{t+5} + \beta_2\triangle NH^i_{t+5} + \beta_3 PR_t + \gamma_t + \gamma_i) \\
&(\textit{Spec 3}) \quad Pr(E_{t+5}=1) = \quad \Phi(\beta_1\triangle\tau^i_{t+5} + \beta_2\triangle NH^i_{t+5} + \beta_3 PR_t + \beta_4 Z_t + \gamma_t + \gamma_i) \\
&(\textit{Spec 4}) \quad Pr(E_{t+5}=1) = \quad \Phi(\beta_1\triangle\tau^i_{t+5} + \beta_2\triangle NH^i_{t+5} + \beta_3 PR_t + \beta_4 Z_t + \beta_5 OR\_Firm_t + \\
&\qquad\qquad\qquad\qquad\quad \beta_6 OR\_Firm_t * \triangle NH^i_{t+5} + \gamma_t + \gamma_i)
\end{aligned}
\tag{32}
$$

where E_{t+5} is a dummy variable equal to one if a firm does not export to the EU in year t and becomes an exporter to the EU in year $t+5$; PR_t is the firm's revenue based labor productivity, and Z_t is a set of additional firm characteristics. Additional firm controls include size, capital intensity, wage level, and multi-plant dummies. In specification four, I include the dummy variable OR firm, which is equal to one if the firm is an exporter to a developing country and not to the EU in year t. I also include industry (γ_i) and time (γ_t) fixed effects and cluster the standard errors at the

industry level.

Results are reported across four columns in Table 16, with the first column focusing on my trade costs measures and subsequent columns including additional firm characteristics. Across all specifications, I find a positive and statistically significant association between product standards harmonization and the probability that a non-exporting firm to the EU becomes an exporter to the EU across Census years. The probability of becoming an EU exporter is higher in industries with greater harmonization of product standards. Surprisingly, EU tariff changes do not affect the probability of becoming an exporter. In specification two and three, I find, as expected, a positive and significant association between firms' productivity and their entry into exporting. Larger and more capital-intensive firms are more likely to become exporters, as are multi-plant firms and firms that pay higher wages.

In line with the theoretical model, specification four shows that being an exporter to a developing market in year t increases the probability of becoming an exporter to the EU in year t+5. This relationship is significant at the 1% level. I also add an interaction of product standards harmonization with the OR firm variable to check whether responses to harmonization vary across types of exporting firms. The sign is, as expected, negative: the probability of entry into the EU market is relatively higher for firms that export to a developing country in the face of product standards harmonization. Hereafter, I further decompose the impact at the extensive margin of trade between OR firms and new exporters.

3.4.4 Extensive Margin Composition

Product standards heterogeneity across market destinations in conjunction with productivity heterogeneity across firms provides a natural hierarchy of firms entering exporting markets. Less productive firms serve less stringent markets (OR firms) while more productive firms also serve most stringent markets (AF firms). The theoretical model predicts that harmonization of product standards triggers entry mainly from OR firms (hypothesis 3). To examine the potential impact of falling trade costs on the probability that OR firms become exporters to the EU, I start by estimating a logistic regression at the firm-product level on my measure of changing trade costs,

firm productivity, and other firm characteristics across Census years. I define $E_{p,t+5}$ as a dummy variable equal to one if a firm exports product p to a developing country but not to the EU in year t and in year $t+5$ that product is exported to the EU. These regressions are given by:

$$\begin{aligned}
&(\textit{Spec 1}) \quad Pr(E_{p,t+5}=1) = \quad \Phi(\beta_1 \triangle \tau^i_{t+5} + \beta_2 \triangle NH^i_{t+5} + \gamma_t + \gamma_i) \\
&(\textit{Spec 2}) \quad Pr(E_{p,t+5}=1) = \quad \Phi(\beta_1 \triangle \tau^i_{t+5} + \beta_2 \triangle NH^i_{t+5} + \beta_3 PR_t + \gamma_t + \gamma_i) \\
&(\textit{Spec 3}) \quad Pr(E_{p,t+5}=1) = \quad \Phi(\beta_1 \triangle \tau^i_{t+5} + \beta_2 \triangle NH^i_{t+5} + \beta_3 PR_t + \beta_4 Z_t + \gamma_t + \gamma_i)
\end{aligned} \tag{33}$$

where the variables are defined as above. Z_t includes an additional dummy variable "Other EU product", which is equal to one if that firm exports another product to the EU in year t. As above, this regressions include year and industry fixed effects and standards errors are clustered at the industry level.

Results for three specifications with an increasing number of regressors are reported in Table 17. Changes in industry-level trade costs are negatively associated with the probability that an OR firm-product enters the EU market across census years. This relation is statistically significant at the 1 percent level in all specifications. Results in the second and third columns indicate that labor productivity is positively associated with the probability of entry only after controlling for other firm attributes. As expected, the fact that a firm exports another product to the EU increase the probability of entry.

To examine the differential impact of harmonization on OR firms and on non-exporting firms, I estimate equations 32 for these two groups of firms separately. Table 18 reports the results, the first three columns present the specifications for OR firms whereas columns 4-6 show the estimations for non-exporting firms. Across all specifications, I confirm that harmonization increases the probability of observing a new exporter to the EU market. This effect is statistically significant across specification. As implied by the theory, this effect is more important for OR firms than for non-exporting firms. Again, tariffs do not significantly affect the probability of entering the EU market for either type of firms.

3.5 Concluding Remarks

With the decline of traditional trade barriers, differences in product requirements across market destinations are increasingly viewed as impediments for trade. Yet despite the growing evidence of the negative impact of product standard heterogeneity, there is little understanding of the gains of harmonization at the micro level. This paper provides, to the best of my knowledge, the first firm-level evidence of the gains from product standards harmonization and decomposes them into the intensive and extensive margins of trade.

In this paper, I develop a heterogeneous firms model featuring the role of product standards differences across market destinations as country-specific fixed costs to export. The model is a three-country version of the Melitz (2003) framework in which I assume that two countries have different but equally costly product standards (countries H and F) while the third country has less stringent product requirements (country R). After setting out the base case scenario without harmonization, I modify the model to allow harmonization between countries F and R and characterize the trade impact in country H. The theory provides three testable results. First, harmonization decreases export sales at $H's$ existing exporters to country F, the intensive margin of trade. Second, harmonization increases the number of $H's$ exporting firms to market F, the extensive margin of trade. Third, new entrants are mainly drawn from the most productive set of H's firms exporting to country R, the extensive margin of trade composition.

To examine the impact of product standards harmonization on the margins of trade, I use the European agreement to harmonize product standards to international norms as a natural experiment. This agreement was achieved thanks to the cooperation between CENELEC —the European Committee for Electrotechnical Standardization— and the IEC —the International Electrotechnical Commission— laid down in the Lugano and Dresden agreements in 1991 and 1996. I combine this information with U.S. linked/longitudinal firm trade data and the U.S. Censuses of Manufactures to empirically confront the results of my theoretical model for the Electronic sector.

An important contribution of my analysis is the creation of a new set of industry level measures

of EU product standards for the Electronic sector. Since there is currently no official mapping between the classification of standards and any industry or product classification, I develop a method to obtain a concordance between five-digit ICS codes and the four-digit standard industrial classification.

The empirical findings largely confirm the theoretical results. First, I confirm that industries with relatively high harmonization and high reduction in tariff rates exhibit relatively high U.S. export value to the EU. Furthermore, I show that this impact is negative for the intensive margin of trade (change in the value of U.S. goods that are already exported to the EU within surviving trade relationships). Second, I find that product standards harmonization increases the probability that higher-productivity firms enter the EU market whereas tariff rates do not affect entry decisions. Third, I show that this impact is more relevant for U.S. firms that were already exporters serving developing countries than for firms entering the export activity. Overall, the empirical findings suggest that EU product standards harmonization contributes significantly to explain the export entry patterns observed in my sample of U.S. firms.

These results have an important policy implication. The U.S. National Export Initiative laid down by President Obama in March 2010 seeks to double U.S. exports over the next five years by enhancing small and medium sized firms' ability to enter export markets and to actively reduce barriers to trade. The results obtained in this paper suggest that working towards a reduction in the differences of product rules across markets could be a supportive policy to incentive firm entry into export markets.

Appendix 1

Proof of proposition 2

1. Primitive assumptions of the model.

   $\lambda > 1$, $a > 0$, $a^* > 0$, and $1 \leq \frac{a^*}{a} \leq 1.3025$. The upper bound of the relative foreign market size is given by equation 11.

2. $G^I(\tau^{ex}) > G^S(\tau^{ex})$: The government objective function evaluated at the exit tariff is greater with integrated markets than with segmented markets.

   Let $\Delta G = G^I(\tau^{ex}) - G^S(\tau^{ex})$. By means of contradiction I will show that $\Delta G > 0$

   $$\Delta G = \frac{a^*(2-\sqrt{2})}{144}\left[a^*\left[23\sqrt{2} - 16 - \lambda(14\sqrt{2}-16)\right] - 12a(3-2\lambda)\right]$$

   Suppose $\Delta G \leq 0$. Thus, the following condition must hold: $\frac{a^*}{a} \leq \frac{12(3-2\lambda)}{23\sqrt{2}-16-\lambda(14\sqrt{2}-16)}$

   Since $1 \leq \frac{a^*}{a}$, then $1 \leq \frac{12(3-2\lambda)}{23\sqrt{2}-16-\lambda(14\sqrt{2}-16)}$

   Solving this inequality, $\lambda \leq \frac{52-3\sqrt{2}}{40-14\sqrt{2}} = 0.9640$, which is a contradiction because $\lambda > 1$. Thus $\Delta G > 0$

3. $G^S(\tau^S) > G^I(\tau^{ex})$: The government prefers segmented markets and the optimal tariff rather than integrated markets and the exit tariff.

