The Costs of Complying with Foreign Product Standards for Firms in Developing Countries: An Econometric Study

Keith E. Maskus, University of Colorado at Boulder

Tsunehiro Otsuki, The World Bank

John S. Wilson, The World Bank

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Abstract:

Standards and technical regulations exist to protect consumer safety or to achieve other goals. However, such regulations can raise setup costs and production costs significantly. We develop econometric models to provide the first estimates of the incremental production costs of enterprises in developing nations in conforming to standards imposed by major importing countries. We use firm-level data generated from 16 developing countries through the World Bank Technical Barriers to Trade Survey Database. Our translogarithmic cost function estimation suggests that standards increase short-run production costs by requiring additional labor and capital. A one-percent increase in investment to meet compliance cost in importing countries raises variable production costs by between 0.06 and 0.13 percent, a statistically significant increase. While the impact is small as a share of production costs, it implies an absolute increase of a similar magnitude to the compliance cost itself. The result suggests that standards and technical regulations may constitute non-tariff trade barriers.

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John S. Wilson, The World Bank, 1818 H Street N.W., Washington DC 20433, jswilson@worldbank.org
Tsunehiro Otsuki, The World Bank, 1818 H Street N.W., Washington DC 20433, totsuki@worldbank.org
Keith E. Maskus, Department of Economics, UCB 256, University of Colorado, Boulder CO 80309, maskus@colorado.edu.
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1. Introduction

Technical regulations, such as product certification requirements, performance mandates, testing procedures, conformity assessments, and labeling standards, exist to ensure consumer safety, network reliability, or other goals. However, such regulations can significantly raise setup and production costs. In consequence, they may act as impediments to competition by blocking firm entry and expansion within a country or, as is frequently alleged by exporting concerns, as barriers to trade.[1] Indeed, there has been a rising use of technical regulations as instruments of commercial policy in the unilateral, regional, and global trade contexts (Maskus and Wilson, 2001). As traditional barriers to trade have fallen, these non-tariff barriers have become of particular concern to firms in developing countries, which may bear relatively larger costs in meeting their requirements than their counterparts in developed nations.

Developing countries are typically "standards takers" rather than "standards makers" since, at the national level, developing their own regulations tends to be more costly than adopting those of the major markets (Stephenson, 1997). At the firm level, complying with differing standards in such major export markets as the European Union (EU), the United States, and Japan can add costs and limit export competitiveness.

These costs associated with foreign standards and technical regulations may be borne publicly and privately. But developing countries typically have neither the public resources required to provide national laboratories for testing and certification nor the capability for collective action to raise their standards. As a result, a significant portion of meeting the costs of standards may be borne by individual firms.

[1] See the case studies in Wilson and Abiola (2003).

Despite the evident importance of this question, to date the impacts of technical standards imposed by importing nations on the production costs of firms in developing countries have not been studied systematically in an econometric framework. Quantification of these effects is important for several reasons. First, it is useful to shed light on competing claims about the efficiency and cost impacts of foreign standards and regulations, including how these rules affect labor and capital usage. To the extent that costs are increased or input use is distorted the prospects for efficient industrial development could be impeded. Second, the estimates should be informative for governments in setting domestic standards by illustrating their potential costs. In this context, harmonization with international standards may not be optimal. Third, a finding that costs are raised would support the view that technical regulations may be used to limit market access. In cases where the importing country's regulations may not conform to WTO obligations, the empirical results could help assess the damages to the exporting country's trade benefits. Thus, information on the cost impacts could facilitate the resolution of trade disputes (Maskus and Wilson, 2001).

In this paper we develop econometric models to estimate the incremental production costs of enterprises in several developing nations associated with conforming to standards and technical regulations imposed by major importing countries. We use firm-level data generated through the World Bank Technical Barriers to Trade Survey Database. Our sample includes 159 firms in 12 industries located in 16 developing countries in Eastern Europe, Latin America, the Middle East, South Asia, and Sub-Saharan Africa. We employ transcendental logarithmic cost functions to separate impacts of initial compliance cost from variable cost elements in production. Our results suggest that the need to comply with foreign technical standards has a significantly positive impact. Specifically, the elasticity of (variable) production costs with respect to standards and technical regulations is estimated to range between 0.06 and 0.13. Evaluated at sample means, this result implies an increase in variable costs of a dollar magnitude that is similar to the rise in initial compliance costs.

In Section 2 we provide background information regarding central issues of technical standards, costs, and trade. In Section 3 we specify the econometric model for assessing the cost effects of meeting foreign standards and technical regulations. In Sections 4 and 5 we discuss the survey data and econometric results, respectively. In Section 6 we make concluding observations.

2. Background

In principle, product standards[2] play a variety of useful roles in overcoming market failures (Stephenson, 1997). For example, emission standards oblige firms to internalize the costs of maintaining an acceptably low degree of environmental damage. Food safety standards ensure that consumers are protected from health risks and deceptive practices, information about which would not ordinarily be available in private markets. For consumers, efficient and non-discriminatory standards allow comparison of products on a common basis in terms of regulatory characteristics, permitting enhanced competition. From the producers' point of view, production of goods subject to recognized standards can achieve economies of scale and reduce overall costs. Since standards themselves embody information about technical knowledge,

[2] The terms "standards" and "standards and technical regulations" are used interchangeably throughout this paper. The WTO provides a clear distinction between standards and technical regulations; the former are voluntary and the latter are mandatory technical requirements. In many cases "standards" cover mandatory technical requirements.

conformity to efficient standards encourages firms to improve the quality and reliability of their products.

Standards also may reduce transaction costs in business by increasing the transparency of product information and compatibility of products and components (David and Greenstein, 1990). This is possible as technical regulations can increase the flow of information between producers and consumers regarding the inherent characteristics and quality of products. In short, consumers can reduce uncertainty in determining product quality due to standardization of products (Jones and Hudson, 1996).

