

Product Standards Harmonization and Firm Heterogeneity in International Trade

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Abstract: As free trade areas have proliferated and statutory tariffs have been dramatically reduced in recent decades, non-tariff barriers (NTBs) to international trade have risen in importance. Destination-specific product standards are one of the major types of NTBs as they impose additional costs on exporters and increases the time required to bring a product to market. This paper examines the response of U.S. manufacturing firms to a reduction of this NTB by looking at the harmonization of European product standards to international norms in the electronics sector. 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 developing markets before harmonization. These firms are characterized by being smaller and less productive than the firms that were already exporting to the EU before harmonization. I also find that harmonization decreases export sales at existing exporters —the intensive margin of trade. Overall, I confirm that product standards harmonization enhances trade. These findings are consistent with a model featuring the role of product standards heterogeneity across market destinations and productivity heterogeneity across firms. These results suggest that working towards a harmonization of product rules across markets could be a supportive policy to incentive small and medium sized firms ability to enter new export markets.

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“These days, it is differences in national regulations, far more than tariffs, that put sand in the wheels of trade between rich countries.” The Economist, May 24th, 1997.

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 destination 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.

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).¹ EU member countries are obliged to adopt these standards and

¹For 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 demonstrate the compliance of low power electronic and electrical apparatus with the basic restrictions related to human exposure to electromagnetic fields (10 MHz - 300 GHz).

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.

Product standards are an important, albeit often overlooked, actor in the international trade arena.² 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

²Sykes (1995) and WTO (2005) present an excellent overview of product standards in the multilateral system and its impact on trade.

destination. 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. These firms are 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.³

Results are largely 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.

³The concordance is available at <http://sites.google.com/site/josedanielreyesp/>

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 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 1 contains theoretical derivations and appendix 2 presents details of the data set.

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.

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.

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

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.

$$q[p(\omega)] = \frac{E^i p(\omega)^{-\sigma}}{P^i} = d^i p(\omega)^{-\sigma} \quad (2)$$

where $d^i = \frac{E^i}{P^i}$ 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:

$$P^i = \left[\int_{\omega \in \Omega^i} p(\omega)^{1-\sigma} d\omega \right] \quad (3)$$

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 cost⁴, 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.⁵ 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 $f_x^H = f_x^F$.⁶ Profit maximization leads to the following pricing rule:

$$p(\omega) = \frac{\sigma}{\sigma - 1} cw \quad (4)$$

where w is the common wage rate hereafter normalized to one. The constant mark up pricing is equal across market destination 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_x^{ij}) can be expressed as:

$$\pi_d^i = c^{1-\sigma} \frac{d^i}{\sigma} \left[\frac{\sigma}{\sigma - 1} \right]^{1-\sigma} - f_d \quad (5)$$

$$\pi_x^{ij} = c^{1-\sigma} \frac{d^j}{\sigma} \left[\frac{\sigma}{\sigma - 1} \right]^{1-\sigma} - f_x^j \quad (6)$$

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

Profit functions for the Home country are depicted in figure 1. In this figure, $c^{1-\sigma}$ is represented in the horizontal axis. Since $\sigma > 1$, this variable increases monotonically with labor productivity, $(\frac{1}{c})$, 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, $d^R < d^F$.⁷

⁴This overhead cost is assumed to be the same across countries.

⁵The basic insights of the model does not change if I allow $\tau^i > 1$, and $\tau^R > \tau^F$.

⁶Home country and Foreign country have different but equally costly product standards.

⁷See appendix 1.

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 5 and 6 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*} .

$$c_d^{i*} = \left[\frac{d^i}{f_d \sigma} \right]^{\frac{1}{\sigma-1}} \left[\frac{\sigma-1}{\sigma} \right] \quad (7)$$

$$c_x^{ij*} = \left[\frac{d^j}{f_x^j \sigma} \right]^{\frac{1}{\sigma-1}} \left[\frac{\sigma-1}{\sigma} \right] \quad (8)$$

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 1 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 .

$$\int_0^{c_d^{i*}} [\pi_d^i] dG(c) + \int_0^{c_x^{ij*}} [\pi_x^{ij}] dG(c) + \int_0^{c_x^{ik*}} [\pi_x^{ik}] dG(c) = f_E \quad \forall i \quad (9)$$

where $\{i, j, k\} \in \{H, F, R\}$ and $i \neq j \neq k$. See appendix 1 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).