   Let $\Delta G = G^S(\tau^S) - G^I(\tau^{ex})$.

   $$\Delta G = \frac{a^2}{2}\left[\frac{(\lambda - \frac{3}{2})^2}{11-2\lambda}\right] + \left[\frac{a^*}{8}\right]^2\left[75 - 52\sqrt{2} - \lambda(34-24\sqrt{2})\right] + \frac{aa^*}{16}\left[\lambda(6\sqrt{2}-8) - 9\sqrt{2} + 12\right]$$

   Since $a > 0$, I can divide ΔG by a^2 without changing the sign of this expression. Below each

component of the next equation is the condition for it to be positive.

$$\frac{\Delta G}{a^2} = \underbrace{\left[\frac{(\lambda-\frac{3}{2})^2}{2(11-2\lambda)}\right]}_{\lambda<\frac{11}{2}=5.5} + \left[\frac{a^*}{8a}\right]^2 \underbrace{\left[75-52\sqrt{2}-\lambda(34-24\sqrt{2})\right]}_{\lambda<\frac{75-52\sqrt{2}}{32-24\sqrt{2}}=24.8} + \frac{a^*}{16a}\underbrace{\left[\lambda(6\sqrt{2}-8)-9\sqrt{2}+12\right]}_{\lambda>\frac{9\sqrt{2}-12}{6\sqrt{2}-8}=1.5}$$

It is easy to see that in the interval $1 < \lambda \leq 1.5$, the second term outweighs the third term. Thus, the first term determines the sign of the equation; so I need the restriction $1 < \lambda < 5.5$ for $\Delta G > 0$[81].

4. $G^S(\tau)$ is strictly concave and $\tau^{ex} < \tau^S$: Since the exit tariff is to the left of the optimal tariff in segmented markets, $G^S(\tau)$ is increasing between τ^{ex} and τ^S.

   $\frac{\partial^2 G^S(\tau)}{\partial^2 \tau} = \frac{2}{9}\lambda - \frac{11}{9} < 0$ because, by step 3, $1 < \lambda < 5.5$.

   $\tau^S = \frac{a(2\lambda+1)}{11-2\lambda}$ and $\tau^{ex} = \frac{a}{2} - \frac{a^*(5\sqrt{2}-4)}{8}$. By means of contradiction suppose that $\tau^{ex} \geq \tau^S$, thus:

$$\frac{a^*}{a} \leq \frac{4}{5\sqrt{2}-1} - \frac{8(2\lambda+1)}{(5\sqrt{2}-4)(11-2\lambda)}$$

   Since $1 \leq \frac{a^*}{a}$

$$1 \leq \frac{4}{5\sqrt{2}-1} - \frac{8(2\lambda+1)}{(5\sqrt{2}-4)(11-2\lambda)}$$

   Solving this inequality, $\lambda \leq 0.12$, which is a contradiction because $\lambda > 1$. Thus $\tau^{ex} < \tau^S$.

5. By steps 2 and 3, $G^S(\tau^{ex}) < G^I(\tau^{ex}) < G^S(\tau^S)$. By step 4, $G^S(\tau)$ is increasing in the interval $[\tau^{ex}, \tau^S]$. Then, by the intermediate value theorem, there exists $\tau' \in (\tau^{ex}, \tau^S)$ such that $G^S(\tau') = G^I(\tau^{ex})$. For the proof of the intermediate value theorem see Rudin (1976), Theorem 4.23, p.93.

[81] Conceptually, it means that government's valuation of local profits cannot be so high to begin with so it prefers to set an AD legislation when tariffs are not constrained by any trade agreement. Recall that the status-quo regime is no AD legislation.

QED

Proof of proposition 3

1. *τ' is increasing in λ.*

   Since λ shifts both segmented markets and integrated markets government functions by the same proportion, and since τ^{ex} does not depend on λ, a necessary and sufficient condition for τ' be increased in λ is to show that $\Delta G(\tau^{ex}) = G^I(\tau^{ex}) - G^S(\tau^{ex})$ is increasing in λ. Since $G^S(\tau)$ is increasing between $[\tau^{ex}, \tau^S]$, then τ' must be increasing in λ (see figure 6).

$$\Delta G = \frac{a^*(2-\sqrt{2})}{144}\left[a^*\left[23\sqrt{2} - 16 - \lambda(14\sqrt{2}-16)\right] - 12a(3-2\lambda)\right]$$

$$\frac{\partial \Delta}{\partial \lambda} = \frac{a^*(2-\sqrt{2})}{144}\left[24a - (14\sqrt{2}-16)a^*\right]$$

   I show that this expression is positive by a contradiction. Divide this equation by a and suppose it is non-positive, thus:

$$\left[24 - (14\sqrt{2}-16)\frac{a^*}{a}\right] \leq 0$$

$$6.32 = \frac{24}{14\sqrt{2}-16} \leq \frac{a^*}{a}$$

   Which is a contradiction since $1 \leq \frac{a^*}{a} \leq 1.3025$.

   Therefore, $\Delta G(\tau^{ex}) \geq 0$ and τ' is increasing in λ.

QED

2. *τ' is decreasing in $\frac{a^*}{a}$.*

   - Suppose that a is a constant and a^* changes. Thus I need to show that τ' is decreasing in a^*.

$G^S(\tau)$ does not depend on a^*. Thus, a sufficient and necessary condition for τ' be decreased in a^* is that τ^{ex} is decreasing in a^* (see figure 6).

$$\tau^{ex} = \frac{a(2-c)}{2} - a^* \left[\sqrt{2} - 1 - \frac{c^2}{8}(3\sqrt{2} - 4)\right]$$

$$\frac{\partial \tau^{ex}}{\partial a^*} = -\left[\sqrt{2} - 1 - \frac{c^2}{8}(3\sqrt{2} - 4)\right]$$

This expression is negative for any degree of product differentiation. Suppose it is not, then $\sqrt{2} - 1 - \frac{c^2}{8}(3\sqrt{2} - 4) \leq 0$, which implies $3.69 = \left[\frac{8(\sqrt{2}-1)}{3\sqrt{2}-4}\right]^{\frac{1}{2}} \leq c$; which is a contradiction because $0 \leq c \leq 1$. Therefore, τ' is decreasing in a^*.

- Suppose that a^* is a constant and a changes. Thus I need to show that τ' is increasing in a. Again this implies that τ^{ex} must be increasing in a

$$\tau^{ex} = \frac{a(2-c)}{2} - a^* \left[\sqrt{2} - 1 - \frac{c^2}{8}(3\sqrt{2} - 4)\right]$$

$$\frac{\partial \tau^{ex}}{\partial a} = \frac{(2-c)}{2} > 0$$

Which is positive for $0 \leq c \leq 1$.

QED

3. *τ' is increasing in c.*

A change in c shifts both government objective functions and the exit tariff. A necessary and sufficient condition for τ' be increased in c is to show that τ^{ex} and $\Delta G(\tau^{ex}) = G^I(\tau^{ex}) - G^S(\tau^{ex})$ are decreasing in c. Since $G^S(\tau)$ is increasing between $[\tau^{ex}, \tau^S]$, then τ' must be increasing in c (see figure 8).

Recall that the relative size of the foreign market must met the following condition $1 \leq \frac{a^*}{a} \leq \frac{4(2-c)}{8(\sqrt{2}-1)-c^2(3\sqrt{2}-4)}$. This implies $1.3025 \leq \frac{a^*}{a} \leq 2.4142$. Furthermore, assume a small deviation

from $c = 1$ such that $\tau^I = \tau^{ex}$ still holds[82].

- τ^{ex} is decreasing in c

$$\tau^{ex} = \frac{a(2-c)}{2} - a^* \left[\sqrt{2} - 1 - \frac{c^2}{8}(3\sqrt{2} - 4)\right]$$

$$\frac{\partial \tau^{ex}}{\partial c} = -\frac{a}{2} + \frac{ca^*}{4}\left[3\sqrt{2} - 4\right]$$

$\frac{\partial \tau^{ex}}{\partial c} < 0$ implies $\frac{a^*}{a} < \frac{2}{c(3\sqrt{2}-4)}$. Since $1 \leq \frac{a^*}{a}$, then $1 < \frac{2}{c(3\sqrt{2}-4)}$ or $c < \frac{2}{3\sqrt{2}-4} = 8.2426$. Given that $0 \leq c \leq 1$, this condition holds.

- $G(\tau^{ex})$ is decreasing in c

$G(\tau^{ex})$ can be written as $G(\tau^{ex}) = AB$, where

$$A = \frac{1}{16}\left[c^4 a^*\left[3\sqrt{2} - 4 + 2\lambda\left(4\sqrt{2} - 3\right)\right] + 4c^3 a\left(2\lambda + 1\right) + 2c^2 a^*\left[2 - \sqrt{2} + 2\lambda\left(5\sqrt{2} - 6\right)\right] + 16ca\left(1 + 2\lambda\right) + 8a^*\left(3\sqrt{2} - 2\right) + 64a\right] > 0$$

$$B = -a^*\left[2 - \sqrt{2}\right]\left[\frac{c+2}{c-2}\right]^2 < 0$$

$$\frac{\partial A}{\partial c} = \frac{1}{16}\left[4c^3 a^*\left[3\sqrt{2} - 4 + 2\lambda\left(4\sqrt{2} - 3\right)\right] + 12c^2 a\left(2\lambda + 1\right) + 4ca^*\left[2 - \sqrt{2} + 2\lambda\left(5\sqrt{2} - 6\right)\right] + 16a\left(1 + 2\lambda\right)\right] > 0$$

[82]Comparing equations 10 and 12 it is possible to find a threshold $\bar{c}$ such that $\tau^{ex} \leq \tilde{\tau^I}$. This condition is quiet cumbersome to be written here but it is available for the interested reader.

$$\frac{\partial B}{\partial c} = 2a^* \left[2 - \sqrt{2}\right] \left[\frac{c+2}{c-2}\right] \left[\frac{4}{(c-2)^2}\right] < 0$$

Then

$$\frac{\partial G(\tau^{ex})}{\partial c} = A\frac{\partial B}{\partial c} + B\frac{\partial A}{\partial c} < 0$$

QED

Appendix 2

This appendix provides an overview to find the equilibrium with no harmonization of product standards standards and with harmonization of product standards between country F and country R.