International standards, in the absence of multilateral consensus on the appropriate level or setup of standards, also provide common reference points for countries to follow so that transaction costs can be reduced. For example, in 1961 *Codex Alimentarius* was developed as a single international reference point in order to draw attention to the field of food safety and quality. Similarly, international standards developed by the International Standards Organization (ISO) provide a basis especially for the developing countries to choose norms that are recognized in foreign markets. In this regard, conformity to global standards can increase export opportunities.

Despite their potential to expand competition and trade, standards may be set to achieve the opposite outcomes. In general, standards selection could act to raise the compliance costs of some firms (e.g., new entrants) relative to other firms (e.g., incumbents) thereby restricting competition (Fischer and Serra, 2000). This outcome may be most likely in the context of international trade, where governments might choose technical regulations to favor domestic firms over foreign rivals, thereby restricting trade. This issue could be particularly problematic for small exporting firms from developing countries, for they would need to absorb the fixed costs of meeting multiple international regulations without enjoying domestic scale advantages.

Because economic theory suggests that technical regulations can either enhance or impede trade, it is unsurprising that empirical evidence is mixed. Some studies support the claim of an efficiency-increasing effect. Swann et al (1996) studied the impacts of standards on British exports and imports over the period 1985-1991. Standards data were constructed as a simple count of the number of standards by industry. Their findings concluded that adherence to British national standards tended to raise both imports and exports. Moenius (1999) found that standards shared by two countries had a positive and significant effect on trade volumes in a gravity model. Gasiorek et al (1992) employed a CGE approach to find that harmonization of standards in the EU would reduce trade costs by 2.5 percent.

In contrast, the fact that regulations can act as barriers to trade is evident in three recent studies. Otsuki, Wilson, and Sewadeh (2001) estimated the impact of changes in the EU standard on maximum aflatoxin levels in food using trade and regulatory survey data for 15 European countries and nine African countries between 1989 and 1998. The results suggested that implementation of proposed new aflatoxin standards in the EU would reduce African exports of cereals, dried fruits, and nuts to Europe by 64% or US$ 670 million. Wilson and Otsuki (2002) studied the impact of pesticide standards on banana trade. The authors examined regulatory data from 11 OECD importing countries and trade data from 19 exporting countries. The results indicated that a ten-percent increase in regulatory stringency—tighter restrictions on the pesticide chlorpyrifos—would lead to a decrease in banana imports of 14.8 percent. In another paper Wilson, Otsuki and Majumdar (2002) addressed the question of whether crosscountry standards for maximum tetracycline (a widely used antibiotic) affected beef trade. They examined the effects of the tetracycline standard on beef trade between six importing and 16 exporting countries. The results suggested that a ten-percent more stringent regulation on tetracycline use would cause a decrease in beef imports by 6.2 percent.

Survey evidence also points to cost-raising characteristics of technical regulations. A survey by the OECD (2000) as well as the interviews conducted by the United States International Trade Commission (1998) shed some light on the size of standards-related costs.[3] According to the OECD study, which was based on 55 firms in three sectors in the United States, Japan and the United Kingdom, the additional costs of complying with foreign standards can be as high as 10 percent. The United States International Trade Commission informally interviewed representatives of the U.S. information technology industry. Interview responses revealed that standards-related costs are considered the most significant trade barrier in that sector.

Overall, therefore, theoretical models and empirical evidence are mixed on the trade impacts of foreign standards. However, the empirical studies undertaken to date adopt indirect, and potentially misleading, approaches to understanding the cost impacts of regulatory requirements. Specifically, the econometric investigations estimate reduced-form or gravity models of bilateral trade in which standards are entered as a determinant of trade flows. The survey evidence is informative but fails to incorporate the responses directly into a well-specified cost function. Thus, a significant omission in this literature is that none of these studies has taken a systematic and parametric approach to estimating the actual cost impacts of complying with international standards. It is of considerable interest to study the extent to which variable

[3] See the discussion in Maskus, Wilson, and Otsuki (2001).

production costs are raised by these compliance needs and whether such compliance efforts have impacts on factor demand within firms. This is the task to which we turn next.

3. Modeling the Cost Effects of Standards

A full accounting of the implications of a firm's decision to comply with standards requires close study of both the costs and benefits of doing so. Our focus here is strictly on the supply side and we leave aside the demand for compliance. Thus, our aim is to provide an initial quantification of the costs incurred by firms in developing countries as they meet technical regulations required in major export markets. It is of considerable interest to determine whether such cost increases are significant.

3.1 Cost Function

Consider a firm exporting a product to a foreign market that mandates conformity with standard s. We assume that the firm's compliance with any domestic standard is a sunk cost and does not affect its decision to meet the foreign requirement. In principle the foreign standard could affect both the firm's fixed costs (e.g., by requiring product redesign) and its variable costs (e.g., by devoting more labor to product certification). To capture this possibility, we model initial investment in compliance with the standard as a quasi-fixed factor and estimate a short-run variable cost function.[4] In this view, fixed costs are incurred in investing in compliance while firms alter their capital and labor usage to meet recurring costs. Thus, our cost estimates reflect short-run equilibrium and cannot be considered estimates of full adjustment to the long run.

In general, then, the cost function for the firm is specified as

[4] See Berndt and Hesse (1986), Morrison (1988), and Badulescu (2003) for further discussion. Badulescu sets out a similar specification in which R&D is a quasi-fixed input across countries.

$$C = C(w, y; s, z) \quad (1)$$

Here, w refers to a vector of factor prices, y is output, s indicates the stringency of the foreign standard, and z is a vector of other variables affecting firm-level costs. The firm minimizes variable costs wx, where x is the vector of variable inputs. The cost function is assumed to have standard properties: non-decreasing in w and y, concave in w, and homogeneous of degree one with respect to w.

This general cost function has the stringency of standards and technical regulations, s, as an argument because differential standards and technical regulations should affect the choice of inputs for producing a given output level. That is, firms are informed about the technical regulations required to sell their products in foreign markets. They make input allocation decisions between production activities in the traditional sense and efforts that are devoted to comply with the standards and technical regulations.