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 7. 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.

$$\widehat{\pi}_x^H = c^{1-\sigma} \left[\frac{d^F + d^R}{\sigma} \right] \left[\frac{\sigma}{\sigma - 1} \right]^{1-\sigma} - \widehat{f}_x \quad (10)$$

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

$$\widehat{c}_x^H = \left[\frac{d^F + d^R}{\widehat{f}_x \sigma} \right]^{\frac{1}{\sigma-1}} \left[\frac{\sigma - 1}{\sigma} \right] \quad (11)$$

The conditional export profit from F and R to H are still given by equation 6, 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.⁸

$$\widehat{\pi}_x^{ij} = c^{1-\sigma} \left[\frac{d^j}{\sigma} \right] \left[\frac{\sigma}{\sigma - 1} \right]^{1-\sigma} - \widehat{f}_x \quad (12)$$

$$\widehat{c}_x^{ij} = \left[\frac{d^j}{\widehat{f}_x \sigma} \right]^{\frac{1}{\sigma-1}} \left[\frac{\sigma - 1}{\sigma} \right] \quad (13)$$

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

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

$$\int_0^{c_d^H} [\pi_d^H] dG(c) + \int_0^{\widehat{c}_x^H} [\widehat{\pi}_x^H] dG(c) = f_E \quad (14)$$

$$\int_0^{c_d^{i*}} [\pi_d^i] dG(c) + \int_0^{c_x^{iH*}} [\pi_x^{iH}] dG(c) + \int_0^{\widehat{c}_x^{ij*}} [\widehat{\pi}_x^{ij}] dG(c) = f_E \text{ for } \{i, j\} \in \{F, R\} \text{ } i \neq j \quad (15)$$

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

⁸To 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 1 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 \hat{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.⁹ Figure 2 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 \hat{f}_x is “near” f_x^R , then all OR firms enter the F market⁵. 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 3 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 up and reduce the optimal quantity demanded of a given firm, see equation 2. 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.¹⁰ 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 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.

⁹See appendix 1 for this condition.

¹⁰Such 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).

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 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)¹¹, 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.

3.1 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 2002.¹² 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.¹³ For 1992 and 1997, plants are classified at the four-digit Standard Industrial

¹¹See 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).

¹²Though CM data are available for earlier periods, I cannot use them because export information on the LFTTD is not available.

¹³The 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.

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 2.

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 1 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 2 shows firms' characteristics by exporting and non-exporting firms for 1992 and 1997.¹⁴ 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 destination. 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.

3.2 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 sector¹⁵ and their relationship with worldwide standards. The database provides an inventory of the “stock” of active standards¹⁶ 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 1990-2007.¹⁷ 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

¹⁴I do not present data for 2002 because the change in industry classification does not allow me to observe entry 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.

¹⁵This sector refers to electrical, electronic and related technologies. More information can be found at www.iec.ch.

¹⁶The primary variable of interest in the total number of standards with which an exporter should comply during a particular year.

¹⁷A list of the ICS codes can be found at www.iso.org/iso/ics6-en.pdf

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.¹⁸ I deal with this issue by proposing a concordance between 5-digit ICS codes (ICS5) and SIC4 industries. The construction 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 database¹⁹ —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 3 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 destination 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 4 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 regulation 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

¹⁸Blind (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.

¹⁹PERINORM is a bibliographic database maintained by the British, French and German standard-setting bodies. It is designated to facilitate industry access to product standards and technical regulations.

within an industry. Mapping standards to products, however, is quite difficult and would have to be done manually.²⁰ Given the number of standards for electronic products this option is not currently feasible.

4 Empirical Analysis

In this section, I explore the firm-level relationship 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.²¹ In terms of the theoretical model, developing countries are embedded into the R region whereas Europe and the U.S. are represented by regions F and H , respectively.