A No harmonization of standards

Since domestic firms with marginal cost below c_d^{i*} and foreign firms from country j with marginal cost below c_x^{ji*} sell into market i, the aggregate price for country i can be written as follows.

$$P^{i\,1-\sigma} = \left[\frac{\sigma}{\sigma-1}\right]^{1-\sigma} \left[\int_0^{c_d^{i*}} c^{1-\sigma} dG(c) + \int_0^{c_x^{ji*}} c^{1-\sigma} dG(c) + \int_0^{c_x^{ki*}} c^{1-\sigma} dG(c)\right] \tag{34}$$

Where $\{i, j, k\} \in \{H, F, R\}$ and $i \neq j \neq k$.

To obtain a tractable closed form solution, marginal cost is assumed to be Pareto distributed with support [0,1] in all three countries. The cumulative distribution function is thus given by $G(c) = c^\gamma$, where γ is a parameter that indexes firm heterogeneity ($\gamma > \sigma - 1$). Using equations 22 and 23 and solving the integrals in the previous expression, we can write the equilibrium price index in terms of exogenous variables.

$$P^{i^*\,1-\sigma} = A\left[f_d^{\left(1-\frac{\gamma}{\sigma-1}\right)} + 2f_x^{i\left(1-\frac{\gamma}{\sigma-1}\right)}\right]^{\frac{\sigma-1}{\gamma}} \tag{35}$$

Where $A = \left[\frac{\sigma}{\sigma-1}\right]^{\sigma-1} \left[\frac{L}{\sigma}\right]^{1-\frac{(\sigma-1)}{\gamma}} \left[\frac{\gamma}{\gamma-(\sigma-1)}\right]^{\frac{\sigma-1}{\gamma}}$.

Since f_d is the same across countries and $f_x^R < f_x^F = f_x^H$, it is easy to show that ${P^{H^*}}^{1-\sigma} = {P^{F^*}}^{1-\sigma} < {P^{R^*}}^{1-\sigma}$. Finally, since $E^i = L$, $d^{R^*} < d^{F^*} = d^{H^*}$.

Equilibrium cutoffs are computed plugging equation A2 into equations 22 and 23. To ensure that the marginal cost threshold to export is lower for the more protectionist stance, the following technical conditions must be assumed: $\frac{f_x^F}{f_x^R} > \frac{P^R}{P^F}$. Finally, it is straightforward to obtain $c_x^{HF^*} < c_x^{HR^*} < c_d^{H^*}$, $c_x^{FH^*} < c_x^{FR^*} < c_d^{F^*}$, and $c_x^{RH^*} = c_x^{RF^*} < c_d^{R^*}$. See figure 11.

B Standards harmonization between country F and country R.

Given that the fixed cost to export to H remains unchanged, H's price index is still given by equation A1. Since f_d did not change either, the equilibrium conditional profit function for domestic firms is the same as in the previous equilibrium. That is to say, H's non-exporters firms are unaltered by foreign product standards harmonization.

Countries F and R now have the same price index given by the following equation.

$$\widehat{P^i}^{1-\sigma} = \left[\frac{\sigma}{\sigma-1}\right]^{1-\sigma}\left[\int_0^{c_d^{i*}} c^{1-\sigma}dG(c) + \int_0^{\widehat{c_x^H}} c^{1-\sigma}dG(c) + \int_0^{\widehat{c_x^{ji}}} c^{1-\sigma}dG(c)\right] \tag{B1}$$

Where $\{i,j\} \in \{F,R\}$ and $i \neq j$.

Using equations 22, 26, 28, and solving the integrals in equation B1, the equilibrium price within the harmonized zone can be written as follows.

$$\widehat{P^i}^{1-\sigma} = A\left[f_d^{\left(1-\frac{\gamma}{\sigma-1}\right)} + \widehat{f_x}^{\left(1-\frac{\gamma}{\sigma-1}\right)}\left(2^{\frac{\gamma}{\sigma-1}-1}+1\right)\right]^{\frac{\sigma-1}{\gamma}} \tag{B2}$$

Where A is defined above.

Given that $f_x^R \leq \widehat{f_x} \leq f_x^F$, it is easy to show that $\widehat{p^H}^{1-\sigma} < \widehat{p^R}^{1-\sigma} = \widehat{p^F}^{1-\sigma}$. Comparing equation B1 with equation A1, it is straightforward to get ${p^{F^*}}^{1-\sigma} < \widehat{p^F}^{1-\sigma}$, which implies $\widehat{d^R} < d^{F^*} = d^{H^*}$

and $d^{F^*} < \widehat{d^F} + \widehat{d^R}$. See figures 12 and 13.

Proposition 1. *Under product standard harmonization, the number of H's exporting firms to market F increases, new exporters are drawn from the most productive set of OR firms* $\left(c_x^{HF^*} < \widehat{c_x^H}\right)$.

Proof. Suppose $c_x^{HF^*} \geq \widehat{c_x^H}$. Thus, by equations 23 and 26, $\frac{d^{F^*}}{f_x^F} \geq \frac{\widehat{d^F}+\widehat{d^R}}{\widehat{f_x}}$, which implies $\frac{d^{F^*}}{\widehat{d^F}+\widehat{d^R}} \geq \frac{f_x^F}{\widehat{f_x}}$. Since $\frac{d^{F^*}}{\widehat{d^F}+\widehat{d^R}} < 1$ and $\frac{f_x^F}{\widehat{f_x}} > 1$, this is a contradiction. Thus $c_x^{HF^*} < \widehat{c_x^H}$ ■

Proposition 2. *If the harmonized standard is undemanding, new H firms enter export markets* $\left(\widehat{c_x^H} > c_x^{HR^*}\right)$. *Conversely, If the harmonized standard is relatively stringent, low productive OR firms drop export activity* $\left(\widehat{c_x^H} < c_x^{HR^*}\right)$.

Proof. Using equations 23 and 26, $\widehat{c_x^H} > c_x^{HR^*}$ can be written as $\frac{2\widehat{d^F}}{\widehat{f_x}} > \frac{d^{R^*}}{f_x^R}$, which implies $\frac{2\widehat{d^F}}{d^{R^*}} > \frac{\widehat{f_x}}{f_x^R}$ and $\frac{2P^{R^*}}{\widehat{P^F}} > \frac{\widehat{f_x}}{f_x^R}$. Plugging equations A1 and B1, this inequality can be written as:

$$\frac{\widehat{f_x}\left(2^{-a}+1\right)}{f_d} + \left(\widehat{f_x}\right)^{1-a} < 2\left[2\frac{f_x^R}{f_d} + \left(f_x^R\right)^{1-a}\right]$$

where $a = 1 - \frac{\gamma}{\sigma-1}$. ■

Thus, if the harmonized standard meets this inequality, it is said to be "close" to f_x^R and new firms enter the export market (figure 13). Otherwise, the harmonized standard is said to be too stringent and low productive OR firms drop export markets (figure 12).

Appendix 3

The empirical analysis uses the U.S. linked/Longitudinal Firm Trade Transaction Database (LFTTD),which links individual U.S. trade transactions to U.S. firms in the Longitudinal Business Database (LBD), in conjunction with firm level information from the Censuses of Manufactures (CM) of the Longitudinal Research Database (LRD) of the U.S. Census Bureau. The impact of European product standards harmonization in Electronics is studied at two levels: the trade flows

level (sections 3.4.1 and 3.4.2) and at the firm level (sections 3.4.3 and 3.4.4).

At the export flow level, I identify exports of electronic products to the E.U. from U.S. manufacturing firms in the following way: From the LFTTD, I aggregate export transaction up at the firm-product-country-year level from 1992 to 2004. Since a product is a 10-digit Harmonized System code (HS10) (schedule B), I merge the concordance between HS10 codes and 4-digit SIC industries (SIC4) from Pierce and Schott (2009) and retain HS10 codes within SIC 36. Next, I drop firms that are classified in industries outside SIC 36 in the LBD as well as exports to countries outside the EU-15 block. Finally, I collapse export value up at the sic4-country-year level. This is the sample used in section 3.4.1. In section 3.4.2, I use the same methodology but before collapsing out firms in the last step, I retain the set of export of electronic products that are exported to the EU within surviving trade relationships (i.e. firm-product pairs that remain as exporters to the EU for the complete set of years of my sample); this sample is the equivalent to the export value from AF firms in the theoretical model. Section 3.4.2 also uses export flows from OR firms, which is constructed by keeping the set of firm-product pairs that begin export activity first in a developing country[83] and then enter into the EU market.

The firm level analysis have two components. The first component is the CM that contains input-output information at the manufacturing establishment level for years 1992, 1997, and 2002. For years 1992 and 1997, I collapse input-output information up at the firm level within each SIC4 industry. Since the 2002 CM classifies establishments in industries using the 6-digit North American Industry classification system (NAICS6), I assign each establishments into the SIC4 industry it was allocated in 1997 and, then, collapse input-output information up at the firm level within each SIC4 industry.[84] The second component is the LFTTD which contains information of the market destinations for exporting manufacturing firms.

[83] China and India are excluded.

[84] The underlying assumption is that establishments do not change industries from 1997 to 2002. Note that I cannot allocate 2002 establishments births into SIC4 industries. This issue is not problematic for the empirical analysis since the theoretical model does not predict any role of harmonization on domestic firm dynamics. I cannot use the public available bridge NAICS-SIC bridge because single NACIS6 codes are mapped to more than one SIC4 code, which makes imposible to assign establishments into SIC4 industries.