3.2 Estimation Models

We estimate firm-level parametric cost functions. This approach requires three central assumptions. The first is that all firms, across industries and countries, share the same technology. Application of the transcendental logarithmic (translog) function to industry-level production data across OECD countries shows that this assumption is unlikely to hold (Harrigan, 1997). In the most general case we should estimate firm-level fixed effects and fully flexible quadratic terms between these effects and all cost-related variables in order to permit factor biases in technical differences. Unfortunately, such a specification would more than exhaust the available degrees of freedom and is infeasible. Thus, we include in vector z industry and country fixed effects in every specification to control for differences in technology relative to the benchmark function. Nonetheless, this approach requires making the residual assumptions that firms within an industry within each country share the same cost functions and that efficiency differences by industry and country are Hicks-neutral.

A second problem is that estimation of a cost function incorporating intermediate inputs requires firm-level data on prices of materials and intermediates, which our survey data do not provide. Accordingly, we specify equation (1) as the cost of producing net output, or value added, introducing only labor and capital as variable inputs. Thus, we assume that the value-added cost function is weakly separable from the aggregator for raw materials and intermediate inputs. The weak separability of the cost function implies that the choice of relative labor and capital inputs will be independent of material and intermediate input prices.[5]

The cost function that reflects this technology is rewritten as

$$C(w, y; s, z) = (C^1(y, w^1; s, z), C^2(y, w^2; s, z)), \qquad (2)$$

where $w^1 = \{w_L, w_K)$ and w^2 is the vector of prices for variable inputs other than labor and capital. These subcomponents of the overall cost function should be homogeneous of degree one in w^1 and w^2, respectively, in order to be consistent with the linear homogeneity of C in w. Thus, this cost function allows for each subcomponent to be estimated separately. Our goal is to estimate the elasticity of value-added cost (which corresponds to C^1) with respect to standards. This elasticity may be written as

[5] In our particular case, the separability condition is written as

$$\frac{\partial}{\partial w_j}\left(\frac{\partial C(w, y; s, z)/\partial w_L}{\partial C(w, y; s, z)/\partial w_K}\right) = 0,\ j \neq L, K \quad \text{or} \quad \frac{\partial}{\partial w_j}\left(\frac{\partial L(w, y; s, z)}{\partial K(w, y; s, z)}\right) = 0,\ j \neq L, K\ .$$

$$\sigma_s \equiv \frac{\partial C^1}{\partial s}\frac{s}{C^1} = \partial \ln C^1 / \partial \ln s \qquad (3)$$

The third assumption is that factor prices are exogenous to firms, permitting their input choices to be made endogenously. However, inspection of our survey data shows that direct application of this assumption to a cross-section of firms is untenable because firms inevitably report different average wage rates (or annual salaries) and returns to capital. Put differently, direct construction of labor and capital prices from the survey data makes use of variables that are endogenous, both in principle and in fact.

Consider, for example, the calculation of average salary per firm, which we define as total payroll divided by firm employment. This computation generates figures for annual wage rates that vary across firms within each country, as suggested by the summary data in Table 4. Thus, the notion that firms inside a country, or even within an industry, face a common wage in a competitive labor market is questionable. Similarly, we calculate an average capital price per firm as operating surplus (value added less payroll), divided by the value of fixed assets. As may be seen in Table 4, these constructed prices vary across firms as well.

One approach to resolving this difficulty would be to apply a national-average (or industry-average) salary and price of capital to all firms. Such aggregate prices could be justified as exogenous to each enterprise. However, to do so would sacrifice the cross-sectional variation in factor prices needed to identify the cost function. To cope with this problem we employ an instrumental variables technique in which we recognize that variations in factor prices across firms depend on other characteristics of firms (Roberts and Tybout, 1997; Bernard and Jensen, 2000). Specifically, we estimate first-stage regressions of constructed labor and capital prices on national-average factor prices, country and industry dummies, firm age (years since founding), and dummy variables indicating the structure of firm ownership.

$$w_L^{ijk} = a_0 + a_1 w_L^k + a_2 w_K^k + \Sigma a_{3j} D^j + \Sigma a_{4k} D^k + a_5 AGE^{ijk} + \Sigma a_{6m} D^m \quad (4)$$

$$w_K^{ijk} = b_0 + b_1 w_L^k + b_2 w_K^k + \Sigma b_{3j} D^j + \Sigma b_{4k} D^k + b_5 AGE^{ijk} + \Sigma b_{6m} D^m \quad (5)$$

Here, superscripts i, j, and k refer, respectively, to firm, industry, and country, while superscript m refers to type of ownership. In the data there are four types of ownership: privately held domestic firms, publicly traded domestic firms (including domestic subsidiaries and joint ventures with domestic firms), subsidiaries of multinational firms (including joint ventures with multinational firms), and state-owned or collective enterprises. In principle, age and ownership are past decisions that should be exogenous to current employment levels. Thus, the instrumentation procedure should generate predicted wages that are exogenous to the second-stage cost function estimation.

With these assumptions, we can develop an estimable translog cost function. Again, we treat the standard with which a firm must comply to be a quasi-fixed factor and estimate a short-run variable cost function. The notion is that for a firm to export it must meet the required compliance cost and therefore it sets aside that component of cost before allocating labor and capital to production activities. We specify the translog form to permit a flexible second-order approximation to a cost structure depending on output, input prices, and standards. Thus, our central specification of costs for firm *i* is as follows.