4.1 Export Value

The existing literature has found robust evidence on the positive impact of product standards harmonization on export volume (Czubala et. al (2009), Shepherd (2010), 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 and the number of zero trade flows are properly taken into account. Specifically, I follow the framework proposed by Helpman et. al. (2008) to estimate a Heckman sample selection model between U.S. export value and my measures of trade costs from 1992 to 2004. An appropriate instrument is a variable 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. The second stage is, then, represented by

²⁰A manual mapping has been implemented for the textiles sector in Shepherd (2006) and used by Shepherd (2007) and by Czubala et. al. (2009).

²¹I 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.

the following equations.

$$\begin{aligned}
(\text{Spec } 1) \quad \ln(x_{jt}^k) &= \beta_0 + \beta_1 \ln(D_j) + \beta_2 \ln(Y_{jt}) + \beta_3 \ln(W_{jt}^i) + \beta_4 \hat{\eta}_{jt}^k + \beta_5 \ln(\tau_t^i) + \beta_6 \ln(NH_t^i) + \\
&\quad \gamma_t + \gamma_k + \epsilon_{jt}^k \\
(\text{Spec } 2) \quad \ln(x_{jt}^k) &= \beta_0 + \beta_3 \ln(W_{jt}^i) + \beta_4 \hat{\eta}_{jt}^k + \beta_5 \ln(\tau_t^i) + \beta_6 \ln(NH_t^i) + \gamma_t + \gamma_k + \gamma_j + \epsilon_{jt}^k \quad (16) \\
(\text{Spec } 3) \quad \ln(x_t^k) &= \beta_0 + \beta_3 \ln(W_t^i) + \beta_4 \hat{\eta}_t^k + \beta_5 \ln(\tau_t^i) + \beta_6 \ln(NH_t^i) + \gamma_t + \gamma_k + \epsilon_{jt}^k
\end{aligned}$$

where x_{jt}^k is the value of US exports of product k to country j in year t . A product is an HS10 code and countries are the original EU-15 members.²² D_j is the distance between the U.S. and country j whereas Y_{jt} is the GDP of country j in year t . The most important difference with the standard gravity equation²³ is the inclusion of the variable W_{jt}^i that controls for the fraction of U.S. firms in industry i that export to country j in year t .²⁴ The variable $\hat{\eta}_{jt}^k$ is the inverse mills ratio, i.e., $\hat{\eta}_{jt}^k = \frac{\phi(Z_i^* \gamma)}{\Phi(Z_i^* \gamma)}$ and it controls for the fact that country pairs with zero trade flows are excluded from equation 16.²⁵ The tariff rate for industry i in year t is given by τ_t^i while the number of non-harmonized standards as a share of the total number of standards in industry i in year t is given by NH_t^i .²⁶ Finally, γ_t and γ_k are sets of year and product fixed effects and robust standard errors are adjusted for clustering at the SIC4 level.²⁷

Regression results are reported in Table 5. The first column reports results from estimating equation specification 1. In the second column country variables are replaced by country fixed effects (specification 2) and in the third columns exports are aggregated at the product-year level (specification 3). The first panel presents the second stage results while the second panel shows the first stage. Results are consistent with the theoretical model: the negative coefficients 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 export value within product-country-year bins. Remarkably, product standard harmonization seems to be more important than tariffs for the propensity to export than for the export volume. Henceforth, I make use of detail firm level data to show that the impact 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.

²²Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and United Kingdom.

²³See, for example, Anderson and Wincoop (2003).

²⁴Helpman et. al. (2008) estimate W_{jt}^i as a predicted component from the first stage of the model. I compute this variable from the underlying firm level data. Details of the construction of the variables are in appendix 2.

²⁵The inverse mills ratio is derived from the first stage that consists of estimating a Probit model that specifies the probability of observing positive trade flows as a function of the observable variables Z_i , which are the RHS variables in equation 16 plus the lagged decision to export.

²⁶Note that an increase in harmonization of standards (reduction in a NTB to international trade) implies a reduction in NH_t^i .