Now, I describe the main variables and the data sources.

1. **Tarrifs:** Tarrifs are compiled through WITS from TRAINS under the HS nomenclature. SIC4 tariffs are weigthed averages of the underlying six-digit HS codes, using EU import value from the U.S. as weights.

2. **NH Share:** The non-harmonized share of products standards is computed as the number of CENELEC standards that are not "identical" to an existing IEC standard as a share of the total number of standards in each SIC4 industry. Product standards information is obtained from the World Bank EU Electrotechnical Standards Database.

3. **Distance:** Partner countries' great-circle distance from the United States. These data are from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII).

4. **GDP:** Partner countries' GDP from CEPII.

5. W_{jt}^{i}**:** Fraction of U.S. firms within SIC4 industry that export to country j in year t. The number of exporting firms comes from the LFTTD whereas the number of U.S. manufacturing firms comes from the LBD. Since the LBD changes to the NAICS industry classification from 2002, I use a NAICS-SIC correspondence provided by the U.S. Census Bureau to obtain a consistent measure throughout my time span.

6. **Labor productivity:** Ratio between total number of workers and total value of shipments at the firm level. These data come from the CM.

Other firm characteristics are from the information contained in the Censuses of Manufactures.

Figures

Figure 1 - Multilateral trade rounds and countries with AD legislation.

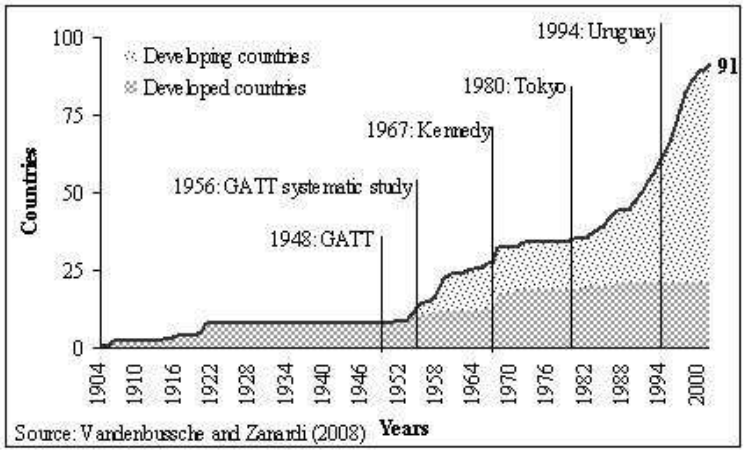


Figure 2 - The three-stage game of trade policy determination.

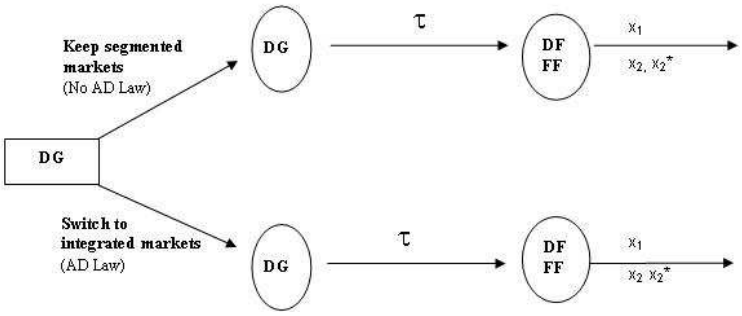


Figure 3 - Degree of product differentiation and response functions with integrated and segmented markets

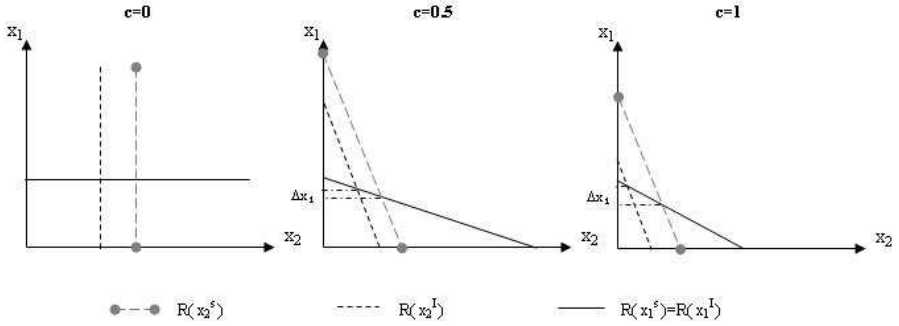


Figure 4 - The choice of policy regimes

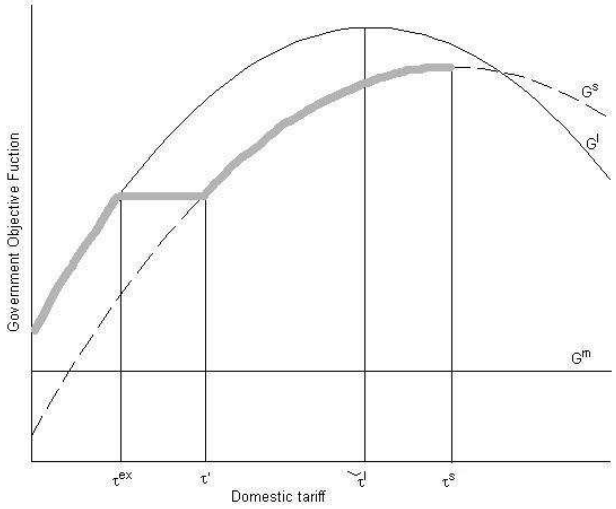
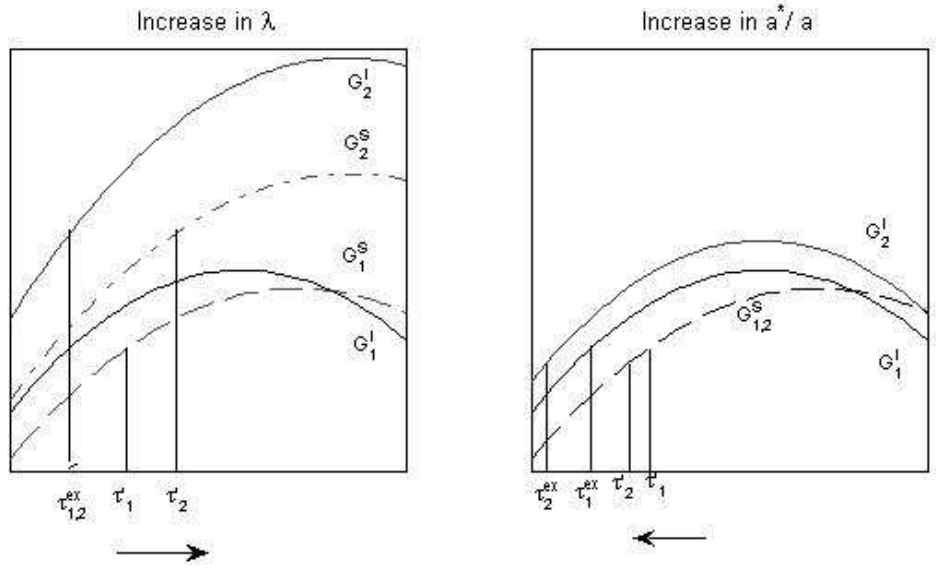


Figure 5 - Valuation of domestic profits, relative market size, and the timing of the adoption decision[85].



[85]The exercise assumes a initial situation (labeled with subscript 1) with the following parameter values: $\frac{a^*}{a} = 1.1$, $\lambda = 1.1$, $c = 1$. Government objective function with segmented markets is represented with dashed lines. The first panel represents an increase in λ to 1.3 whereas the second panel corresponds an increase in $\frac{a^*}{a}$ to 1.25. The arrow at the bottom of each graph shows the direction of change in the threshold tariff for adoption of AD legislation.

Figure 6 - Effect of AD legislation on profits, domestic prices, and consumer welfare.

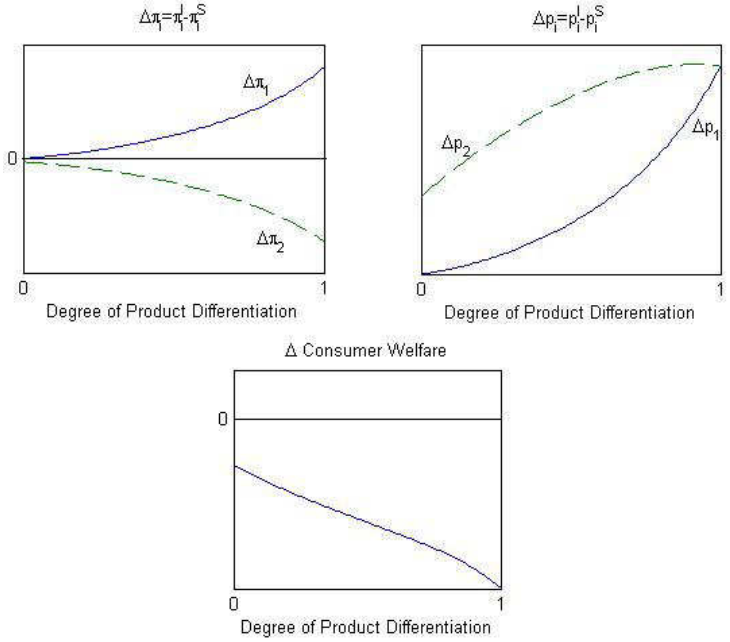
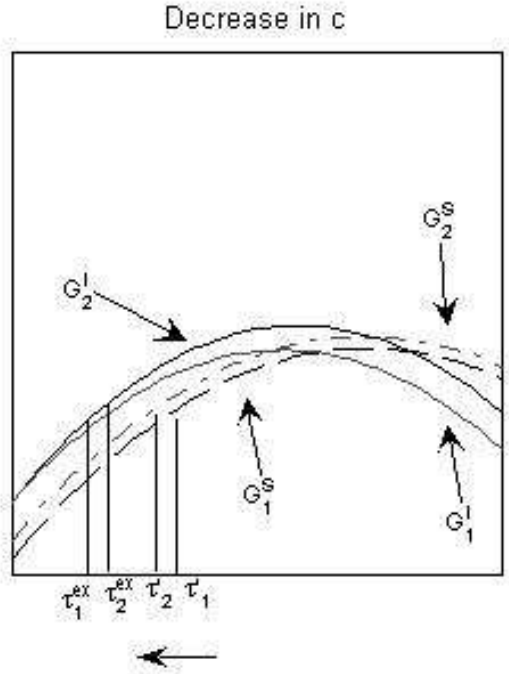


Figure 7 - Degree of product differentiation and the timing of the adoption[86].