$$
\begin{aligned}
\ln \widetilde{C}_i &= \beta_0 + \beta_y \ln y_i + \beta_L \ln w_{Li} + \beta_K \ln w_{Ki} + \frac{1}{2}\beta_{LL}(\ln w_{Li})^2 + \frac{1}{2}\beta_{KK}(\ln w_{Ki})^2 \\
&+ \frac{1}{2}\beta_{yy}(\ln y_i)^2 + \beta_{LK}\ln w_{Li}\ln w_{Ki} + \beta_{Ly}\ln w_{Li}\ln y_i + \beta_{Ky}\ln w_{Ki}\ln y_i + \beta_s \ln s_i \\
&+ \beta_{Ls}\ln w_{Li}\ln s_i + \beta_{Ks}\ln w_{Ki}\ln s_i + \beta_{ys}\ln y_i \ln s_i + \frac{1}{2}\beta_{ss}(\ln s_i)^2 \\
&+ \sum_{n=1}^{N}\beta_{zn} z_n + \sum_{c=1}^{C}\beta_{zc} z_c + \beta_D D_{dom} + \varepsilon_i
\end{aligned} \qquad (6)
$$

where $\widetilde{C}$ denotes value-added (cost of labor and capital, referred to as production cost hereafter), w_L denotes the instrumented wage rate, w_K denotes the instrumented unit price of capital, y denotes sales as a measure of output, and s denotes the firm-specific measure of standards. Summary data on these variables are provided in Table 4 for the estimation sample. The variables z_n and z_c denote industry-specific and country-specific factors, respectively, affecting firm costs. We capture these additional factors by means of industry and country fixed effects. For this purpose we use the four-industry aggregation listed in Table 2 and the 16 countries in Table 3.

Our setup cost for compliance is designed specifically in the survey to measure cost associated with foreign technical regulations and standards. Some of the surveyed firms indicated that it is also necessary to comply with domestic technical regulations and standards in order to sell their products in the domestic market. Because information is not available on the cost of complying with domestic technical regulations and standards, a dummy variable (D_{dom}) is used to control for the possible cost difference associated with the domestic requirement. It takes the value one if a firm reports that it is required to comply with domestic technical regulations and standards, and the value zero otherwise. The variable ε_i is the error term, which is assumed normally distributed with zero mean.

Equation (6) is the translog cost function, which we estimate simultaneously with the following equation for the share of labor in variable costs:

$$S_{Li} = \beta_L + \beta_{LL} \ln w_{Li} + \beta_{LK} \ln w_{Ki} + \beta_{Ly} \ln y_i + \beta_{Ls} \ln s_i + \mu_i \qquad (7)$$

The error term is also assumed normally distributed with zero mean and it reflects stochastic disturbances in cost minimization. We eliminate the capital-share equation from the estimation because it is fully determined by equations (6) and (7) and the constraints below.

Note that in writing these equations we have imposed the required symmetry in cross-variable coefficients. Further, the linear homogeneity condition imposes the following constraints:

$$\begin{aligned} &\beta_L + \beta_K = 1 \\ &\beta_{KK} + \beta_{LK} = 0 \\ &\beta_{LL} + \beta_{LK} = 0 \\ &\beta_{Ly} + \beta_{Ky} = 0 \\ &\beta_{Ls} + \beta_{Ks} = 0 \end{aligned} \qquad (8)$$

Equations (6) and (7) are estimated jointly in an iterative three-stage least squares procedure (I3SLS), subject to the constraints in equations (8). When one of the share equations is dropped, the I3SLS produce is the preferred approach since the estimators are consistent and asymptotically efficient (Berndt and Wood 1975). The I3SLS procedure guarantees identical translog cost parameters irrespective of which share equation is dropped. The parameters for the dropped equation can be recovered by using the symmetry condition and the conditions in equations (8).

From equation (6) we can determine the direct elasticity of production costs with respect to foreign standards as $\sigma_s^d = \beta_s + \beta_{ss} \ln s_i$, which varies with the level of standards. We are interested as well in the impacts of the standards on factor demands. The coefficient β_{Ls} in the share equation (7) measures the bias in labor use (impact on labor share) from an increase in the foreign standard ($\phi_{Ls} \equiv \partial S_L / \partial \ln s = \beta_{Ls}$), and likewise for the bias in capital use ($\phi_{Ks} \equiv \partial S_K / \partial \ln s = \beta_{Ks}$). In effect, the need to meet this standard could generate an overall increase in costs, along with a bias in factor use toward labor or capital.

While the direct cost elasticity is of some interest, we can calculate the total elasticity of cost with respect to a change in the stringency of standards, accounting for impacts on factor use, as

$$\sigma_S \equiv \partial \ln \tilde{C} / \partial \ln s = \beta_s + \beta_{ss} \ln s_i + \beta_{Ls} \ln w_{Li} + \beta_{Ks} \ln w_{Ki} + \beta_{ys} \ln y_i . \qquad (9)$$

This elasticity will vary with different observations on factor prices and output. Likewise, we can calculate the total elasticity of scale as

$$\sigma_y \equiv \partial \ln \tilde{C} / \partial \ln y = \beta_y + \beta_{yy} \ln y_i + \beta_{Ly} \ln w_{Li} + \beta_{Ky} \ln w_{Ki} + \beta_{ys} \ln s_i . \qquad (10)$$

Finally, the Allen partial elasticities of substitution between inputs i and j (σ_{ij}) are:

$$\sigma_{ii} = \frac{\beta_{ii} + S_i^{\,2} - S_i}{S_i}, \; i = L \text{ or } K$$

$$\sigma_{ij} = \frac{\beta_{ij} + S_i S_j}{S_i S_j}, \qquad i = L, j = K . \qquad (11)$$

4. Data and Variable Construction

The data used for cost estimation are taken from a new survey undertaken by the World Bank explicitly for the purpose of assessing compliance costs of firms in developing countries facing technical standards in their potential export markets. Because the data are constructed from firm-level surveys we provide an overview of their development.

4.1 The World Bank Technical Barriers to Trade Survey Data

The World Bank Technical Barriers to Trade Survey is the first comprehensive questionnaire designed to elicit information from individual firms in developing countries about how their operations are affected by foreign technical requirements.[6] The survey was administered in the year 2002 to 689 firms in 17 developing countries. The objective of the survey is to obtain information on the relevant standards, government regulations, and technical barriers to trade confronting exporters from developing countries seeking to enter major developed-country markets.