²⁷Year fixed effects control for observable and unobservable characteristics that change across years and are common to countries and products; like exchange rates and other type of European trade policy tool. Product fixed effects control for characteristics that vary across products but not across years or across countries.

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 16 on the export volume constructed from the firm-level exports of the set of firm-product pairs that remain as exporters to the EU for the complete set of years of my sample. This group is equivalent to the set of AF firms in the theoretical model.

Results are reported across the first three columns in table 6. As a way to present preliminary evidence on the different impact that harmonization exerts at the extensive margin of trade, columns 4 to 6 report the results of estimating equations 16 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 sometimes significant coefficient for the role of product standard harmonization in AF firms' export volume. 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 always 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.

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 ($\Delta\tau_{t+5}^i$) and as the log difference on my measure of product standard heterogeneity over the preceding five years (ΔNH_{t+5}^i). These regressions are given by:

$$\begin{aligned}
 (\text{Spec } 1) \quad Pr(E_{t+5} = 1) &= \Phi(\beta_1 \Delta\tau_{t+5}^i + \beta_2 \Delta NH_{t+5}^i + \gamma_t + \gamma_i) \\
 (\text{Spec } 2) \quad Pr(E_{t+5} = 1) &= \Phi(\beta_1 \Delta\tau_{t+5}^i + \beta_2 \Delta NH_{t+5}^i + \beta_3 PR_t + \gamma_t + \gamma_i) \\
 (\text{Spec } 3) \quad Pr(E_{t+5} = 1) &= \Phi(\beta_1 \Delta\tau_{t+5}^i + \beta_2 \Delta NH_{t+5}^i + \beta_3 PR_t + \beta_4 Z_t + \gamma_t + \gamma_i) \\
 (\text{Spec } 4) \quad Pr(E_{t+5} = 1) &= \Phi(\beta_1 \Delta\tau_{t+5}^i + \beta_2 \Delta NH_{t+5}^i + \beta_3 PR_t + \beta_4 Z_t + \beta_5 OR_Firm_t + \\
 &\quad \beta_6 OR_Firm_t * \Delta NH_{t+5}^i + \gamma_t + \gamma_i)
 \end{aligned} \tag{17}$$

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 7, 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.

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:

$$\begin{aligned}
(\text{Spec } 1) \quad Pr(E_{p,t+5} = 1) &= \Phi(\beta_1 \Delta \tau_{t+5}^i + \beta_2 \Delta NH_{t+5}^i + \gamma_t + \gamma_i) \\
(\text{Spec } 2) \quad Pr(E_{p,t+5} = 1) &= \Phi(\beta_1 \Delta \tau_{t+5}^i + \beta_2 \Delta NH_{t+5}^i + \beta_3 PR_t + \gamma_t + \gamma_i) \\
(\text{Spec } 3) \quad Pr(E_{p,t+5} = 1) &= \Phi(\beta_1 \Delta \tau_{t+5}^i + \beta_2 \Delta NH_{t+5}^i + \beta_3 PR_t + \beta_4 Z_t + \gamma_t + \gamma_i)
\end{aligned} \tag{18}$$

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 8. 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 17 for these two groups of firms separately. Table 9 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.

4.5 New Exporters to the Developing World

The theoretical model is ambivalent regarding the impact of harmonization on entry to market R . If the harmonized product standard is “close” to the most stringent standard before harmonization, some *OR* firms abandon the foreign market; otherwise some domestic firms enter export markets. Above, I showed that harmonization increases the probability that a non-exporting firm enters the EU market, albeit at a smaller rate than for *OR* firms. Now, I check whether product standards harmonization influences the probability of observing a non-exporting firm entering the developing market by estimating equations 17 for this set of observations.²⁸ Results are reported in Table 10. Across specifications, the reduction in tariffs increases the probability of firm entry into the developing world whereas product standard harmonization does not affect such probability.

²⁸Now, $Et+5$ is defined as a dummy variable equal to one if a firm does not export at all in year t and becomes an exporter to the developing world in year $t+5$.

This result is at odds with the theoretical model since harmonization have an impact on entry from non-exporting firms to markets F and R in the same way. This discrepancy may be due to the fact that the full harmonization assumed by the theoretical model is not actually observed in the real world and/or that tariffs barriers are more important than non-tariff barriers in developing countries. More work on this area —both at the theoretical and at the empirical level— may prove useful.