[86]The exercise assumes the same initial values as in figure 6. The change in c corresponds to a decrease of product differentiation to 0.9.

Figure 8 - Breakdown by Type of EU standard in Electronics

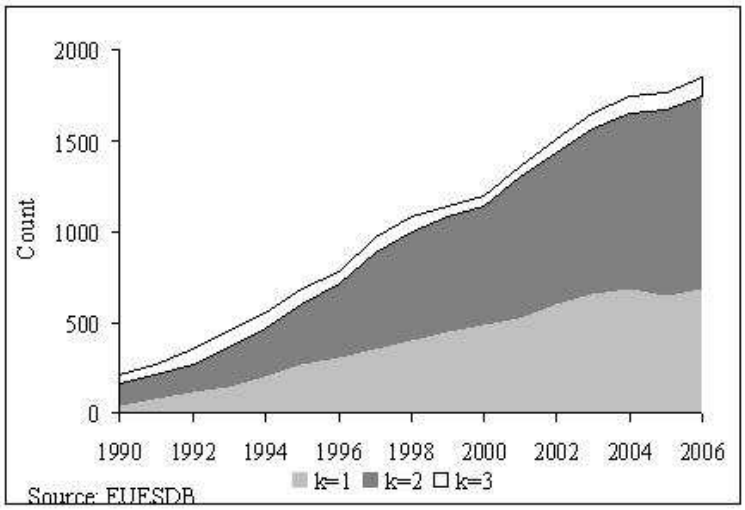


Figure 9 - Breakdown by Type of EU standard in Electronics

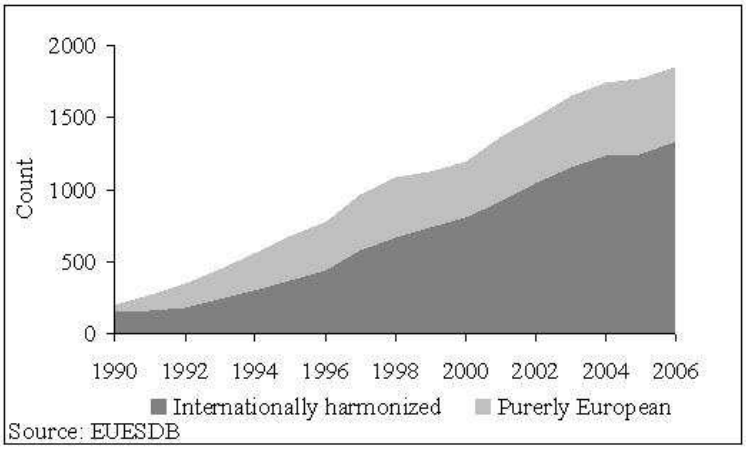


Figure 10 - Internationally Harmonized Standards as a Share of Total Standards

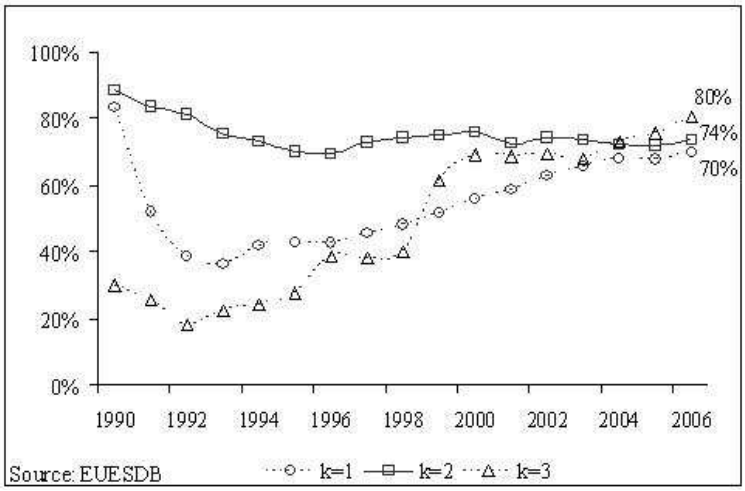


Figure 11 - Home Profits and Productivity Cutoffs Before Harmonization

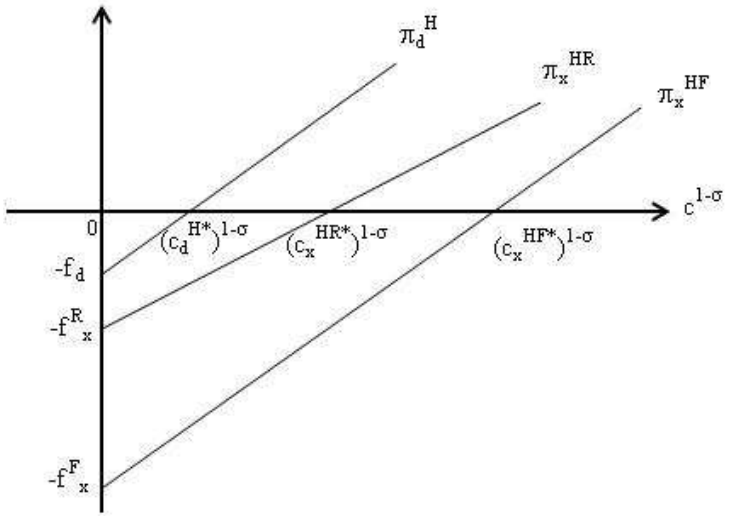


Figure 12 - Home Profits and Productivity Cutoffs After Harmonization I

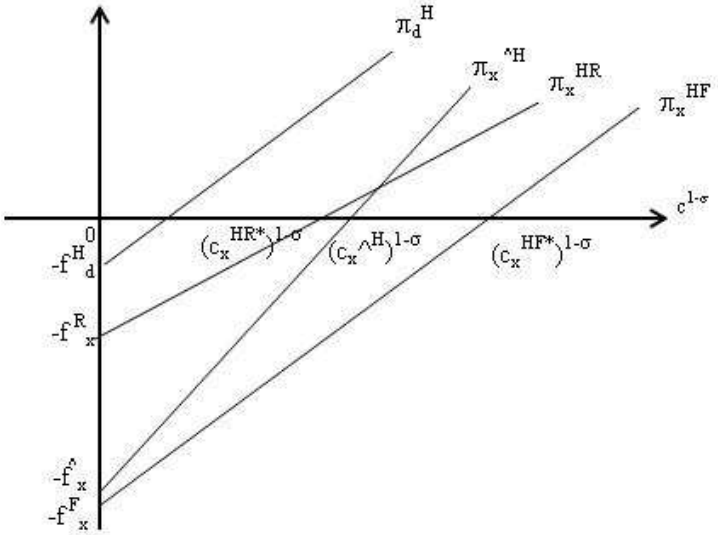
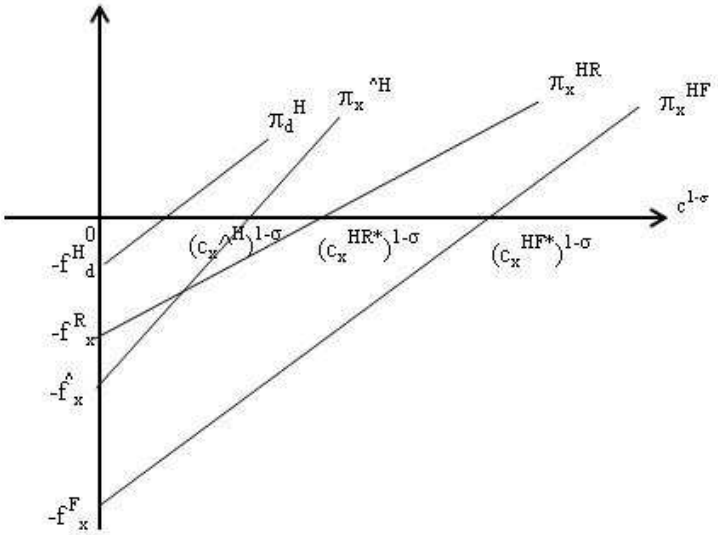


Figure 13 - Home Profits and Productivity Cutoffs After Harmonization II



Tables

Table 1: New Approach Directives for which CENECEL has Issued Harmonized Standards.

Directive Area	**Directive reference**
Electromagnetic Compatibility	2004/108/EC
Explosive Atmospheres	94/9/EC
Gas Appliances	90/396/EEC
Interoperability of European High-speed Railway	96/48/EC
Interoperability of trans-European conventional rail	2001/16/EC
Low-Voltage Equipment	2006/95/EC
Machinery	98/37/EC + 2006/42/EC
Measuring Instruments	2004/22/EC
Medical Devices	93/42/EEC
Medical Devices: Active Implantable	90/385/EEC
Medical Devices: In Vitro Diagnostic	98/79/EC
Non-automatic Weighing Instruments	90/384/EEC
Personal Protective Equipment	89/686/EEC
Pressure Equipment	97/23/EC
Radio & Telecom Terminal Equipment	99/5/EC
Recreational Craft	94/25/EC
Safety of Toys	88/378/EEC

Source: CENELEC, facts and figures (as a January 20008)

Table 2: Preparation Stages for IEC Standards.