The countries cover a range of economic development and export experience yet have sufficiently deep agricultural and industrial structures to permit sectoral comparisons. Countries were selected for study in five regions. These include Poland, the Czech Republic, and Bulgaria (East Europe); Argentina, Chile, Panama, and Honduras (Latin America); Jordan and Iran (Middle East); India and Pakistan (South Asia); and South Africa, Nigeria, Uganda, Mozambique, Kenya, and Senegal (Sub-Saharan Africa). Information on the number of firms interviewed in each country and included in the estimation sample is listed in Table 3.

[6] Wilson and Otsuki (2003) describe this survey in detail.

The survey also embodies a diverse sectoral composition. The majority of firms are categorized as manufacturing. The largest single industry is textiles and apparel (46 firms) followed by raw agricultural products (18 firms) and processed food and tobacco (24 firms; see Table 2). For analytical purposes we group the industries into four broad categories, namely raw food; processed food, tobacco, drug and liquor; equipment; and textiles and materials.

Firms were asked to provide information about numerous characteristics, including product composition, age, form of ownership, employment, payroll, value of fixed assets, intermediate inputs, raw materials, and others. Of particular interest is the export orientation of firms. The majority of the respondent companies in the sample export at least some of their products. The procedure for selecting firms meant that the sample consists of firms that are either currently exporting or are willing to export but have chosen not to do so for some reason. The number of firms that are currently exporting is 646 or 93.6 percent of the total. The number of firms that are clearly not exporting is 43 or 6.4 percent of the total. Seventy percent of the firms in the total sample face the need to comply with technical regulations (as defined in the survey) in their export markets.

Across all five regions, 55 percent of the firms may be categorized as the headquarters location of a privately held, non-listed company. About 20 percent are the headquarters location of a publicly traded or listed company and 18 percent are subsidiaries or joint ventures of a domestic enterprise. About 6.5 percent are subsidiaries of foreign firms or joint ventures with foreign partners. Only a small portion of firms are state-owned or collective enterprises.

4.2 A Measure of Standards

A direct measure of the stringency of foreign standards and technical regulations facing this variety of industries and importing partner countries is difficult to define. However, the relative increase in setup cost incurred for complying with these standards is a good proxy for their stringency. One advantage of using reported investment to represent stringency is that this measure is expressed in dollar terms and therefore is comparable across industries and countries. In practical terms such an aggregation is necessary because the precise specifications of technical standards facing firms vary across industries and cannot be meaningfully aggregated at that stage. Another advantage is that expenditure for compliance can be interpreted as a quasi-fixed factor, permitting us to specify a short-run variable cost function.

Our measure of foreign standards and technical regulations is constructed from respondents' answers to the question summarized in Table 1. Respondents were asked the following question: "What are the approximate costs of the items below as a percentage of your total investment costs over the last year?" As may be seen, three categories were listed and respondents indicated such costs within broad ranges.[7] To focus on incremental investment as a measure of quasi-fixed costs, we construct a standards-cost aggregate from the first three categories. Weighted-average setup costs with regard to each category were computed by multiplying the midpoint percentage within each range by reported investment cost of each firm, yielding a dollar figure per category per firm. To develop the overall measure per firm we simply added these various cost categories. Thus, to quantify the perceived impact of meeting foreign standards and technical regulations we develop a measure of incremental contributions to

[7] The survey also asked two questions about measures of recurrent labor costs, which we do not employ in this paper.

setup costs arising from additional plant and equipment and product redesigns (in total and for multiple markets).

Unfortunately, not all firms responded to all three categories. Thus, to include only those cases with responses in all of these categories greatly would reduce the number of observations available for the regression analysis. We therefore aggregated these standards variables by summing across the three categories, assigning a category value of zero to firms with missing responses, for those firms where at least one category response was positive. Presumably, this procedure understates the severity of such costs and should result in conservative cost estimates.[8]

Therefore, we use the increase in previous year's reported investment cost for compliance as a measure of the short-run fixed cost of standards and technical regulations. As shown in Table 4, the total standard cost varies from a minimum of $357 to a maximum of $12.3 million. Reported setup costs for compliance obviously are greater for larger firms.

5. Estimation Results

The first-stage regressions to develop instrumented labor and capital prices were run based on equations (4) and (5). The instruments used include per capita GDP, real interest rates, firm age, country and industry dummies, and dummy variables indicating the structure of firm ownership. Per capita GDP and real interest rates were used to represent national average wage rates and national average price of capital, respectively. We used the lending interest rate available from the World Development Indicators. The interest rates were adjusted for inflation

[8] This selection procedure raises a significant concern about selectivity bias. To control for this we included in supplemental regressions a dummy variable taking on the value of 1 for firms that answered all three categories and a value of zero otherwise. This made virtually no difference in the results.

as measured by the GDP deflator. These two equations were estimated jointly using seemingly unrelated regression (SUR). The instrumented wage rates and capital prices were then used in the cost function and share equation regressions.

In the second stage a cost function was run under alternative specifications. The maximum number of observations included in these regressions was 159. As mentioned earlier, this loss in observations is largely due to the low response to the questions regarding compliance with the foreign standards and technical regulations. The translog cost function was estimated with the labor share equation jointly by using maximum likelihood estimation with iterated three-stage least squares. The I3SLS method was used to obtain consistent estimators by guaranteeing invariance of the estimated coefficients of the share equations irrespective of which of the share equations is dropped (Berndt and Wood, 1975).

The parameter estimates with respect to translog models are presented in Table 5, with standard errors reported in parentheses. In the first specification we exclude the quadratic term on standards and the cross-terms on standards, input prices, and output. Thus, this model tests for the notion that technical regulations affect costs only directly, without secondary impacts through scale and variable inputs. The second equation contains the full translog specification and is consistent with theory. Both of these regressions employ the instrumented factor prices from the first stage. The third equation also follows the full specification but for comparison purposes uses the raw (uninstrumented) wage rates and unit prices of capital. Finally, the fourth model is estimated under the full translog but employs a different definition of the standards variable, one that only contains the categories for one-time product redesign costs (excluding plant and equipment investment). In this case the sample size falls to 96. Our interest here is in seeing if the redesign costs alone have different impacts on costs.