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. Census 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.

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Appendix 1

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.

$$P^i = \left[\frac{\sigma}{\sigma - 1} \right]^{1-\sigma} \left[\int_0^{c_d^{i*}} c^{1-\sigma} dG(c) + \int_0^{c_x^{ji*}} c^{1-\sigma} dG(c) + \int_0^{c_x^{ki*}} c^{1-\sigma} dG(c) \right] \quad (\text{A1})$$

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 7 and 8 and solving the integrals in the previous expression, we can write P^i in terms of exogenous variables.

$$P^{i*} = A \left[f_d^{(1-\frac{\gamma}{\sigma-1})} + 2f_x^{i(1-\frac{\gamma}{\sigma-1})} \right]^{\frac{\sigma-1}{\gamma}} \quad (\text{A2})$$

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 $P^{H*} = P^{F*} < P^{R*}$ and $d^{R*} < d^{F*} = d^{H*}$.

Equilibrium cutoffs are computed plugging equation A2 into equations 7 and 8. 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 1.

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.

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

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

Using equations 7, 11, 13, and solving the integrals in equation B1, the equilibrium price within the harmonized zone can be written as follows.

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

Where A is defined above.

Given that $f_x^R \leq \widehat{f}_x \leq f_x^F$, it is easy to show that $\widehat{p}^H < \widehat{p}^R = \widehat{p}^F$. Comparing equation B1 with equation A1, it is straightforward to get $p^{F*} < \widehat{p}^F$, which implies $\widehat{d}^R < d^{F*} = d^{H*}$ and $d^{F*} < \widehat{d}^F + \widehat{d}^R$. See figures 2 and 3.

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 ($c_x^{HF*} < \widehat{c}_x^H$).*

Proof. Suppose $c_x^{HF*} \geq \widehat{c}_x^H$. Thus, by equations 8 and 11, $\frac{d^{F*}}{f_x^F} \geq \frac{\widehat{d}^F + \widehat{d}^R}{\widehat{f}_x}$, which implies $\frac{d^{F*}}{d^F + d^R} \geq \frac{f_x^F}{f_x}$. Since $\frac{d^{F*}}{d^F + d^R} < 1$ and $\frac{f_x^F}{f_x} > 1$, 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 ($\widehat{c}_x^H > c_x^{HR*}$). Conversely, If the harmonized standard is relatively stringent, low productive OR firms drop export activity ($\widehat{c}_x^H < c_x^{HR*}$).*

Proof. Using equations 8 and 11, $\widehat{c}_x^H > c_x^{HR*}$ can be written as $\frac{2\widehat{d}^F}{f_x} > \frac{d^{R*}}{f_x^R}$, which implies $\frac{2\widehat{d}^F}{d^{R*}} > \frac{\widehat{f}_x}{f_x^R}$ and $\frac{2P^{R*}}{P^F} > \frac{\widehat{f}_x}{f_x^R}$. Plugging equations A1 and B1, this inequality can be written as:

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

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 3). Otherwise, the harmonized standard is said to be too stringent and low productive OR firms drop export markets (figure 2).

Appendix 2 —To be written—

Figures

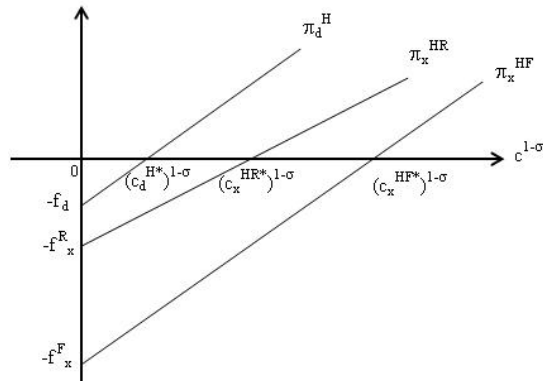


Figure 1 - Home profits and productivity cutoffs before harmonization.