Project stage	**Associated Document**
Preliminary stage	Preliminary work item
Proposal stage	New work item proposal
Preparatory stage	Working draft(s)
Committee stage	Committee draft(s)
Enquiry stage	Enquiry draft *
Approval stage	Final draft International Standard*
Publication stage	International IEC Standard

* A draft is approved if a two-thirds majority of the votes cast by members of the technical committee are in favour and no more than one-quarter ot the total number of votes cast are negative.
Source: ISO/IEC Directives, Part 1
http://www.iec.ch/tiss/iec/Directives-Part1-Ed6.pdf

Table 3: Finished Products and Parts and Components in Trade in Electronics

Group (k)	SITC	Product
1. Electronic components	7761	Television picture tubes,cathode ray
	7762	Other electr.valves and tubes
	7763	Diodes,transistors and sim.semi-conductor devices
	7764	Electronic microcircuits
	7768	Piezo-electric crystals,mounted,parts of 776-
2. Consumer electronics and Telecoms	7611	Television receivers,colour
	7612	Television receivers,monochrome
	7621	Radio-broadcast receivers for motor vehicles
	7622	Radio-broadcast receivers portable,incl.sound rec.
	7628	Other radio-broadcast receivers
	7631	Gramophones & record players,electric
	7638	Other sound recorders and reproducers
	7641	Elect.line telephonic & telegraphic apparatus
	7642	Microphones,loudspeakers,amplifiers
	7643	Radiotelegraphic & radiotelephonic transmitters
	7648	Telecommunications equipment
	7649	Parts of apparatus of division 76-
3. Information Technology	7511	Typewritters;cheque-writting machines
	7512	Calculating machines,cash registers.ticket & sim.
	7518	Office machines, n.e.s.
	7521	Analogue & hybrid data processing machines
	7522	Complete digital data processing machines
	7523	Complete digital central processing units
	7524	Digital central storage units,separately consigned
	7525	Peripheral units,incl.control & adapting units
	7528	Off-line data processing equipment. n.e.s.
	7591	Parts of and accessories suitable for 751.1-,751.8
	7599	Parts of and accessories suitable for 751.2-,752-

Table 4: Count by Category of EU Standards in Electronics

Cat.	1	2	3	Total
1990	42	121	40	203
1991	77	134	55	266
1992	111	153	83	347
1993	144	219	89	452
1994	199	272	83	554
1995	260	336	84	680
1996	307	399	75	781
1997	354	531	79	964
1998	405	592	85	1082
1999	445	631	57	1133
2000	480	661	58	1199
2001	524	771	67	1362
2002	604	831	78	1513
2003	657	910	84	1651
2004	679	977	89	1745
2005	644	1026	99	1769
2006	685	1057	107	1849

Source: EUESDB (2008)

Categories: 1. Electronic Components, 2. Consumer Electronics and Telecomns, 3. Information Technology.

Table 5: Count by Type of EU Standards in Each Category

Cat	1		2		3		Total	
(k)	IEC	Non-IEC	IEC	Non-IEC	IEC	Non-IEC	IEC	Non-IEC
1990	35	7	107	14	12	28	154	49
1991	40	37	112	22	14	41	166	100
1992	43	68	124	29	15	68	182	165
1993	52	92	165	54	20	69	237	215
1994	83	116	199	73	20	63	302	252
1995	111	149	235	101	23	61	369	311
1996	131	176	276	123	29	46	436	345
1997	161	193	386	145	30	49	577	387
1998	195	210	439	153	34	51	668	414
1999	230	215	473	158	35	22	738	395
2000	267	213	502	159	40	18	809	390
2001	306	218	560	211	46	21	912	450
2002	379	225	617	214	54	24	1050	463
2003	430	227	670	240	57	27	1157	494
2004	462	217	704	273	65	24	1231	514
2005	435	209	735	291	75	24	1245	524
2006	477	208	778	279	86	21	1341	508

Source: EUESDB (2008)

Table 6: EU-15 Import Composition by Region

Region	**Electronic Components**	**Consumer Electronics and Telecom**	**Information Technology**
East Asian & Pacific	83.9%	81.2%	93.2%
Europe and Central Asia	3.3%	14.4%	0.9%
Latin America and Caribbean	7.4%	2.8%	5.1%
Middle East & North Africa	4.3%	0.6%	0.2%
South Asia	0.7%	0.4%	0.3%
Sub-Sahara Africa	0.5%	0.6%	0.3%
	100%	100%	100%

Table 7: Base Line Results with Different Estimation Methods

	OLS$(m>0)$	**tobit(1+m)**	**ET-tobit**	**Heckman (outcome)**	**Heckman (selection)**	**ppml**
$Hstd_t^1$	0.611***	1.118***	0.972***	0.504***	0.065	0.631***
	(0.058)	(0.069)	(0.059)	(0.090)	(0.049)	(0.101)
$Hstd_t^2$	0.747***	0.848***	0.747***	0.996***	0.807***	0.732***
	(0.081)	(0.089)	(0.075)	(0.117)	(0.075)	(0.149)
$Hstd_t^3$	0.73***	1.663***	1.411***	0.865***	0.733***	1.033***
	(0.054)	(0.045)	(0.038)	(0.042)	(0.029)	(0.144)
$NHstd_t^1$	-0.137***	-0.158***	-0.140***	0.190	0.595***	0.188***
	(0.051)	(0.061)	(0.052)	(0.121)	(0.071)	(0.041)
$NHstd_t^2$	-0.051	0.517***	0.425***	-0.144	-0.178***	0.144
	(0.058)	(0.080)	(0.068)	(0.097)	(0.062)	(0.122)
$NHstd_t^3$	0.266***	0.203***	0.191***	0.435***	0.342***	0.475***
	(0.051)	(0.053)	(0.044)	(0.052)	(0.034)	(0.087)
Tappl	-0.023**	-0.072***	-0.061***	-0.023***	-0.041***	0.07***
	(0.009)	(0.005)	(0.004)	(0.005)	(0.003)	(0.018)
ldistw	-1.252***	-1.377***	-1.233***	-1.277***	-0.36***	-0.781***
	(0.145)	(0.046)	(0.039)	(0.045)	(0.028)	(0.265)
DEU_memb	1.105***	1.360***	1.271***	1.089***	0.214***	0.949***
	(0.130)	(0.086)	(0.071)	(0.079)	(0.072)	(0.159)
Dcolony	0.835***	1.408***	1.148***	0.844***	0.464***	0.08
	(0.122)	(0.054)	(0.046)	(0.045)	(0.036)	(0.094)
Dcomm_lang	0.254**	0.841***	0.683***	0.282***	0.344***	0.392***
	(0.110)	(0.053)	(0.044)	(0.045)	(0.032)	(0.110)
D_posexp_t-1					1.075***	
					(0.015)	
Constant	4.375***	10.029***	9.99***	-0.107	1.361***	7.861***
	(1.482)	(0.523)	(0.440)	(1.168)	(0.332)	(2.785)
Observations	43524	100215	100215	94320	94320	100215
R-squared	0.75					

Notes: Standard errors in brackets. * significat at 10%; ** significat at 5%; *** significat at 1%

Table 8: Base Line Results with Different Estimation Methods

	ET-tobit	**Heckman (outcome)**	**Heckman (selection)**	**ET-tobit**	**Heckman (outcome)**	**Heckman (selection)**
$Hstd^1_{t-2}$	1.28***	0.297***	0.669***			
	(0.087)	(0.098)	(0.057)			
$Hstd^2_{t-2}$	1.461***	0.466***	0.702***			
	(0.092)	(0.094)	(0.061)			
$Hstd^3_{t-2}$	1.73***	0.756***	0.767***			
	(0.045)	(0.046)	(0.032)			
$NHstd^1_{t-2}$	0.114**	0.14**	-0.006			
	(0.050)	(0.066)	(0.031)			
$NHstd^2_{t-2}$	-0.059	0.206***	-0.110**			
	(0.068)	(0.069)	(0.044)			
$NHstd^3_{t-2}$	0.464***	0.123**	0.191***			
	(0.052)	(0.052)	(0.036)			
$Hstd^1_{t-5}$				0.625***	-0.012	0.413***
				(0.093)	(0.104)	(0.066)
$Hstd^2_{t-5}$				0.671***	0.179*	0.353***
				(0.094)	(0.097)	(0.068)
$Hstd^3_{t-5}$				1.456***	0.565***	0.706***
				(0.055)	(0.057)	(0.041)
$NHstd^1_{t-5}$				0.002	0.023	-0.05
				(0.054)	(0.068)	(0.035)
$NHstd^2_{t-5}$				0.358***	0.267***	0.118**
				(0.066)	(0.069)	(0.047)
$NHstd^3_{t-5}$				0.004	-0.076	0.014
				(0.051)	(0.051)	(0.037)
Tappl	-0.049***	-0.026***	-0.034***	-0.024***	-0.013	0.027***
	(0.005)	(0.006)	(0.003)	(0.008)	(0.009)	(0.005)
ldistw	-1.335***	-1.308***	-0.405***	-1.382***	-1.377***	-0.430***
	(0.040)	(0.046)	(0.029)	(0.043)	(0.050)	(0.033)
DEU_memb	1.001***	1.048***	0.141*	0.719***	0.891***	0.071
	(0.070)	(0.079)	(0.073)	(0.071)	(0.080)	(0.073)
Dcolony	1.091***	0.843***	0.439***	1.006***	0.785***	0.431***
	(0.047)	(0.046)	(0.037)	(0.050)	(0.050)	(0.041)
Dcomm_lang	0.710***	0.300***	0.358***	0.726***	0.347***	0.371***
	(0.046)	(0.046)	(0.033)	(0.048)	(0.049)	(0.035)
D_posexp_t-1			1.029***		0.975***	
			(0.016)		(0.018)	
Constant	9.148***	5.022***	2.277***	12.647***	7.42***	1.373***
	(0.472)	(0.693)	(0.343)	(0.511)	(0.739)	(0.388)
Observations	9148	5022	2277	12647	742	1373