All equations include industry and country fixed effects. The fit of each model is good with adjusted R-squared coefficients of around 0.9. According to the procedures described in Berndt and Wood (1975), we examined local concavity in input prices and positivity of input shares for the translog model. Our fully specified translog cost functions were found to satisfy these conditions.

The results of the translog model estimation suggest that the signs for the coefficients for the linear and quadratic terms of the wage rate and capital price are all positive and statistically significant. However, the signs and significance of the coefficients for the linear and quadratic terms of the log of standards are mixed. In the restricted model I, the direct coefficient β_S is positive, suggesting that costs rise with the relative severity of foreign standards. However, in the general models II, III, and IV both the linear and quadratic coefficients on standards are negative, suggesting that the direct effect of standards is negative or cost saving.

However, such direct impacts fail to account for the impacts of foreign technical regulations through factor use and scale. We compute the total elasticity of costs with respect to standards as in equation (9), reporting the results in Table 6. We evaluate this elasticity at the mean and first and third quartiles of standards, sales, and input prices. It may be seen that the total elasticity of domestic costs in producing value added with respect to variations in foreign standards ranges from 0.055 to 0.325, depending on the estimation approach and sample quartile. This estimate is significantly positive at the mean in Model II and consistently positive and significant in Models III and IV.

These differences require some explanation. The highest elasticities are registered in Model III, in which the variable factor prices are not instrumented. Taken literally, the result would suggest a quantitatively large impact of the severity of foreign standards on variable input costs in exporting firms. That is, having satisfied the fixed setup costs required by foreign technical regulations, variable costs would increase via a large induced increase in labor and capital demand. Indeed, the computed elasticities of labor and capital demand in Table 9 are highest in this specification, suggesting that a one-percent rise in foreign standards would induce an 0.3-percent increase in labor and an 0.24-percent increase in capital employment.

However, these estimates fail to account for the endogeneity between production costs and factor prices in our firm-level data. The instrumental variables approach in Models II and IV should offer more reliable estimates. It may be seen that, using the fuller specification of standards costs in Model II, including both plant and equipment charges and redesign costs, the estimated cost elasticity in Table 6 is approximately 0.06, which is significantly positive only at the mean of the sample. Thus, our estimate with the preferred econometric approach and the larger sample suggests that increases in foreign standards compliance costs modestly affect variable cost.

Interestingly, however, the estimated total cost elasticity is considerably higher in Model IV, which incorporates only the product-redesign costs as a fixed factor. In that specification the estimated elasticity is around 0.13 and is highly significant at the sample mean. This finding indicates that the need to reorient product characteristics to meet foreign standards adds significantly to short-run variable costs. While the results in Models II and IV are not strictly comparable because of the different samples, this provides some indication that it is the need to meet foreign requirements on product characteristics that matters rather more for sustaining export positions. As may be seen in Table 9, the need for redesign implies induced increases in demand for labor and capital of perhaps 0.12 - 0.15 percent.

While the estimated elasticities of variable cost with respect to the severity of foreign standards seem modest, the implied cost impacts should be kept in perspective. As noted in Table 7, at the sample mean a one-percent increase in compliance costs amounts to $4,250 for the larger sample ($1,620 for the smaller sample). In turn, the table lists the dollar increment in variable costs implied by the elasticities in each model at the sample mean. As may be seen, this increase is $5,270 in Model II and $12,904 in Model IV. Thus, the implied expansion of variable costs is, in fact, of a similar magnitude to the rise in required investment to meet compliance costs. Viewed this way the impact on overall costs for the average firm, including both compliance expenditures and variable charges, is economically significant.

Estimates of the scale elasticity (equation (10) are also presented in Table 6. This parameter measures the percentage change in variable cost with respect to a one-percentage change in output and may be interpreted as the ratio of marginal cost to average cost. These scale elasticities range between 0.91 and 1.11. It is therefore not clear whether the average firm in our sample exhibits economies of scale or diseconomies of scale.

We have assumed so far that the elasticity of costs with respect to standards is constant across industries. Unfortunately, we do not have sufficient numbers of observations to run a separate cost function regression per industry even using the aggregated industries. We instead examine the constancy of the elasticity by letting the elasticity vary across industries in a pooled regression. That is, we estimate equations (6) and (7), incorporating interaction terms between the standards variables and four aggregate industry dummies. Let j denote j^{th} industry. Equations (6) and (7) will be rewritten as:

$$\begin{aligned}\ln \tilde{C}_i &= \beta_0 + \beta_y \ln y_i + \beta_L \ln w_{Li} + \beta_K \ln w_{Ki} + \frac{1}{2}\beta_{LL}(\ln w_{Li})^2 + \frac{1}{2}\beta_{KK}(\ln w_{Ki})^2 \\ &+ \frac{1}{2}\beta_{yy}(\ln y_i)^2 + \beta_{LK} \ln w_{Li} \ln w_{Ki} + \beta_{Ly} \ln w_{Li} \ln y_i + \beta_{Ky} \ln w_{Ki} \ln y_i + \sum_j \beta_s^j D^j \ln s^j{}_i \\ &+ \sum_j \beta_{Ls}^j D^j \ln w_{Li} \ln s^j{}_i + \sum_j \beta_{Ks}^j D^j \ln w_{Ki} \ln s^j{}_i + \sum_j \beta_{ys}^j D^j \ln y_i \ln s^j{}_i \\ &+ \frac{1}{2}\sum_j \beta_{ss}^j D^j (\ln s^j{}_i)^2 + \sum_{n=1}^{N} \beta_{zn} z_n + \sum_{c=1}^{C} \beta_{zc} z_c + \beta_D D_{dom} + \varepsilon_i\end{aligned} \tag{12}$$