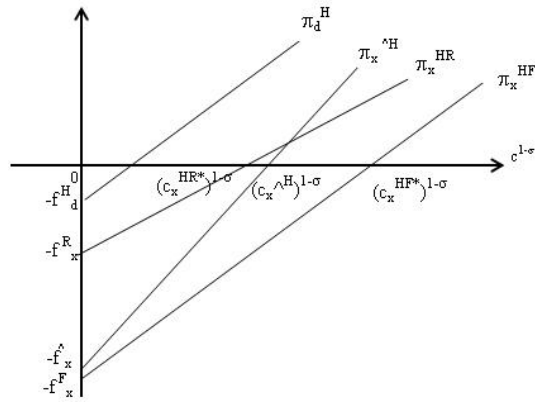


Figure 2 - Home Profits and productivity cutoffs after harmonization I.

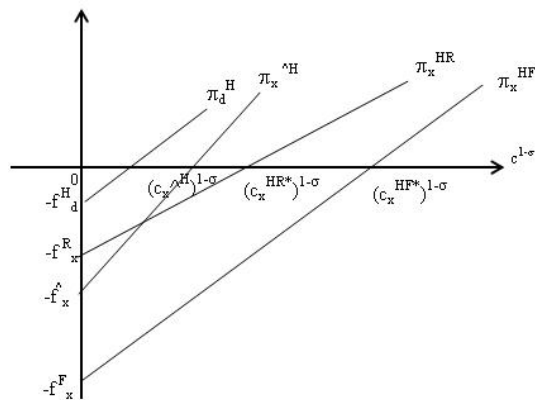


Figure 3 - Home Profits and productivity cutoffs after harmonization II.

Tables

Table 1: 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 2: 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 3: 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 4: Trade Costs by Four-Digit SIC Industry and Year

SIC4	Tariff Rate (Percent)			Share Non-harmonized Stds (Percent)		
	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 5: Total U.S. Export value to the EU, 1992-2004

Regressor	1	2	3
Ln(Distance)	-2.655*** (0.086)		
Ln(GDP)	0.380*** (0.009)		
Ln(Tariff rate)	-0.227*** (0.013)	-0.207*** (0.013)	-0.362*** (0.041)
Ln(NH share)	-0.026** (0.011)	-0.030*** (0.011)	-0.109*** (0.035)
Ln(W)	0.360*** (0.009)	0.275*** (0.010)	0.486*** (0.040)
$\hat{\eta}$	-0.828*** (0.017)	-0.829*** (0.017)	-0.169** (0.066)
Ln(Distance)	-0.422*** (0.040)		
Ln(GDP)	0.200*** (0.004)		
Ln(Tariff rate)	-0.002 (0.007)	-0.004 (0.007)	-0.013 (0.032)
Ln(NH share)	-0.034*** (0.006)	-0.039*** (0.006)	-0.025 (0.028)
Lag export decision	2.092*** (0.008)	2.072*** (0.008)	2.970*** (0.039)
Year fixed effects	Yes	Yes	Yes
Product fixed effects	Yes	Yes	Yes
Country fixed effects	No	Yes	-
Observations	149606	149606	10646

Notes: Heckman sample selection model on trade flows. Robust standard errors adjusted for clustering at the four-digit SIC level are in parentheses. Product fixed effects are for two-digit HS codes. The dependent variable in the first stage (second panel) is a dummy variable for whether there is trade at the hs10-country-year level. The dependent variable in the second stage (first panel) is the log of export value at the hs10-country-year level. *** 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 6: AF firms and OR firms export value to the EU, 1992-2004