Notes: Standard errors in brackets. * significat at 10%; ** significat at 5%; *** significat at 1%

Table 9: Robustness Checks

	Heckman (outcome)	**Heckman (outcome)**	**Heckman (outcome)**	**Heckman (outcome)**	**Heckman (outcome)**	**Heckman (outcome)**	**Heckman (outcome)**
$Hstd_t^1$	0.66***	0.711***	0.708***	0.478***			
	(0.091)	(0.068)	(0.197)	(0.139)			
$Hstd_t^2$	0.727***	0.573***	1.138***		0.902***		
	(0.120)	(0.205)	(0.223)		0.116		
$Hstd_t^3$	0.726***	0.938***	1.041***			0.585***	
	(0.044)	(0.069)	(0.092)			(0.088)	
$NHstd_t^1$	-0.139	-0.096	-0.044	0.300			
	(0.123)	(0.107)	(0.249)	(0.229)			
$NHstd_t^2$	0.004	0.338	-0.222		-0.102		
	(0.100)	(0.208)	(0.187)		(0.096)		
$NHstd_t^3$	0.354***	0.303**	0.362***			-0.252*	
	(0.053)	(0.079)	(0.111)			(0.135)	
H_std microcir.							1.023***
							(0.113)
NH_ microcir.							-0.576
							(0.909)
Tappl	-0.007	-0.013	-0.021*	-0.018***	-0.050***	-0.015	-0.041
	(0.005)	(0.010)	(0.011)	(0.007)	(0.008)	(0.015)	(0.031)
ldistw	-1.988***	-1.375***		-1.330***	-1.197***	-1.361***	-1.288***
	(0.054)	(0.052)		(0.089)	(0.070)	(0.067)	(0.108)
DEU_memb		0.829***	1.100***	0.042***	1.280***	1.408***	
		(0.080)	(0.185)		(0.154)	(0.114)	(0.116)
Dcolony	0.881***	0.772***		0.636***	1.007***	0.982***	0.545***
	(0.047)	(0.052)		(0.085)	(0.068)	(0.065)	(0.111)
Dcomm_lang	0.294***	0.373***		0.191**	0.286***	0.335***	0.414***
	(0.046)	(0.051)		(0.086)	(0.068)	(0.064)	(0.109)
Constant	-1.330	0.453	-3.885***	6.848***	2.10**	10.421***	8.613***
	(1.183)	(1.232)	(0.856)	(0.976)	(0.890)	(1.023)	(4.544)
Observations	87120	64845	6288	31440	31440	31440	13800
Comments	no new EU10	period 96-06	EU15 block	Cat1	cat2	Cat3	microcir.

Notes: Standard errors in brackets. * significat at 10%; ** significat at 5%; *** significat at 1%

Table 10: Four Digit SIC Codes and Descriptions

SIC4	Description
3612	Transformers
3613	Switchgear and switchboard apparatus
3621	Motors and generators
3624	Carbon or graphite products
3625	Relays and industrial controls
3629	Electrical industrial apparatus
3631	Household cooking equipment
3632	Refrigerators and refrigerating equipment
3633	Household laundry equipment
3634	Electric housewares and fans
3635	Household vacuum cleaners
3639	Household appliances, nec
3641	Electric lamps
3643	Current-carrying wiring devices
3644	Noncurrent-carrying devices
3645	Residential Electric Lighting fixtures
3647	Vehicular lighting equipment
3648	Lighting equipment, nec
3651	Radio and tv receiving sets, phonographs, record players record
3652	Phonograph records; pre-recorded magnetic tapes or wires master
3661	Telephone and telegraph apparatus
3663	Radio, broadcast, and television communications equipment
3669	Other communications equipment, nec
3671	Electron tubes
3672	Printed circuit boards
3674	Semiconductors and related devices
3675	Electronic capacitors
3676	Resistors for electronic applications
3677	Electronic coils and transformers
3678	Connectors, for electronic applications
3679	Electronic components, nec
3691	Storage batteries
3692	Primary batteries
3694	Electrical starting and ignition equipment for internal combustion engines
3695	Recording media
3699	Electrical equipment and supplies, nec

Notes: This table provides the codes and description of the 36 four digit SIC industries included in the sample. Some names are truncated to reduce clutter.

Table 11: Firm Characteristics by Type of Firm and Year

	Number		tvs		Exports		Employment		MU firms	
	1992	1997	1992	1997	1992	1997	1992	1997	1992	1997
Firms	7,985	8,443	26.1	39.9	–	–	170.4	177.6	31.6	30.0
No exporting firms	4,015	3,690	4.0	4.7	–	–	44.6	41.7	12.5	9.9
Exporting firms	3,970	4,753	48.5	67.2	30.2	45.7	297.6	283.1	50.8	45.7
EU	2,722	3,108	64,1	95.9	43.7	69.5	383.8	384.8	59.1	55.9
No EU	1,248	1,645	14.4	13.0	0.5	0.7	109.6	91.1	32.9	26.4

Notes: Table breaks out the number of firms, the average total value of shipments (tvs), the average value of exports, the average employment and the share of multi-plant firms (MU) according to the type of firm by year. EU exporters are firms that export to the EU whereas No EU exporters are firms that export to any other region but the EU. Total value of shipments and exports are in millions of nominal U.S. dollars.

Table 12: Concordances between ICS classification and SIC4 classification.

SIC4	ICS	ICS Description	SIC4	ICS	ICS Description
3612	13.140	Noise with respect to human beings	3644	29.035	Insulating materials
3612	29.180	Transformers. Reactors	3644	29.080	Insulation
3612	29.200	Rectifiers. Converters. Stabilized power supply	3645	29.140	Lamps and related equipment
3612	29.240	Power transmission and distribution networks	3647	29.140	Lamps and related equipment
3613	29.120	Electrical accessories	3648	29.140	Lamps and related equipment
3613	29.130	Switchgear and controlgear	3651	17.140	Acoustics and acoustic measurements
3621	27.100	Power stations in general	3651	33.100	Electromagnetic compatibility (EMC)
3621	29.160	Rotating machinery	3651	33.160	Audio, video and audiovisual engineering
3624	25.180	Industrial furnaces	3652	33.160	Audio, video and audiovisual engineering
3625	29.130	Switchgear and controlgear	3661	33.040	Telecommunication systems
3625	29.260	Electrical equipment for working in special conditions	3661	33.160	Audio, video and audiovisual engineering
3629	31.060	Capacitors	3663	33.160	Audio, video and audiovisual engineering
3631	13.120	Domestic safety	3663	33.180	Fibre optic communications
3631	97.030	Domestic electrical appliances in general	3669	33.160	Audio, video and audiovisual engineering
3631	97.040	Kitchen equipment	3671	31.100	Electronic tubes
3632	13.120	Domestic safety	3672	29.120	Electrical accessories
3632	97.030	Domestic electrical appliances in general	3672	31.180	Printed circuits and boards
3632	97.040	Kitchen equipment	3674	31.080	Semiconductor devices
3633	13.120	Domestic safety	3674	31.200	Integrated circuits. Microelectronics
3633	97.030	Domestic electrical appliances in general	3675	31.060	Capacitors
3633	97.060	Laundry appliances	3676	31.040	Resistors
3634	13.120	Domestic safety	3677	13.140	Noise with respect to human beings
3634	97.040	Kitchen equipment	3677	29.180	Transformers. Reactors
3634	97.060	Laundry appliances	3677	29.200	Rectifiers. Converters. Stabilized power supply
3634	97.170	Body care equipment	3677	29.240	Power transmission and distribution networks
3635	13.120	Domestic safety	3678	29.120	Electrical accessories
3635	97.030	Domestic electrical appliances in general	3678	29.240	Power transmission and distribution networks
3635	97.080	Cleaning appliances	3679	31.200	Integrated circuits. Microelectronics
3639	13.120	Domestic safety	3691	29.220	Galvanic cells and batteries
3639	61.080	Sewing machines and other equipment for the clothing industr	3692	29.220	Galvanic cells and batteries
3639	91.140	Installations in buildings	3694	43.060	Internal combustion engines for road vehicles
3639	97.030	Domestic electrical appliances in general	3695	33.160	Audio, video and audiovisual engineering
3641	29.140	Lamps and related equipment	3699	17.220	Electricity. Magnetism. Electrical measurements
3643	29.060	Electrical wires and cables	3699	31.040	Resistors
3643	29.140	Lamps and related equipment	3699	31.260	Optoelectronics. Laser equipment
3644	13.260	Protection against electric shock. Live working	3699	97.120	Automatic controls for household use

Notes: This table presents the concordance between four-digit SIC industries and five-digits ICS classification codes. The description of ICS codes are presented. Some names are truncated to reduce clutter.