$$S_{Li} = \beta_L + \beta_{LL} \ln w_{Li} + \beta_{LK} \ln w_{Ki} + \beta_{Ly} \ln y_i + \sum_j \beta_{Ls}^j D^j \ln s_i + \mu_i \tag{13}$$

where $D^r = 1$ if $j = r$ and $D^r = 0$ if $j \neq r$. The fifth constraint in (8) should also be rewritten accordingly:

$$\beta_{Ls}^j + \beta_{Ks}^j = 0 \quad \text{where } j = 1,..,J \tag{14}$$

This revision of the equations and a constraint permits us to compute elasticities for four aggregated industries, including equipment, textiles and materials, raw food, and processed food. The j^{th} industry's total elasticity of cost with respect to standards is:

$$\sigma_s^j = \beta_s^j + \beta_{ss}^j \ln s_i + \beta_{Ls}^j \ln w_{Li} + \beta_{Ks}^j \ln w_{Ki} + \beta_{ys}^j \ln y_i . \tag{15}$$

The results for each model are presented in Table 8. There appear to be no significant impacts on variable costs in processed foods, tobacco, drugs, and liquors. Estimated cost elasticities are consistently positive in the other sectors and standards seem to affect variable costs especially in equipment (Model II) and textiles and material (Model IV).

Finally, Table 9 displays the elasticities of labor and capital demand with respect to standards. These may be defined as

$$\sigma_{Ls} \equiv \partial \ln L / \partial \ln s = \partial \ln C / \partial \ln s - \partial \ln S_L / \partial \ln s \qquad (16)$$

$$\sigma_{Ks} \equiv \partial \ln K / \partial \ln s = \partial \ln C / \partial \ln s - \partial \ln S_K / \partial \ln s$$

Using the elasticity of cost with respect to standards, evaluated at the mean, the full translog model with instrumented input prices (Model II) implies that σ_{Ls} =0.060 and σ_{Ks} =0.056. This indicates that a rise in compliance setup costs increases both labor and capital usage, with a slightly greater increase in labor demand. As noted above, these effects are larger in Model IV. The Allen partial elasticities of substitution in Table 10 indicate a moderate substitutability between labor and capital (σ_{KL}) in the sample. The own-elasticity estimates indicate that labor is highly elastic with respect to its own price and that capital is much less elastic.

6. Conclusions

This paper estimates the impact on short-run costs of complying with standards and technical regulations required by importing countries by using firm-level data on technical barriers to trade for 16 developing countries based on the World Bank Technical Barriers to Trade Survey Database. The translog model results indicate that incremental production costs are greater for a firm confronting more stringent standards and technical regulations. Using the broader measure of standards in Model II, variable production costs are 0.058 percent higher when the initial setup cost for compliance with foreign standards is increased by one percent. In this case 0.060 percent additional labor and 0.056 percent additional capital are employed.

Using the narrower cost definition, focusing on product redesign costs, the impacts on variable costs are considerably higher, at 0.13 - 0.14 percent, with correspondingly higher impacts on variable factors. We focus on only labor and capital cost, but other types of input costs may arise as additional plants and production units will require additional raw material, energy and intermediate inputs.

Our analysis demonstrates the possible supply response in developing country enterprises when changes in foreign standards and technical regulations take place. It can also be inferred how much more (less) cost is incurred when a firm switches between export markets that vary in the severity of standards and technical regulations. It is conceivable that firms might avoid higher-cost markets in light of the impacts on production expenditures.

The results may be cautiously interpreted as indications of the extent to which standards and technical regulations constitute non-tariff barriers to trade. While the relative impact on costs is small in terms of the underlying elasticity, it could be decisive for particular firms and countries. In this context, there is scope for assessing the damages to the exporting country's trade benefits where the importing country's regulations may not conform to WTO obligations. Policy solutions then might be sought by identifying the extent to which subsidies or public support programs are needed to offset the cost disadvantage that stems from international technical regulations.

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Table 1. Question on Cost Impact of Complying with Foreign Standards as a Share in Total Investment (number of firms)

Share of investment costs	1-10%	11-25%	26-50%	51-75%	76-100%	>100%	Total
Additional plant or equipment	62	32	14	6	3	3	120
One-time product redesign	70	17	5	3	1	0	96
Product redesign for each market	57	15	4	4	0	0	80

Table 2. Industries in the Sample

Aggregate Industry	Sub-industry	Count
Raw food	Raw agricultural and meat products	**18**
Subtotal		***18***
Processed food, tobacco, drug and liquor	Processed food, tobacco, drug and liquor	**24**
Subtotal		***24***
Equipment	Electronics	**11**
	Industrial equipment	**4**
	Transportation equipment, and auto parts	**10**
	Other equipment	**6**
Subtotal		***31***
Textiles and Materials	Metal and mineral	**15**
	Chemical	**11**
	Leather	**3**
	Plastics material	**9**
	Textiles and apparel	**46**
	Wood product	**2**
Subtotal		***86***
Total		***159***

Table 3. Number of Surveys Used for the Analysis by Country

Region	Country	Count
East Europe	Bulgaria	23
	Czech Republic	6
	Poland	9
East Europe Total		***38***
Latin America & Caribbean	Argentina	5
	Chile	7
	Honduras	3
	Panama	6
Latin.America & Caribbean Total		***21***
Middle East	Iran	14
	Jordan	6
Middle East Total		***20***
South Asia	India	33
	Pakistan	30
South Asia Total		***41***
Sub-Saharan Africa	Kenya	8
	Nigeria	1
	Senegal	2
	South Africa	25
	Uganda	5
Sub-Saharn Africa Total		***39***
16 Country Total		***159***

Table 4. Data Summary

Variable	Mean	Std. Dev.	Min	Max
Value Added (US$1,000)	9,087	22,744	13	189,463
Sales (US$1,000)	21,382	49,297	48	336,216
Wage rate (US$1,000)	3.14	3.14	0.11	15.38
Wage rate instrumented (US$1,000)*	2.47	1.78	0.34	8.15
Unit price of capital (US$1,000)	1.92	4.10	0.00	29.91
Unit price of capital instrumented (US$1,000)*	0.82	0.63	0.06	4.01
Per capita GDP (US$1,000)	2.22	1.89	0.26	7.47
Real interest rate (lending) (%)	9.00	4.78	1.68	29.09
Number of years since foundation	27.58	23.71	2	142
Standards (compliance costs of previous year) (US$1,000)	425	1,441	0.357	12,310

*Please see Section 5 for the instruments used for the wage rate and the unit price of capital.