	AF firms			OR firms		
	1	2	3	1	2	3
Ln(Distance)	-2.491*** (0.013)			-1.687*** (0.202)		
Ln(GDP)	0.261*** (0.130)			-0.012 (0.020)		
Ln(tariff rate)	-0.095*** (0.016)	-0.101*** (0.016)	-0.063 (0.050)	-0.086*** (0.024)	-0.076*** (0.024)	-0.089* (0.048)
Ln(NH share)	0.101*** (0.023)	0.116*** (0.022)	0.071 (0.068)	-0.055** (0.024)	-0.063*** (0.023)	-0.063* (0.043)
ln(W)	0.262*** (0.013)	0.234*** (0.013)	0.571*** (0.047)	0.016 (0.021)	0.055** (0.021)	0.010 (0.035)
$\hat{\eta}$	-1.026*** (0.019)	-1.031*** (0.019)	-1.413*** (0.082)	-0.074*** (0.029)	-0.958*** (0.029)	-1.119*** (0.061)
Ln(Distance)	-0.356*** (0.054)			-0.915*** (0.064)		
Ln(GDP)	0.166*** (0.005)			0.285*** (0.005)		
Ln(tariff rate)	-0.014 (0.009)	-0.013 (0.009)	-0.070 (0.038)	-0.031*** (0.009)	-0.031*** (0.009)	-0.066*** (0.025)
Ln(NH share)	-0.046*** (0.007)	-0.050*** (0.007)	-0.014** (0.007)	-0.025*** (0.008)	-0.026*** (0.008)	-0.055** (0.022)
Lag export decision	2.516*** (0.011)	2.506*** (0.011)	3.579*** (0.050)	1.654*** (0.013)	1.630*** (0.013)	2.163*** (0.033)
Year fixed effects	yes	yes	yes	yes	yes	yes
Product fixed effects	yes	yes	yes	yes	yes	yes
Country fixed effects	No	yes	yes	No	yes	—
Observations	149606	149606	10646	149606	149606	10646

Notes: Heckman sample selection model on trade flows. AF firms is the export value computed from firm-products that enter exporting markets directly to the EU and that remain in the EU from 1992-2004. OR firms is the export value computed from firm-products that enter export market first to a developing country and then to the EU. Robust standard errors adjusted for clustering at the four-digit SIC level are in parentheses. Product fixed effects are for two-digit HS codes. The dependent variable in the first stage (second panel) is a dummy variable for whether there is trade at the hs10-country-year level. The dependent variable in the second stage (first panel) is the log of export value at the hs10-country-year level. AF firms *** 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 7: Probability of Entering the EU Market, All firms.

Regressor	spec1	spec2	spec3	spec4
Change in tariff rate	0.122 (0.198)	0.127 (0.209)	0.199 (0.209)	0.204 (0.218)
Change in NH share	-0.155*** (0.053)	-0.140** (0.057)	-0.145** (0.059)	-0.149*** (0.460)
Ln(labor Productivity)		0.469*** (0.112)	0.256** (0.103)	0.236** (0.111)
Ln(employment)			0.255** (0.106)	0.223** (0.105)
Ln (K/L)			0.083** (0.038)	0.074* (0.038)
Ln(Wage)			0.260** (0.125)	0.255** (0.126)
Part of Multiple-Plant Firm			0.409*** (0.080)	0.362*** (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 8: Probability of Entering the EU Market, OR firm-product pairs.

Regressor	spec1	spec2	spec3
Change in tariff rate	-0.439*** (0.000)	-0.380*** (0.057)	-0.144*** (0.082)
Change in NH share	-1.631*** (0.000)	-1.530*** (0.098)	-0.687*** (0.152)
Ln(labor Productivity)		-0.082 (0.081)	0.155** (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 year 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 9: Probability of Entering the EU Market, OR firms and non-exporting firms.

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

Table 10: Probability of Entering the Developing Market, Non-Exporting firms.

Regressor	spec1	spec2	spec3
Change in tariff rate	-1.821** (0.720)	-1.791** (0.726)	-1.584** (0.800)
Change in NH share	0.038 (0.140)	0.046 (0.139)	0.022 (0.149)
Ln(Labor Productivity)		0.297*** (0.093)	0.158 (0.114)
Ln(employment)			0.230 (0.217)
Ln (K/L)			0.105* (0.062)
Ln(wage)			0.374 (0.269)
Part of Multiple-Plant Firm			0.602** (0.255)
Year Fixed Effects	yes	yes	yes
Industry Fixed Effects	yes	yes	yes
Observations	1898	1898	1898
Log likelihood	-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. Dependent variable indicates whether a non-exporting firm becomes an exporter to the developing world 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.