Table 13: Trade Costs by Four-Digit SIC Industry and Year

	Tariff Rate (Percent)			Share Non-harmonized Stds (Percent)		
SIC4	1992	1997	2002	1992	1997	2002
3612	5.6	4.1	2.9	80.0	61.5	51.0
3613	4.5	3.6	2.5	65.0	54.8	47.7
3621	3.5	2.6	2.0	61.1	37.0	66.7
3624	4.8	3.8	3.1	25.0	6.7	4.5
3625	4.6	3.2	2.3	85.9	57.4	51.6
3629	4.9	3.8	0.0	27.3	67.3	68.1
3631	4.7	3.5	2.7	98.0	49.4	31.4
3632	3.0	2.3	1.8	98.0	49.4	31.4
3633	4.4	3.2	2.2	94.4	51.4	37.5
3634	5.2	3.7	2.7	95.2	40.2	29.8
3635	4.3	2.9	2.2	95.2	61.5	39.5
3639	4.8	3.4	2.4	94.0	60.2	46.2
3641	5.1	3.6	2.6	50.7	34.2	29.5
3643	4.5	3.5	2.0	53.3	41.4	40.0
3644	5.9	4.9	2.9	25.4	24.2	22.0
3645	0.0	4.9	3.7	50.7	34.2	29.5
3647	4.9	3.5	2.7	50.7	34.2	29.5
3648	5.8	4.4	3.5	50.7	34.2	29.5
3651	8.3	7.1	6.0	22.2	22.7	21.3
3652	3.2	4.1	2.7	10.5	6.5	9.0
3661	7.3	6.9	0.5	15.0	11.7	10.4
3663	3.8	5.3	3.3	14.8	19.0	14.0
3669	4.2	2.8	1.6	10.5	6.5	9.0
3671	7.8	5.0	4.0	75.0	69.2	69.2
3672	6.2	5.2	0.0	45.7	42.3	38.9
3674	10.9	6.6	0.0	100.0	96.9	53.3
3675	5.8	4.2	0.0	27.3	67.3	68.1
3676	5.5	3.7	0.4	54.5	82.1	70.0
3677	4.3	3.9	2.5	71.4	61.3	50.9
3678	5.0	3.8	2.4	50.9	53.9	51.8
3679	6.2	4.2	1.3	100.0	100.0	66.7
3691	4.0	3.1	2.3	9.1	31.3	27.7
3692	8.9	6.2	4.5	9.1	31.3	27.7
3695	4.9	3.8	0.6	10.5	6.5	9.0
3699	4.6	3.2	2.1	44.6	48.6	39.0
Average	5.2	4.1	2.2	53.5	44.5	37.8

Notes: This table summarizes tariffs and the number of no harmonized standards as a share of total standards across four-digit SIC industries. Tariffs are weighted averages of the underlying six-digit HS codes, using EU import value from the U.S. as weights. The final row is the unweighted average of all manufacturing industries included in the analysis.

Table 14: U.S. Export value to the EU, SIC4-Country-Year. 1992-2004

Regressor	Propensity to export dummy	ln (Export value)	Propensity to export dummy	ln (Export value)
Ln(Distance)	-0.693***	-3.007***	-0.422***	-2.655***
	(0.033)	(0.086)	(0.040)	(0.086)
Ln(GDP)	0.311***	0.500***	0.200***	0.380***
	(0.003)	(0.009)	(0.004)	(0.009)
Ln(Tariff rate)	-0.035***	-0.278***	-0.002	-0.227***
	(0.005)	(0.013)	(0.007)	(0.013)
Ln(NH share)	-0.097**	-0.059***	-0.034***	-0.026**
	(0.005)	(0.011)	(0.006)	(0.011)
Ln(W)		0.376***		0.360***
		(0.010)		(0.009)
Lag export decision			2.092***	
			(0.008)	
$\hat{\eta}$				-0.828***
				(0.017)
Sample	Full	positive export value	Full	positive export value
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Observations	7020	4971	7020	4971
Estimation	Probit	OLS	Heckman First-stage	Heckman Second-stage

Notes: Robust standard errors adjusted for clustering at the country level are in parentheses. Industry fixed effects are for four-digit SIC codes. *** Significant at the 1% level; ** significant at the 5% level; * significant at the 10% level. Coefficients for the regressions constant and dummy variables are suppressed.

Table 15: U.S. Export value to the EU: AF firms and OR firms, SIC4-Country-Year. 1992-2004

	AF firms' export value		OR firms' export value	
Regressor	Propensity to export dummy	ln (Export value)	Propensity to export dummy	ln (Export value)
Ln(Distance)	-0.356***	-2.491***	-0.915***	-1.687***
	(0.054)	(0.130)	(0.064)	(0.202)
Ln(GDP)	0.166***	0.261***	0.285***	-0.012
	(0.005)	(0.013)	(0.005)	(0.020)
Ln(Tariff rate)	-0.014	-0.095***	-0.031***	-0.086***
	(0.009)	(0.016)	(0.009)	(0.024
Ln(NH share)	-0.046***	0.101**	-0.025***	-0.055**
	(0.007)	(0.023)	(0.008)	(0.024)
Ln(W)		0.262***		0.016
		(0.013)		(0.021)
Lag export decision	2.516***		1.654***	
	(0.011)		(0.013)	
$\hat{\eta}$		-1.026***		-0.828***
		(0.019)		(0.017)
Sample	Full	positive export value	Full	positive export value
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Observations	7020	4971	7020	4971
Estimation	Heckman First-stage	Heckman Second-stage	Heckman First-stage	Heckman Second-stage

Notes: Robust standard errors adjusted for clustering at the country level are in parentheses. Industry fixed effects are for four-digit SIC codes. *** Significant at the 1% level; ** significant at the 5% level; * significant at the 10% level. Coefficients for the regressions constant and dummy variables are suppressed.

Table 16: Probability of Entering the EU Market, All firms.

Regressor	spec1	spec2	spec3	spec4
Change in tariff rate	0.122	0.127	0.199	0.204
	(0.198)	(0.209)	(0.209)	(0.218)
Change in NH share	-0.155***	-0.140**	-0.145**	-0.149***
	(0.053)	(0.057)	(0.059)	(0.460)
Ln(labor Productivity)		0.469***	0.256**	0.236**
		(0.112)	(0.103)	(0.111)
Ln(employment)			0.255**	0.223**
			(0.106)	(0.105)
Ln (K/L)			0.083**	0.074*
			(0.038)	(0.038)
Ln(Wage)			0.260**	0.255**
			(0.125)	(0.126)
Part of Multiple-Plant Firm			0.409***	0.362***
			(0.080)	(0.081)
OR firm				0.769***
				(0.124)
x change in NH share				-0.037*
				(0.019)
Year fixed effects	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes
Observations	4294	4294	4294	4294
log likelihood	-1993.16	-1973.75	-1869.62	-1850.18

Notes: Firm-level logistic regression results. Robust standard errors adjusted for clustering at the four-digits SIC level are in parentheses. Industry fixed effects are for three-digit SICs. Dependent variable indicates whether a non-exporting firm to the EU becomes an exporter to the EU between year t and year t+5. Regressions cover two panels: 1992 to 1997 and 1997 to 2002. *** Significant at the 1% level; ** significant at the 5% level; * significant at the 10% level. Coefficients for the regressions constant and dummy variables are suppressed.

Table 17: Probability of Entering the EU Market, OR firm-product pairs.

Regressor	spec1	spec2	spec3
Change in tariff rate	-0.439***	-0.380***	-0.144***
	(0.000)	0.057)	(0.082)
Change in NH share	-1.631***	-1.530***	-0.687***
	(0.000)	(0.098)	(0.152)
Ln(labor Productivity)		-0.082	0.155**
		(0.081)	(0.073)
Ln(employment)			0.251**
			(0.114)
Ln (K/L)			-0.282***
			(0.060)
Ln(Wage)			-0.134
			(0.119)
Part of Multiple-Plant Firm			-1.370***
			(0.120)
Other EU product			0.650**
			(0.135)
Year Fixed Effects	yes	yes	yes
Industry Fixed Effects	yes	yes	yes
Observations	4867	4867	4867
Log likelihood	-1874.07	-1873.11	-1751.01

Notes: Firm-product level logistic regression results. Robust standard errors adjusted for clustering at the four-digits SIC level are in parentheses. Industry fixed effects are for three-digit SICs. Dependent variable indicates whether a firm-hs10 pair is observed in a developing country but not in the EU in yeat t and it is observed in the EU in year t+5. Regressions cover two panels: 1992 to 1997 and 1997 to 2002. *** Significant at the 1% level; ** significant at the 5% level; * significant at the 10% level. Coefficients for the regressions constant and dummy variables are suppressed.

Table 18: Probability of Entering the EU Market, OR firms and non-exporting firms.

	OR firms			Non-exporting firms		
Regressor	spec1	spec2	spec3	spec1	spec2	spec3
Change in tariff rate	0.012	-0.006	0.053	0.075	0.115	0.193
	(0.253)	(0.256)	(0.249)	(0.260)	(0.255)	(0.255)
Change in NH share	-0.238**	-0.233**	-0.242**	-0.143***	-0.128**	-0.133**
	(0.102)	(0.103)	(0.107)	(0.052)	(0.051)	(0.054)
Ln(Labor Productivity)		0.118	-0.020		0.647***	0.452***
		(0.118)	(0.128)		(0.185)	(0.119)
Ln(employment)			0.382**			0.216
			(0.150)			(0.165)
Ln (K/L)			0.052			0.090
			(0.059)			(0.058)
Ln(wage)			-0.081			0.57**
			(0.163)			(0.185)
Part of Multiple-Plant Firm			0.215			0.493***
			(0.141)			(0.168)
Year Fixed Effects	yes	yes	yes	yes	yes	yes
Industry Fixed Effects	yes	yes	yes	yes	yes	yes
Observations	1129	1129	1129	2153	2153	2153
Log likelihood	-882.296	-867.525	-811.514	-490.385	-488.763	-466.03

Notes: firm level logistic regression results. Robust standard errors adjusted for clustering at the four-digits SIC level are in parentheses. Industry fixed effects are for three-digit SICs. OR firms indicate whether an exporting firm to the a developing country but not to the EU becomes an exporter to the EU between year t and year t+5. Non-exporting firms indicate whether a non-exporting firm becomes an exporter to the EU between year t and year t+5. Regressions cover two panels: 1992 to 1997 and 1997 to 2002. *** Significant at the 1% level; **significant at the 5% level; * significant at the 10% level. Coefficients for the regressions constant and dummy variables are suppressed.

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