Table 5. Cost Function Estimation (Fixed Effects: Industry, Country)

Parameters	Model I (I3SLS)	Model II (I3SLS)	Model III (I3SLS)	Model IV (I3SLS)
β_0	-0.810 (0.660)	-1.585** (0.804)	0.031 0.977	-1.751 (1.146)
β_y	0.761*** (0.145)	1.068*** (0.219)	1.153*** 0.309	1.181*** (0.296)
β_{yy}	0.019 (0.018)	-0.040 (0.034)	-0.116** 0.016	-0.067 (0.041)
β_L	0.351*** (0.083)	0.376*** (0.087)	0.286*** 0.067	0.416*** (0.104)
β_K	0.649*** (0.083)	0.624*** (0.087)	0.714*** 0.067	0.584*** (0.104)
β_{LL}	0.079*** (0.013)	0.077*** (0.013)	0.078*** 0.005	0.065*** (0.012)
β_{KK}	0.079*** (0.013)	0.077*** (0.013)	0.078*** 0.005	0.065*** (0.012)
β_{LK}	-0.079*** (0.013)	-0.077*** (0.013)	-0.078*** 0.005	-0.065*** (0.012)
β_{Ly}	-0.011 (0.011)	-0.016 (0.012)	0.006 0.51	-0.016 (0.014)
β_{Ky}	0.011 (0.011)	0.016 (0.012)	-0.006 0.51	0.016 (0.014)
β_s	0.055* (0.031)	-0.254* (0.153)	-0.528** 0.015	-0.391 (0.257)
β_{ss}		-0.050** (0.025)	-0.084** 0.018	-0.079** (0.037)
β_{Ls}		-0.002 (0.010)	-0.024*** 0.004	-0.016 (0.014)
β_{Ks}		0.002 (0.010)	0.024*** 0.004	0.016 (0.014)
β_{ys}		0.058** (0.026)	0.133*** 0.037	0.090** (0.036)
β_D	0.008 (0.113)	0.013 (0.111)	-0.355*** 0.025	0.002 (0.172)
Fixed Effects	Industry, Country	Industry, Country	Industry, Country	Industry, Country
w_L and w_k Instrumented	yes	yes	no	yes
Standards	Redesign and Equipment	Redesign and Equipment	Redesign and Equipment	One-time Redesign
Statistics				
N	159	159	159	96
Adjusted R-squared	0.923	0.923	0.873	0.924
Log likelihood	-95.435	-92.754	-108.765	-47.915

Note: The adjusted R-squared is computed as one minus the ratio of the residual sum of squares to the total sum of squares, adjusted by the degrees of freedom. Figures in parentheses are standard errors and coefficients are significantly different from zero as indicated by *** (1%), ** (5%) and *(10%).

Table 6: Elasticity of Variable Cost with respect to Standards and Scale

Elasticity with respect to	Elasticity evaluated at	Model I	Model II	Model III	Model IV
Standards	25 percentile	na	0.055 (1.473)	0.207*** (4.320)	0.142* (1.894)
	mean	0.055* (1.760)	0.058* (1.765)	0.270*** (6.188)	0.132*** (2.619)
	75 percentile	na	0.056 (1.436)	0.325*** (6.177)	0.146*** (2.882)
Scale	25 percentile	0.893*** (21.031)	0.998*** (12.927)	0.851*** (7.785)	0.876*** (13.705)
	mean	0.914*** (23.734)	1.112*** (11.217)	1.068*** (7.404)	1.086*** (17.460)
	75 percentile	0.939*** (19.446)	1.242*** (9.609)	1.296*** (6.945)	1.255*** (14.515)

Note: Numbers in parentheses denote asymptotic t-values.

Table 7. Estimated Impact on Mean Dollar Variable Costs of One-Percent Increase in Mean Setup Costs

	Model I	Model II	Model III	Model IV
One-percent Increase in Mean Setup Costs	$4,250	$4,250	$4,250	$1,620
Mean Impact	$4,998	$5,270	$24,535	$12,904

Table 8: Elasticity of Variable Cost with respect to Standards by Industry

Model	Model I	Model II	Model III	Model IV
Machinery and Equipment	0.114** (2.000)	0.322*** (3.862)	0.475*** (3.888)	0.225 (1.409)
Processed Food, Tobacco, Drug, and Liquor	-0.004 (-0.060)	-0.053 (-0.633)	0.077 (0.667)	-0.026 (-0.148)
Raw Food	0.018 (0.310)	0.079 (1.175)	0.419*** (4.795)	0.190 (1.177)
Textiles and Materials	0.058* (1.740)	0.033 (0.866)	0.236*** (4.738)	0.124** (2.214)

Note: Numbers in parentheses denote asymptotic t-values.

Table 9: Effect of Standards and Technical Regulations on Input Demand

	Model I	Model II	Model III	Model IV
Labor Demand (σ_{Ls})	na	0.060	0.299	0.148
Capital Demand (σ_{Ks})	na	0.056	0.240	0.116

Table 10: Substitution Elasticity Estimates

	Model I	Model II	Model III	Model IV
Allen Elasticity of substitution between L and K (σ_{KL})	0.639	0.636	0.627	0.694
Own elasticity of L (σ_{LL})	-1.456	-1.450	-1.404	-1.600
Own elasticity of K (σ_{KK})	-0.280	-0.279	-0.280	-0.301